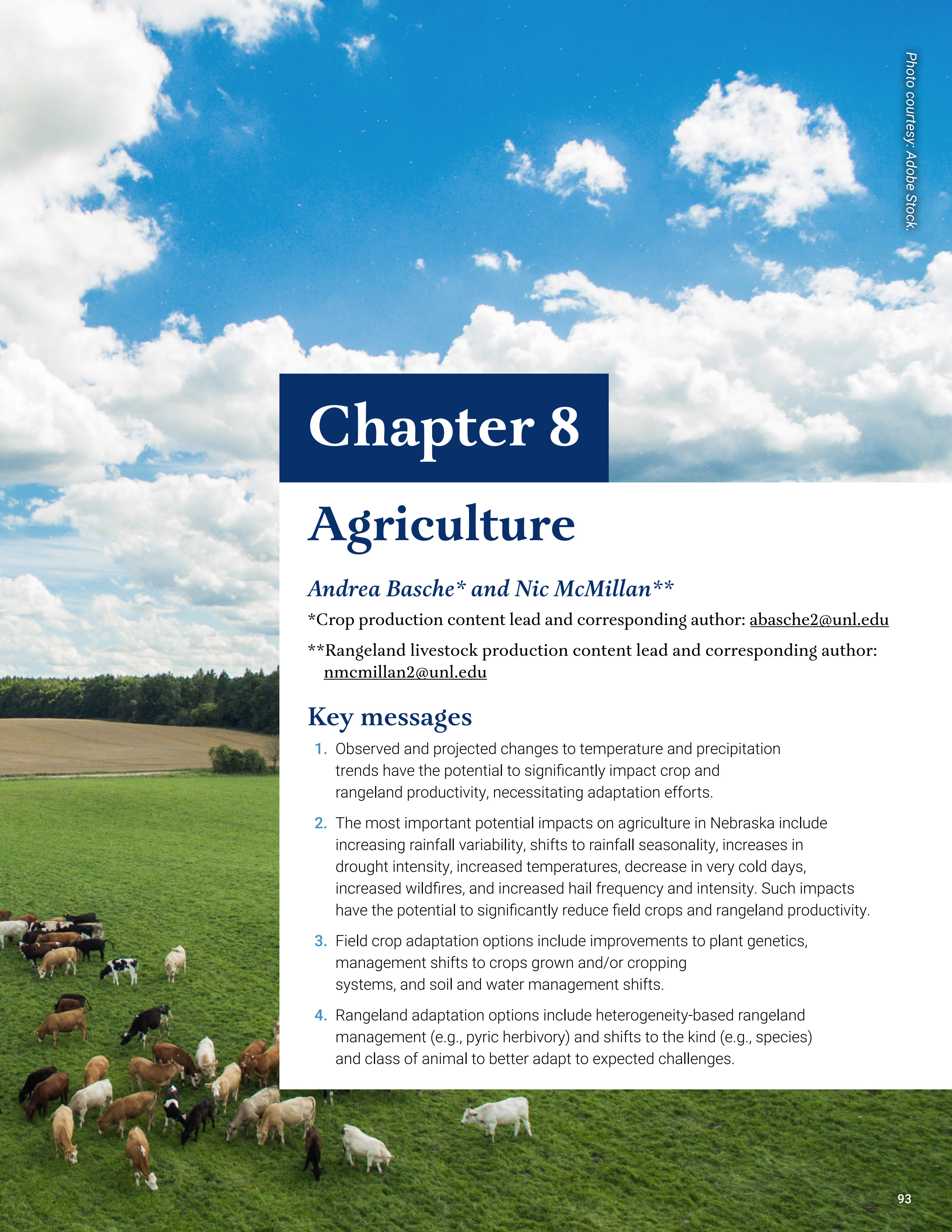
Understanding and Assessing Climate Change: Preparing for Nebraska's Future

2024 Climate Change Impact Assessment Report
Chapter 8 - Agriculture



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Chapter 8

Agriculture

Andrea Basche and Nic McMillan***

*Crop production content lead and corresponding author: abasche2@unl.edu

**Rangeland livestock production content lead and corresponding author: nmcmillan2@unl.edu

Key messages

1. Observed and projected changes to temperature and precipitation trends have the potential to significantly impact crop and rangeland productivity, necessitating adaptation efforts.
2. The most important potential impacts on agriculture in Nebraska include increasing rainfall variability, shifts to rainfall seasonality, increases in drought intensity, increased temperatures, decrease in very cold days, increased wildfires, and increased hail frequency and intensity. Such impacts have the potential to significantly reduce field crops and rangeland productivity.
3. Field crop adaptation options include improvements to plant genetics, management shifts to crops grown and/or cropping systems, and soil and water management shifts.
4. Rangeland adaptation options include heterogeneity-based rangeland management (e.g., pyric herbivory) and shifts to the kind (e.g., species) and class of animal to better adapt to expected challenges.

Introduction

Understanding the potential effects of climate change on the agricultural sector in Nebraska is of critical importance, given its significant contributions to the state's overall economy, environment, land, and water use, as well as human health and well-being. Nebraska is the fifth-ranking state in the U.S. for overall agricultural sales and is within the top five producing states for crops, grains/oilseeds, cattle, and hogs, and it is one of the leading states in the country for irrigated acres (USDA, 2022; USDA NASS 2023; USDA ERS, 2017). Specific to cattle, the top cash receipt for the state, Nebraska is a leading beef production state in the U.S., with a total of 6.25 million cattle and calves as of 2024 (USDA NASS, 2024; USDA ERS, 2024a). Agricultural land use comprises over 85% of the state's area, consisting of more than 21 million acres of cropland and 21 million acres of pastureland—approximately 44 million acres of working farms (USDA NASS, 2023; U.S. Census Bureau, 2021). The potential impacts of climate change on the agricultural sector, given its critical importance to the state, make adaptation necessary (Bolster et al., 2023; Burchfield, 2022). Further, the state is increasingly recognizing the impacts, mitigation needs, and adaptation opportunities climate change presents for the agricultural sector. For example, the Nebraska Department of Environment and Energy recently published a climate action plan to identify measures to reduce greenhouse gas emissions and was awarded a significant investment from the Environmental Protection Agency through a Climate Pollution Reduction Grant (CPRG) (NDEE, 2024b; EPA, 2024b). In the following sections, we focus on known physical climate impacts and their potential to affect key elements of the agricultural sector in Nebraska. We also include some potential adaptation options from recent research.

Important climate impacts for the agricultural sector

The 2023 National Climate Assessment and research in the state of Nebraska outline many observed and predicted climatological trends for temperature and precipitation, with the potential to cause significant impacts on agricultural production (see supplemental report part 2, Table SR 8). Precipitation trends observed or predicted include increasing rainfall variability, shifts to rainfall seasonality, and increases in the days with very heavy rain (Marvel et al., 2023). Importantly, drought is projected to increase in intensity and potential frequency (Knapp et al., 2023; Chapter 3). Increases in evaporative demand, with shifts to streamflow and runoff, can strain the state's important irrigation resources. Temperature shifts include an overall increase in mean temperatures as well as a decrease in the number of very cold days. Although the total number of very hot days (>95°F) decreased slightly from 1991 to 2020 compared to the 1951 to 1980 period in the eastern portion of the state, the number of extremely hot days (90°F or higher) is projected to be two to four times larger than during the historical period (Chapter 4). Other potentially challenging risks for the agriculture sector include increased wildfire and hail frequency and intensity (Knapp et al., 2023; Chapter 4).

Impacts on crop production

Corn and soybean

Corn and soybeans are annual crops that grow and mature primarily during summer. As a result, these crops are exposed to growing season stressors, including increases in the number of very hot days and shifting rainfall variability. Risks of shifting rainfall variability include periods of too much or not enough rain, extended drought, and potential increases in hail (see supplemental report, Table A.7). Heavier rain in spring can complicate planting conditions, and drought in summer can limit yield potential. Recent research provides important evidence for how heat and water stress might impact future corn and soybean yields and their potential cultivation in the state. Yang and Wang (2023) project that corn yields in the Midwest, including much of the geographic extent of Nebraska, could decline by 12% in the mid-21st century and up to 40% by the end of the century. Their results for soybean yields were mixed; some models predict yield increases by mid-century, with significant decreases by the end of the century. Their research found that crop yields in our region are currently limited by water stress, but that is likely to shift to heat stress by the end of the century. Another estimate of corn yields in the future projects yield declines by the end of the century, ranging from 11% to 43%, depending on the representative carbon pathway—the projection of future greenhouse gas concentrations—considered (Robertson et al., 2018). However, other researchers have found that temperature stress from corn has decreased over recent years (Leng, 2017). Using future climate projections, Burchfield (2022) found that much of Nebraska could become less biophysically suitable for corn and soybeans by the end of the 21st century without further adaptation efforts.

Wheat

Wheat is a cool-season crop, planted in the fall. It begins its vegetative growth before a period of dormancy, then continued growth and development into spring and early summer. This growth habit subjects it to potential anticipated impacts, including shifting in the seasonality of rainfall, increases in drought intensity, and increases in temperatures. According to models built on experiments in eastern Colorado, Robertson et al. (2018) estimated that wheat yields could decline between 37% and 50%. Additionally, known climatic changes are anticipated to increase the range and persistence of many wheat pests, including weeds, diseases, and insects, primarily due to increased drought and high temperatures (Bajwa et al., 2020). However, when accounting for policy and market shifts in addition to projected climate change, Fei et al. (2017) suggest that wheat production could shift toward cooler conditions—northward in the southern Great Plains and westward in the Northern Plains—leading to the potential for an increase in wheat acreage in Nebraska. Burchfield (2022) similarly found that parts of southern Nebraska could become more suitable for wheat cultivation by the end of the 21st century.

Environment and irrigation

Increases in rainfall variability, higher temperatures, and changes to runoff and streamflow have the potential to impact crop production and contribute to environmental degradation. These observed and anticipated climate impacts could also constrain Nebraska's important irrigation resources. Approximately 90% of irrigated acres in Nebraska rely on groundwater, specifically the High Plains Aquifer. This water resource significantly increases crop and water productivity (Evett et al., 2020). At present, Nebraska's groundwater levels are estimated to be declining at a slower rate than that of more southern locations in the Great Plains (Evett et al., 2020). However, aquifer levels in the state's western region have steadily declined for several decades, and in the southeast, groundwater levels fluctuate annually because of precipitation (Chapter 5). In recent decades, groundwater-level declines in extreme dry years have not been recharged to the same extent as in extreme wet years; drought years tend to have approximately double the impact on groundwater levels compared to above-average rainfall years (Chapter 5).

Observed and anticipated climate impacts also pose risks to soil, water, and air quality. For example, Zhang et al. (2021) created nitrogen budgets at a county level across the Corn Belt. They found evidence that the nitrogen surplus, defined as nitrogen not recovered by crops, will be exacerbated across Nebraska when conditions are more extreme, including wetter, hotter, and drier-than-normal seasons. This work estimates that nearly 70% of crop nitrogen losses across the U.S. are derived from the Corn Belt region. This underscores the importance of understanding interventions to reduce losses given the observed and predicted increases in temperature and precipitation extremes (Zhang et al., 2021). Additionally, transitions from lower to higher rainfall seasons, as seen across the region in 2012 and 2013, significantly increased nitrate loading in surface waters due to excess soil nitrogen from drought that mobilized with heavier rain. Such "whiplash" conditions are anticipated to increase with climate change and potentially threaten water bodies to exceed safe drinking water conditions (Loecke et al., 2017). Lambert et al. (2020) found increasing dust from agricultural expansion between 2000 and 2018 across most of Nebraska, particularly in planting and harvest seasons. With the anticipated increases in drought, there is potential for further impact on economic and human health associated with dust aerosols and storms (Lambert et al., 2020). Finally, for soil quality, modeling analyses investigating soil changes with climate change find the potential for decreases in soil carbon when there are declines in crop yield (Wienhold et al., 2018). However, other research notes that crop rotation will impact the direction of potential soil carbon changes (Nash et al., 2018; Robertson et al., 2018).

Climate change adaptation strategies for crop production

While projections for yield declines and environmental impacts have the potential to be significant, adaptation options exist—including shifts to agronomy, plant breeding, crop diversity, and water management. For crop and soil management, options that include flexibility and monitoring in heavier or lesser rainfall scenarios could become increasingly important. Producers likely already use these practices to account for weather or seasonal variability. Nebraska Extension's *Weather-Ready Nebraska* tool includes several adaptation ideas. These include more frequent applications of inputs to reduce losses (i.e., split application of nitrogen), reducing seeding rates, and shifting planting timing and/or planting shorter or longer season varieties to accommodate for shifts in rain (UNL, n.d.). For example, prior to the introduction of more drought-tolerant corn hybrids, some dryland farmers would plant maturing hybrids very early in the season to harvest very early (i.e., March to August) to take advantage of spring moisture and the potential to double crop a more drought-tolerant species (T. Hoegemeyer, personal communication, September 30, 2024). Heavier rainfall seasons highlight the importance of residue management for erosion prevention (UNL, n.d.). Relatedly, Kukal and Irmak (2017) found that corn and soybean precipitation use efficiency (cropping system water use in terms of seasonal precipitation) during the period from 1982 to 2013 is higher on average in Nebraska than in other states in the region. Their results suggest that soil or other management practices sustaining the effective use of rainfall contribute to crop productivity. This could result from a high percentage of conservation tillage practices in Nebraska. Additionally, many well-known soil management practices, including those associated with soil health (such as conservation tillage, cover crops, and crop rotation), are known to improve soil hydrology and have the potential to buffer negative climate impacts in both flooding and drought conditions (Basche & DeLonge 2017, 2019). Additionally, improvements to soil health, notably water and nutrient cycling, documented recently on Nebraska farms, present an opportunity to reduce potential climate impacts and confer broader ecosystem services (Krupek et al. 2022a, 2022b). Kukal and Irmak's (2018) analysis of county-level yields in Nebraska (corn, soybean, sorghum) from 1968 to 2013 found that irrigated yields were robust across years, suggesting this as a potential adaptation strategy.

For crop genetics, recent research has highlighted the mechanisms by which corn plants will experience heat stress, suggesting some adaptation options. Li et al. (2020) exposed corn plants in a field setting to heat stress during V12-VT (max temperature of 41.7°C or 107°F compared to 35.3°C or 96°F in control plots) and found significant impacts on photosynthesis in corn. This included disruptions to chloroplasts, mitochondrial membrane structure, and stomatal conductance. Li and Howell (2021) described how the genes behind heat shock proteins and how hormonal responses contribute to thermotolerance and, therefore, could be targeted for future plant breeding. Relatedly, the motivation for "short corn" plant breeding efforts includes its reduced vulnerability to windstorms and the potential for increased productivity with higher plant populations (Stokstad, 2023). Adaptation efforts for wheat, including plant breeding for higher temperatures during critical reproductive growth stages and to account for the potential of longer and sometimes wetter growing seasons, will become more important (Morgounov et al., 2018). Additionally, exploring different genetic resources for wheat varieties may be another beneficial adaptation strategy, as a variety of kamut has been found to be more resistant to diseases from pests such as wheat stem sawfly (Adhikari et al., 2018). Continued investments in plant breeding efforts are important to sustain the viability of important field crops.

Although Burchfield (2022) finds that there will be a reduction in the biophysical suitability of corn and soybean production in Nebraska, their agricultural suitability is driven by the significant existing investments in programs such as crop insurance and other government support. Given anticipated changes, the investments needed to sustain current crops may have a high cost; for example, crop insurance payouts have increased in recent decades due to weather events (Reyes & Elias, 2019). As a result, there is a need to simultaneously explore adaptation options that include crop diversification—specifically, identifying crops that may be more biophysically adapted to be incorporated into future cropping systems. For example, a recent report projecting the potential for crops grown in Kansas by 2050 found opportunities associated with a shift from crops with lower water demand, such as planting sorghum instead of corn, millet instead of soybean, and rye or oats instead of wheat (Suttles et al., 2024). However, to be successful, these new crops need reliable support via infrastructure, markets, knowledge, equipment, and more. Such needs present significant challenges for producers and potential new business opportunities. Producers in the region note current time and resource limitations as barriers to shifting crops grown (Kasu et al., 2019).

A longer growing season presents expanded opportunities for cover cropping, relay cropping, perennial grain or forage crops, and the potential for increased livestock integration on cropland. Utilizing tools such as advances in plant breeding and crop and climate models could support the optimization of such cropping systems (Basche et al., 2016; Gesch et al., 2023; Jungers et al., 2023; Smart et al., 2021; Thivierge et al., 2023). Growing a variety of crops, especially those tolerant to waterlogged conditions, can help farmers spread risk and reduce the overall impact of extreme rainfall on their operations (USDA, n.d.). However, these crop diversification practices would similarly require continued and new investments in infrastructure such as markets, equipment, and knowledge.

Although irrigation could be considered an adaptation strategy, it cannot be assumed that the same quantity of water will always be available, given the historical trend of extremely dry years leading to more significant groundwater declines compared to recharge from extremely wet years (Chapter 5). Conservation irrigation efforts include shifts to irrigation technologies such as methods of application and scheduling of application, shifts to crops grown, and improved crop genetics for water use (Evett et al., 2020). Gibson et al. (2019) found that Nebraska's irrigated water use for corn and soybean production could be reduced without sacrificing yields. Groundwater withdrawal limits put in place by Natural Resources Districts and conservation efforts since at least the 1970s have been somewhat effective at increasing water resource sustainability (Evett et al., 2020; Chapter 5). In the future, however, increases in aridity, decreases or shifts to runoff and streamflow, increased evapotranspiration, and the lengthening of the growing season have the potential to put additional pressure on groundwater resources (Chapter 5; Knapp et al., 2023). Installing on-farm drainage systems, such as retention ponds or drainage ditches, can help manage excess water and prevent flooding (Magdoff & Van Es, 2021).

Impacts on rangeland livestock production

Increasingly variable timing, intensity, and frequency of rainfall events will likely alter plant communities across Nebraska's rangelands, impacting traditional livestock production strategies in the state. Rangelands are often water-limited landscapes, and their ability to support different kinds (i.e., species) and classes (e.g., stocker cattle, cow-calf, etc.) of livestock is determined, in part, by spatial and temporal patterns of rainfall (Holechek, 2011). Increased intensity and frequency of drought are expected under all emissions scenarios by the mid- to late 21st century, with summer drought more probable than spring drought (Knapp et al., 2023). Early season precipitation, when coupled with mid- to late growing season drought, is predicted to favor a shift from highly productive warm-season (C_4) to less productive cool-season (C_3) dominated plant communities in mesic rangelands (i.e., tallgrass prairie), a characteristic that was also observed during the Dust Bowl in the 1930s (Knapp et al., 2020). Summer drought is also expected to lower rangeland productivity in arid and semi-arid short and mixed-grass rangelands. Specifically, studies in mixed-grass and shortgrass rangelands across the U.S. and southern Canada—similar to some of those found in Nebraska—suggest steep reductions in forage and litter production and increased bare ground during times of frequent and sustained summer drought (Carroll et al., 2021; Erichsen-Arychuk et al., 2002). Drought-induced plant community changes, like shifting from warm-season- to cool-season-dominated rangelands, will impact the timing and duration of grazing, as many producers currently tailor their management strategies on rangelands to follow seasonal changes in warm-season forages. Likewise, concomitant reductions in annual rangeland forage productivity following drought-induced plant community shifts will likely reduce livestock production across affected rangelands (Allred et al., 2013).

Increased drought frequency, especially during the late growing season, is likely to increase the frequency and impacts of wildfire on rangeland livestock production. However, specific effects are likely dependent upon the scale (i.e., acreage) of affected operations. Increased biomass production following high precipitation events early in the growing season, coupled with later season drought, increases the likelihood of wildfire by increasing the abundance and density of fine fuels (like standing dead biomass or litter). While the effect of fire on rangeland vegetation is often positive for livestock producers (Scasta et al., 2016), increased fire frequency is well known to promote the spread and establishment of many invasive annual grasses of concern to the livestock industry in Nebraska, like cheatgrass (*Bromus tectorum* L.; Hobbs & Huenneke, 1992; Lear et al., 2020).

Changes to plant community composition resulting from altered precipitation patterns are likely to decrease—or significantly alter—livestock production across Nebraska's rangelands due to declining forage availability and quality throughout the growing season. However, the effect of invasive species and other plant compositional changes on rangeland function is debated and suspected to be scale-limited (Fridley et al., 2007; McMillan et al., 2023; Peng et al., 2019). It is also likely that the effect of many drought-driven disturbances, like wildfire, on rangeland livestock production is also tied to the relative spatial extent of the disturbance compared to that of the affected operation(s) and the inherent heterogeneity (e.g., spatial variability in soil texture, topography, soil depth, etc.) of the affected operations (Briske et al., 2020). Variance scaling—the idea that increasing scale leads to increased variance—is a universal phenomenon widely studied well beyond rangeland ecology and management, including fields like astrophysics, mathematics, and geography (Hulshof & Umaña, 2022; Levin, 1992). It is intuitive that ranches operating at larger spatial scales (i.e., more acreage) are more likely to hold more inherent heterogeneity than smaller operations and are more likely to overcome expected challenges stemming from drought-driven disturbances. The effect of other drought-driven disturbance feedbacks on rangeland livestock production—like the positive feedback between wildfire and cheatgrass invasion—is, consequently, also exacerbated by grazing management practices that focus on uniform forage consumption, like high-density short duration stocking strategies (Allred et al., 2014; Fuhlendorf et al., 2012, 2009b; Fuhlendorf & Engle, 2001; Scasta et al., 2016). Therefore, smaller operations and those that utilize homogeneity-based grazing management practices face an elevated risk of being negatively impacted by the increased frequency and intensity of drought-driven disturbances expected from continued climate change.

Increased drought frequency and intensity will pressure livestock producers to develop and maintain permanent or semi-permanent water facilities (e.g., water tanks) to meet their livestock's basic physiological requirements during drought. Ungulate grazers, like cattle, can get most, or nearly all, of their daily water requirement from the forage they consume (Kay, 1997; King, 1983). However, plant moisture depends upon soil moisture, and during severe drought, livestock must use permanent or ephemeral water sources to meet their daily water requirement (Kay, 1997). As drought becomes more intense and frequent, plant growth and photosynthesis rates decline (Chaves et al., 2003), and high-quality forage becomes spatially limited over time. Livestock experiencing long-term severe drought conditions will have more restricted movement as areas that effectively meet their basic physiological (nutrient and water) requirements become increasingly limited with persistent drought conditions, and providing those resources becomes more difficult for producers.

However, it is important to note that significant effort has been made to develop water facilities for livestock across rangelands in Nebraska, which will buffer these adverse effects for many producers. Other producers also utilize irrigated crop fields or hay meadows in their grazing plans. While producers who can integrate irrigated pastures or cropland into their grazing management plans will be buffered from some of the adverse effects of severe drought, irrigated acres do not—and likely cannot—represent a significant proportion of Nebraska's rangeland livestock production capacity (e.g., Sandhills upland range). For example, 46% of the state (22.7 million acres) is considered unirrigated rangeland compared to 11% of the state (5.4 million acres) that is considered irrigated, sub-irrigated, or planted for silage, pasture, other seeded forages, and hay (Nebraska Rangelands, n.d.). Even without experiencing drought, cattle consistently spend more time in riparian habitats and the water when air temperature exceeds 75 to 81°F (24 to 27°C) (Allred et al., 2013). Therefore, the combined effects of drought and increased temperatures expected under current climate predictions will continue to intensify livestock and producer demand for ground and surface water, as well as the potential adverse effects of heavy livestock selection for riparian areas across Nebraska's rangelands.

Woody plant encroachment into grasslands significantly threatens rangeland livestock production, specifically in highly productive grassland ecosystems like the tallgrass prairie (Engle et al., 2008). However, data on the specific effects that climate change will have on woody plant expansion and the effect on livestock production are mixed at best. For example, eastern redcedar (*Juniperus virginiana* L.) expansion into rangelands is considered a major threat to livestock production in Nebraska, and significant resources have been dedicated to combating its spread (Fogarty et al., 2023). However, recent species distribution models for eastern redcedar under current and future climate conditions across Kansas, Oklahoma, and Texas suggest a significant eastward shift in its distribution, driven by an anticipated increase in aridity across the region (J. Yang et al., 2024a). Although recent modeling efforts did not include Nebraska, it is logical to assume that effects will not be arbitrarily limited to states in the southern Great Plains and similar population shifts can be expected with future climate change. Despite changes to eastern redcedar distribution due to climate change, the expansion of other woody plants that are more difficult to control—those that are not easily managed with prescribed fire like smooth sumac (*Rhus glabra* L.)—will likely continue. Further, elevated atmospheric CO_2 has been tied to increased growth rates in woody plants, likely accelerating woody expansion into rangelands (Dodds et al., 2023; Kgope et al., 2010) and exacerbating the negative effect of woody plant encroachment on rangeland livestock production. However, specific effects of climate change on the spatial distribution of encroachment at the local, state, and regional scales—and the effects on livestock production—remain largely unresolved.

Climate change adaptation strategies for rangeland livestock production

Many of the adverse effects of climate change on rangeland livestock production in Nebraska are tied to processes occurring at scales much larger than a single landowner parcel or even an ecoregion (e.g., the Sandhills). For example, changing wildfire frequencies and intensities in Nebraska's rangelands cannot be solely attributed to singular changes in management, like decades of fire suppression that encourages invasive species, but are more likely the result of highly complex, interactive, multi-scale processes ranging from local to global scales (Dodds et al., 2023; MacDougall & Turkington, 2005). Continuing top-down, "command and control" rangeland management strategies or policies are unlikely to enable livestock producers to meet the increasing demand for rangeland-derived products despite the adverse effects of climate change (Holling & Meffe, 1996). Instead, management strategies and policy actions aimed at embracing rangeland variability (i.e., heterogeneity) instead of trying to reduce or control it will be key to building resilient rangeland systems to meet the growing demand for rangeland livestock products despite continued climate change (Allred et al., 2013; Fuhlendorf & Engle, 2001; Fuhlendorf et al., 2009b; McMillan et al., 2023, 2022b; Scasta et al., 2016).

Heterogeneity-based rangeland management remains the only strategy known to enable livestock producers to overcome the challenges of climate change and simultaneously improve other ecosystem functions that are important to Nebraskans. Pyric herbivory—fire-driven grazing—is perhaps the most well-known and studied rangeland management strategy in the Great Plains explicitly employed to promote rangeland heterogeneity (Fuhlendorf & Engle, 2001). Pyric herbivory relies explicitly on the highly interactive relationship between fire and grazing, where cattle are disproportionately more attracted to recently burned areas than unburned ones, to increase rangeland heterogeneity (Allred et al., 2011). For example, when applied in patches, pyric herbivory promotes biomass variability across rangelands where the average biomass in a patch depends upon time since fire; more recently burned patches have significantly less biomass than patches with a longer time since fire. Increased heterogeneity created by pyric herbivory is known to buffer livestock producers from the negative effects of invasive species (Cummings et al., 2007; McMillan et al., 2022a; Sherrill et al., 2022) and drought (Allred et al., 2014), while promoting broader ecosystem function and resiliency (Fuhlendorf et al., 2009a; Hovick et al., 2015; McGranahan et al., 2018). Other rangeland and grazing management strategies have been proposed to solve the climate crisis using high-density, short-duration livestock grazing (Savory, 1983; Teague & Barnes, 2017; Teague et al., 2013). However, despite their growing popularity with the public and among several nongovernmental organizations, the expected benefits of high-density, short duration livestock grazing strategies have been largely rejected by decades of rangeland ecology research in the U.S. (Briske et al., 2008, 2011, 2013; Carter et al., 2014).

Livestock producers in Nebraska may also alter their kind (i.e., species) and class of animal to better adapt to expected challenges stemming from climate change. It is well documented that most cattle breeds change their behavior in response to heat at 75°F (24°C). At those temperatures, cattle selection for riparian zones, wetlands, and woody vegetation (broadly) is significantly higher than for other parts of the landscape (Allred et al., 2013). American plains bison (*Bison bison* L.), on the other hand, do not start to alter their behavior in response to air temperature until anywhere from 82 to 90°F (28 to 32°C) (Allred et al., 2013; McMillan et al., et al., 2022b). As a result, some livestock operations across the U.S. have started to adopt bison as a potential alternative to traditional livestock to cope with the effects of climate change. Other potential strategies include altering the class of animals (e.g., moving from cow-calf to stocker steers) or increasing the diversity of animal kinds and classes in a livestock operation to better balance the risk and uncertainty of future climate change effects. For example, multispecies grazing—i.e., utilizing multiple species simultaneously in a livestock grazing operation—may be a way to improve the profitability and resiliency of livestock production in a variable climate (Wilcox et al., 2022). When combined with pyric herbivory, diversifying the suite of livestock kinds and classes in an operation may also help livestock producers combat woody plant encroachment, which is expected to accelerate with continued climate change (Ding & Eldridge, 2024; Wilcox et al., 2022).