**NORTH CENTRAL**
Climate Adaptation
Science Center

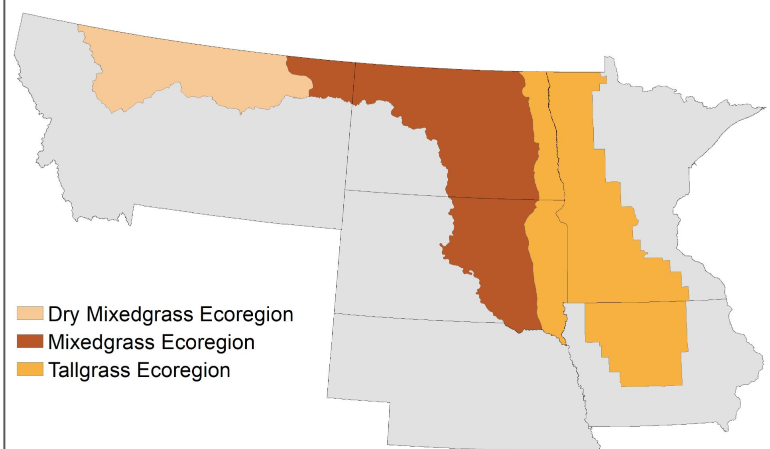
# Climate Change Impacts on Introduced Cool-Season (C3) Grasses in the Prairie Pothole Region, USA

## The Prairie Pothole Region

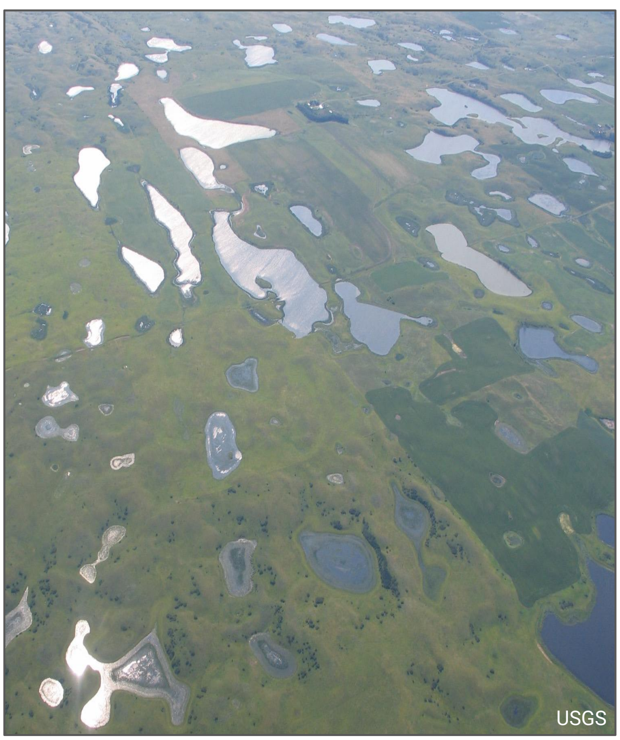
The Prairie Pothole Region (PPR) spans ~170 million acres in the northern Great Plains. The region is characterized by **mixed-grass** and **tallgrass prairies**, composed of native cool-season (C3) and warm-season (C4) grasses, interspersed with abundant wetlands or **"potholes."**

To safeguard biodiversity and maintain wildlife habitat, grassland conservation is a management priority on the **nearly 1 million acres** of National Wildlife Refuge System lands in the region.

**Ecoregions that make up the PPR**




source: ppjv.org




## The Issue

Large areas of the PPR have been converted to agriculture and other uses, with only about **30% of native grasslands remaining overall**. Specifically in the Dakotas, only about 3% of original tallgrass prairie remains.

Remaining grasslands in the PPR are **under threat** from introduced perennial cool-season (C3) grasses such as smooth bromegrass (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*) that can outcompete native species.

Climate change – through the combined effects of increased temperature, elevated $CO_2$, and more variable precipitation – can affect the **growth**, **competitive ability**, and thus **spread** of introduced cool-season grasses.

To maintain resilient grasslands, we need to **better anticipate** how smooth bromegrass and Kentucky bluegrass will respond to climate change.

# Introduced Cool-Season (C3) Grasses in the Prairie Pothole Region

Smooth bromegrass and Kentucky bluegrass make up more than half of the plant cover in native prairies on refuge lands.

**Drivers of Invasion**

Intentional planting
Warm, wet conditions
Nitrogen enrichment
Altered disturbance regimes (fire, grazing)

**Kentucky Bluegrass**
(*Poa pratensis*)
Image: Chris Helzer, TNC

Sod-forming
Can change soil hydrology
Creates a large seed bank

**Smooth Bromegrass**
(*Bromus inermis*)
Image: Cami Dixon, USFWS

Deep-rooted
Limits light for native plants
Changes nutrient availability

Both cool-season (C3) perennials
Reproduce by seed and rhizomes
Outcompete native species

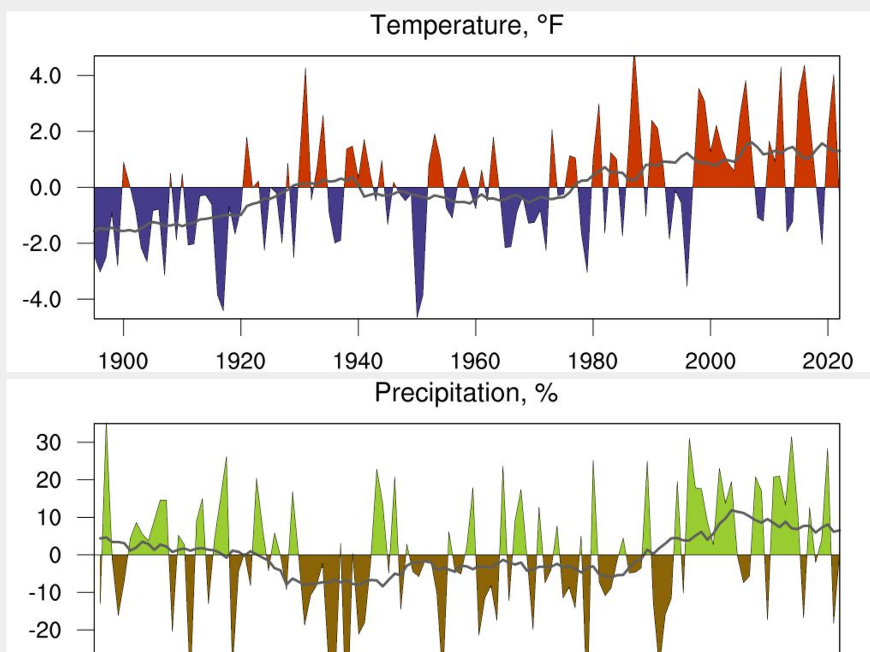
# Climate Trends in the Prairie Pothole Region

***Climate variability:*** Precipitation varies substantially from year to year, affecting grassland productivity and composition.

***Climate gradient:*** Annual precipitation is highest in the southeastern part of the region, averaging about 30 inches in northwestern Iowa, compared with 15 inches in north-central Montana.

***Long-term trends:*** Annual precipitation, temperature, and the growing season length have all increased over recent decades.

***Future climate change:*** The region is expected to get much warmer. Precipitation is expected to increase, but with more variation from year to year, including periods of extreme drought.




Above plots show anomalies (changes) in annual temperature (ºF) and precipitation (%) between 1895 and 2022 for the PPR (45-49ºN, 97-99.5ºW) relative to the 20th century mean. The grey trendline is a 20-year running mean. The temperature and precipitation have increased by 2 ºF and 10%, respectively, in recent decades. Data Source: NOAA NCEI nclimgrid

# Climate Change Effects on Introduced Cool-Season (C3) Grasses

### Effects of Precipitation Seasonality and Variation

- Increased precipitation **benefits** cool-season (C3) grasses, especially during spring and fall.
- Although cool-season (C3) grasses are physiologically less adapted to drought than warm-season (C4) grasses, smooth bromegrass and Kentucky bluegrass **may be able to persist** through warm, dry summers, in large part due to their greater productivity in spring and fall, and strong competitiveness.

### Effects of Elevated $CO_2$ and Warming Temperatures

- Longer growing seasons can facilitate earlier emergence and enhanced growth of cool-season grasses in spring. If moisture is adequate, extended falls would also **increase** tiller production and growth.
- Elevated $CO_2$ tends to increase grassland productivity and favors cool-season (C3) grass species over warm-season (C4) species, at least initially. However, that competitive advantage could **eventually reverse** due to changes in soil nitrogen.

### Interactions with Other Vegetation Changes

- Encroachment by native shrubs modifies the environment in ways that can **favor** the spread of smooth bromegrass and Kentucky bluegrass.
- Introduced legumes, such as yellow sweet clover (*Melilotus officinalis*), may **increase the competitiveness** of introduced cool-season grasses by increasing nitrogen availability.

Short-term weather events within a longer climate change trend can affect seasonal soil moisture and thus abundance of introduced perennial cool-season grasses. In the next few decades, the Prairie Pothole Region is expected to experience **more warming,** elevated atmospheric $CO_2$ levels, and an **overall increase in precipitation**, though **extreme droughts** in different seasons are still likely, each with their own unique effects on soil moisture and grassland plants.

| Regional Climate Trends | Seasonal Weather Scenario | Expected Effect on Soil Moisture | Expected Effect on Introduced Cool-Season (C3) Grasses |
|---|---|---|---|
| Increases in temperature; elevated $CO_2$; overall increase in precipitation amounts and year-to-year variability | Below-average precipitation: **Fall/Winter** | Initially deficient in early spring | Slows spring emergence |
| | Below-average precipitation: **Spring** | Diminishes more quickly following soil thaw without additional input from spring precipitation | Slows late spring and early summer growth and flowering |
| | Below-average precipitation: **Summer** | Steady reduction over the course of the season; decline exaggerated by hotter summer temperatures | Smaller effect due to reduced productivity of cool-season grasses during summer months |
| | Above-average precipitation: **Summer** | Maintains higher-than usual soil moisture; could be offset by increased evapotranspiration under warmer temperatures | Delays senescence, lengthens the growth period for cool-season grasses |

## Implications for Grassland Management


Current treatments to limit the proliferation of smooth bromegrass and Kentucky bluegrass include **grazing** and **prescribed fire**.

Ongoing and future climate change will complicate grassland management in the PPR. For example, climate change **may alter fire behavior and suitable burn windows,** potentially limiting its use. This would affect the two species differently; for example, Kentucky bluegrass is more susceptible to burning than smooth bromegrass.

The effects of treatments also depend on seasonal precipitation and water availability, which will vary more under future climate. This could create **additional management challenges and opportunities,** such as treatments being more effective at “knocking back” introduced grasses during drought years, although this needs to be studied further.

Many questions remain for how management of introduced grasses can adapt to climate change in the Prairie Pothole Region. The **Native Prairie Adaptive Management** program provides annual decision support to USFWS managers, and data are used for retrospective analysis to provide further insights into various aspects of grazing and prescribed fire (e.g., timing of burning). Additional research is needed to inform adaptive management models with anticipated climate change effects for both native and introduced species.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https://nccasc.colorado.edu/rcap-projects


### Selected Resources


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