GREAT PLAINS

While farming and ranching are still the primary land uses of the Great Plains,urban areas provide housing and jobs for two-thirds of the region's people. Native ecosystems and agricultural fields intermingle with small rural communities and the expanding metropolitan centers. The region produces much of the nation’s grain,meat,and fiber, including over 60% of the wheat,87% of the sorghum,and 36% of the cotton. The region is home to over 60% of the nation’s livestock,including both grazing and grain-fed-cattle operations. Recreation,wildlife habitat,and water resources are also found on the landscapes of the Great Plains. The Prairie Pothole region provides important habitat for migratory waterfowl. Surface water in rivers,streams,and lakes,and groundwater in aquifers provide water for urban,industrial,and agricultural uses, as well as riparian and aquatic ecosystems. Soil organic matter is a major resource of the Great Plains as it provides improved soil water retention,soil fertility, and long-term storage of carbon.

Climate determines many aspects of life on the Plains. For agriculture, weather determines the planting and harvesting dates for crops,livestock grazing and breeding seasons, and water availability. The high natural variability of climate is a characterizing feature of the region. Farmers and ranchers have survived by being adaptive and incorporating new technologies to buffer their production against the variable climate. For urban centers,the availability of water often constrains urban and industrial development. Dams,diversions, channels,and groundwater pumping have influenced nearly all freshwater ecosystems in the region. Ongoing social and economic changes in the Great Plains will continue to increase demands on the region's land and water resources and challenge its physical and social infrastructure. Climate change will present additional challenges to long-term planning for new infrastructure and the sustainable use of land and water.

KEY ISSUES

- **Alteration in Timing and Amount of Water**
- **Changes in Climate Extremes**
- **Invasive Species Effects on Economy and Ecology**
- **Stress on Human Communities**
- **Conservation of Soil Organic Matter**

Observed Climate Trends

Across the Northern and Central Great Plains,temperatures have risen more than 2ºF (1ºC) in the past century, with increases up to 5.5ºF (3ºC) in parts of Montana,North Dakota,and South Dakota. In the southern Great Plains,the 20th century temperature record shows no trend. Over the last 100 years,annual precipitation has decreased by 10% in eastern Montana,North Dakota,eastern Wyoming,and Colorado. In the eastern portion of the Great Plains,precipitation has increased by more than 10%. Texas has experienced significantly more high intensity rainfall. The snow season ends earlier in the spring, reflecting the greater seasonal warming in winter and spring.

Increasing Soil Carbon Helps Buffer Against Climate Change Impacts

Martin Kleinschmit, a farmer and rancher in Bow Valley, Nebraska, says that farmers have a lot at risk as global climate heats up, but they also have a lot to gain by participating in the solution to climate change. By conserving soil organic matter, farmers can improve soil health and productivity as well as capture and store (sequester) carbon in the extensive crop and rangelands of the Great Plains. The higher temperatures and greater numbers of droughts and floods projected for the region could threaten crops, raise production expenses, and increase the risk of failure. To protect our food supply, healthy soils able to withstand erratic weather patterns are needed.

Increasing the carbon content of the soil will help to mitigate global warming by keeping carbon dioxide out of the atmosphere, but it will do even more to buffer the soil against the threats of climate change. Presently, most US farmland has only half or less of its historical level of organic matter. Soil scientists have established that a 6-inch (15 cm) block of soil with 1 to 2% organic matter can hold only about one inch (2.5 cm) of rain before it runs out the bottom. With 4

Scenarios of Future Climate

Climate model scenarios project that temperatures will continue to rise throughout the region,with the largest increases in the western parts of the Plains. The Canadian model projects greater increases throughout the region than the Hadley model. The climate model projections,as well as other tools utilized in analyzing impacts,include a greater number of heat events – three days in a row above 90ºF – a major cause of heat stress for people and livestock. Seasonally, more warming is expected in winter and spring than in summer and fall. Precipitation generally increases in the region in the Hadley model,and in the northern parts in the Canadian model. Precipitation decreases in the lee of the Rocky Mountains in both models.This is accentuated in the Canadian model,with decreases of up to 25% in an area centered on the Oklahoma panhandle and covering northern Texas,eastern Colorado,and western Kansas. Smaller decreases are seen in the Hadley model in a band from northern Texas through Montana. Although precipitation increases are projected for parts of the Great Plains,increased evaporation due to rising air temperatures are projected to surpass these increases, resulting in net soil moisture declines for large parts of the region.

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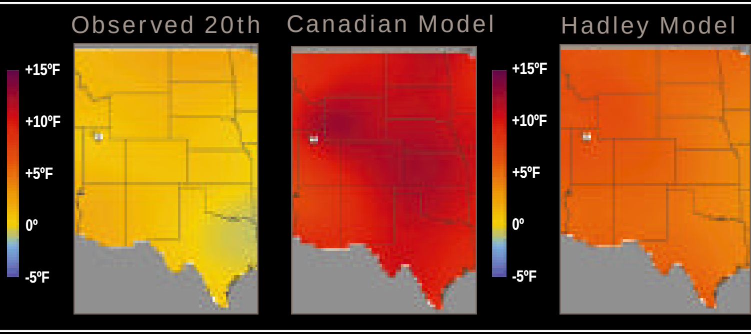
Temperature Change - 20th & 21st Centuries

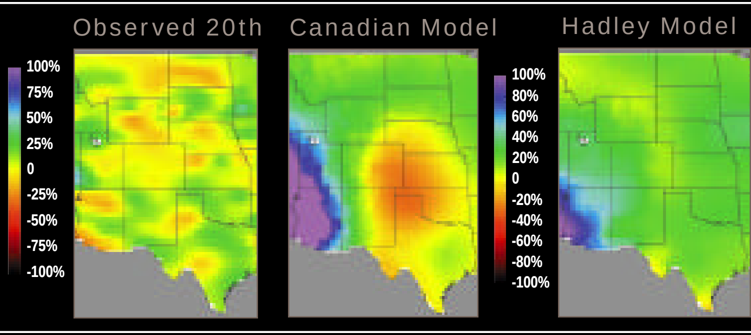
The observed changes in air temperature for the Great Plains over the 20th century indicate a greater warming in the north than in the south on average.



The model scenarios indicate additional 5ºF (Hadley model) to 12ºF (Canadian model) increases over the 21st century for much of the Plains.

Precipitation Change - 20th & 21st Centuries

Precipitation averages over the 20th century indicate a decrease in precipitation to the east of the Rockies. Several areas, most notably Texas, had precipitation increases.



The Canadian model projects decreases in precipitation in the southern Plains and increases in the north. The Hadley model projects increases over almost the entire region, but some decreases are also evident east of the Rockies.

to 5% organic matter, that same soil can hold 4-6 inches (10 to 15 cm) of rain before it leaves the root zone and takes with it the water-soluble nutrients. Increasing soil organic matter also reduces the risks of flooding and erosion, and retains moisture longer so plants have access to it during periods of dry weather. Soil organic matter lessens the need for (and expense of) irrigation, reduces ground water pollution, and reduces the amount of run-off, lessening

the threat of stream pollution. It also lowers the cost of fertilization since nutrients not lost to erosion and leaching need not be replaced. Agricultural incentives that encourage net carbon sequestration in soil provide an opportunity to promote food security in a changing climate and reduce the threat of climate change at the same time.

GREAT PLAINS KEY ISSUES

Alteration in Timing and Amount of Water

Water supply, demand,allocation,storage,and quality are all climate-sensitive issues affecting the regional economy. Farming and ranching use over 50% of the region's water resources. Ground-water pumping for irrigation has depleted aquifers in portions of the Great Plains by withdrawing water much faster than it can be recharged.Under today's irrigation demands, water table levels are thus dropping in parts of the southern Great Plains. The projected climate-induced changes in water resources are likely to exacerbate the current competition for water among the agricultural sector, natural ecosystems,and urban,industrial,and recreational users.

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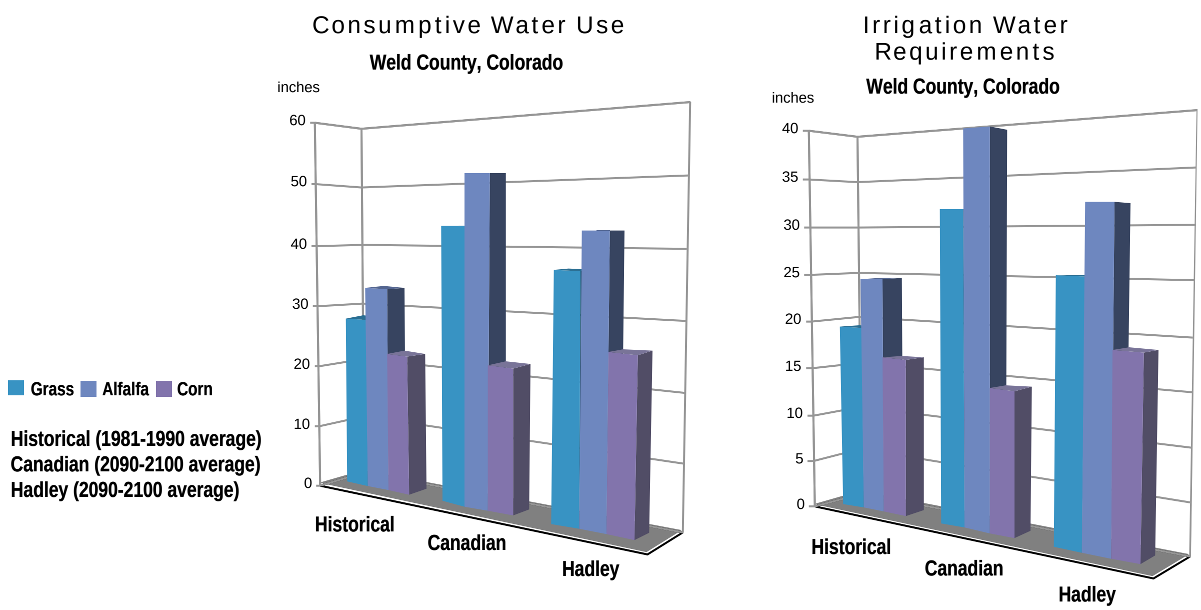
Adaptations: It is possible that current strategies to deal with drought, water shortages, extreme weather, and variability could help the region cope with future climate change impacts. These strategies include switching to crops that use less water, retiring marginal lands,adopting conservation tillage,and enhanced watershed storage capacity and groundwater recharge activities. Water availability for crops could possibly be improved using new and existing technologies for crop residue management,wind breaks, mulches, soil carbon management,tillage practices,precision agriculture,and more efficient methods of water application. While these strategies would improve water use efficiency, adaptive strategies would also need to include maintaining water quality. Flexible policies and institutions would help to adapt to unanticipated hydrologic changes.



Lack of soil moisture can greatly reduce yield of crops and forage. Under both climate scenarios, the consumptive demand for water on grass pasture increases more than 50% while the water needs for irrigated corn change little. Perennial crops such as alfalfa experience an increase in consumptive demand for water; the size of the increase depends on the climate scenario.

Water supplies for agriculture have been decreasing in many parts of the Great Plains, partly due to increases in urban uses. Irrigation water needs for grass and alfalfa are projected to increase under both climate scenarios while those for corn rise slightly. The changes in irrigation needs reflect the seasonal shift in precipitation that favors corn more than perennial crops such as grass, hay, and alfalfa.

Changes in Climate Extremes

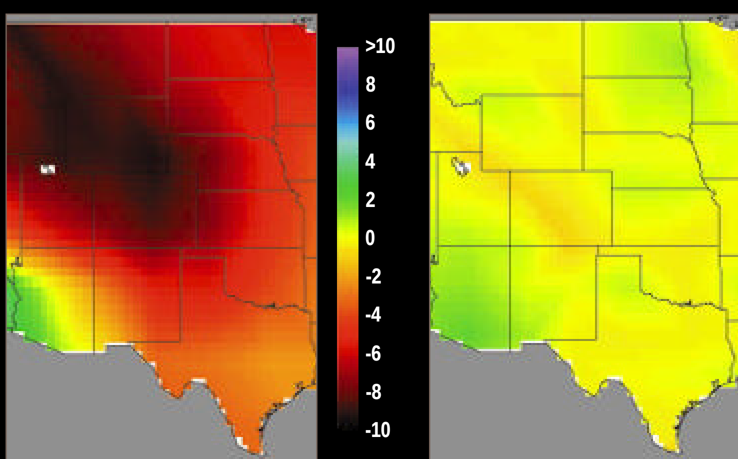
The potential for new patterns in climate extremes raises questions about the ability of current coping strategies to deal with future impacts.

Extreme climate and weather events have major effects on urban and rural lives. The April 1997 flood put approximately 90% of Grand Forks,North Dakota under water and caused over $1 billion in damages. A short-term heat wave in July 1995 caused the deaths of over 4,000 feedlot cattle in Missouri. The severe drought from Fall 1995 through Summer 1996 in the agricultural regions of the southern Great Plains resulted in about $5 billion in damages. There is some chance that the projected increase in drought tendency in the Sand Hills of the Great Plains will result in expansion or shifting of sand dunes if vegetation cover is not maintained. The potential for new patterns in climate extremes raises questions about the ability of current coping strategies to deal with future impacts.

Adaptations: Better access to more accurate and timely information about near-term weather including extreme events,and longer-term forecasts could help reduce risk and uncertainty in decision making. For example,heat stress events are projected to occur more often in the central and southern Great Plains in the future. This information can help intensive-livestock operators weigh strategic decisions about investments in cooling systems. Real-time weather information can prepare them to implement an immediate response to cool their animals.

Palmer Drought Severity Index Change
21st Century

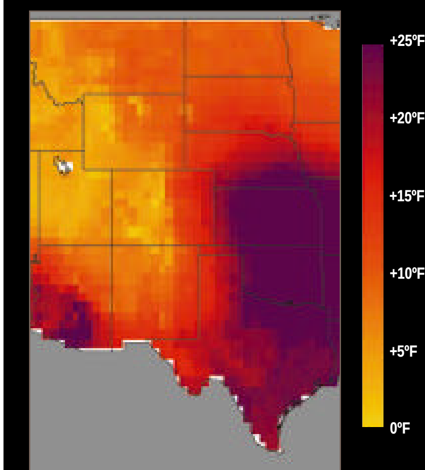
Canadian Model | Hadley Model



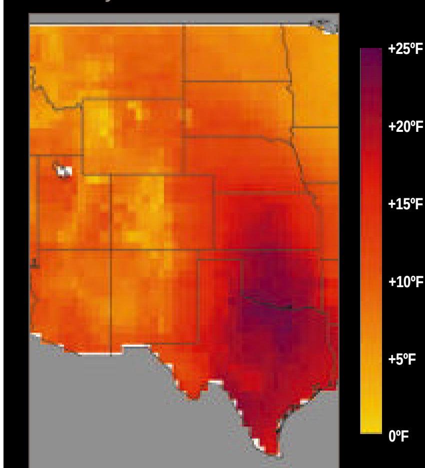
The Palmer Drought Severity Index (PDSI) is a commonly used measure of drought severity taking into account differences in temperature, precipitation, and capacity of soils to hold water. These maps show projected changes in the PDSI over the 21st century, based on the Canadian and Hadley climate scenarios. A PDSI of –4 indicates extreme drought conditions. The most intense droughts are in the –6 to –10 range, similar to the major droughts of the 1930s. By the end of the century, the Canadian scenario projects that extreme drought will be a common occurrence over much of the Great Plains, while the Hadley model projects much more moderate drought conditions.

July Heat Index Change
21st Century

Canadian Model



Hadley Model



Both models project substantial increases in the July heat index (which combines heat and humidity) over the 21st century. These maps show the projected increase in average daily July heat index relative to the present. The largest increases are in southern areas, where the Canadian model projects increases of more than 25˚F.

GREAT PLAINS KEY ISSUES

Invasive Species Effects on Economy and Ecology

The native grasslands,shrublands, forests,and riparian ecosystems of the Great Plains are home to a variety of plants and animals. Nearly 60% of the bird species that breed in the US do so in the Great Plains. Agriculture and urban development have disrupted these native ecosystems,and invasive species are currently a serious challenge in both native ecosystems and agricultural systems. For example,leafy spurge currently reduces grazing capacity on grasslands. Field bindweed lowers crop production in Kansas by $40 million a year. Projected climate change is likely to alter the current biodiversity. A possible migration of invasive species across the Great Plains is a concern to stakeholders because the rapid rate of climate change is likely to be disadvantageous to native species. The exact social costs will depend upon the particular invasive species or type of change in biodiversity.

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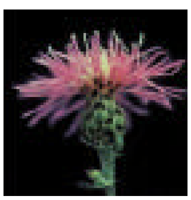
Adaptations: Effective coping strategies would help provide plants and animals with habitats for adaptation such as maintaining a diversity of vegetation types and connectivity between the types. Preserving intact riparian areas, wetlands, and natural areas is likely to slow or reduce future invasions and is beneficial even in the absence of climate change.

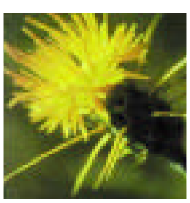
Stress on Human Communities

Rural communities,already stressed by their declining populations and shrinking economic base,are dependent on the competitive advantage of their agricultural products in domestic and foreign markets. Large corporate enterprises,the result of agribusiness modernization and consolidation,have greater resources and technology with which to buffer themselves against both economic and climatic variability. Thus,a changing climate is an additional stress that disproportionately impacts family farmers and ranchers. In urban



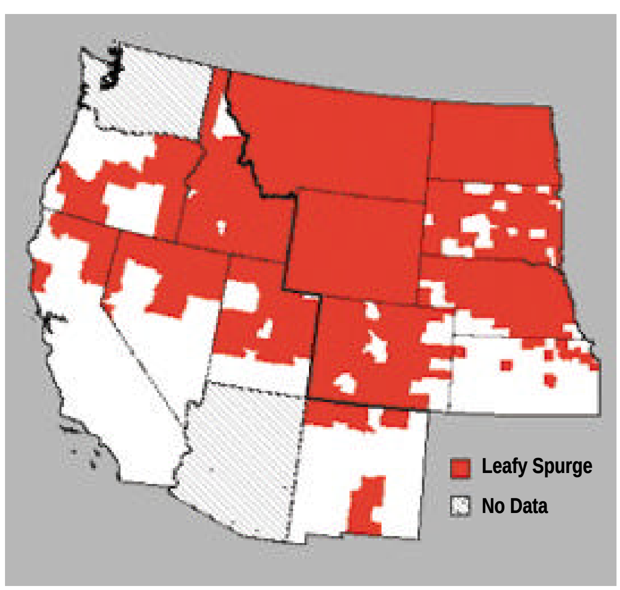
Spotted knapweed has infested over 5 million acres in Montana and is a threat to pristine natural areas such as the Grand Teton National Park in Wyoming.

Leafy spurge currently reduces grazing capacity, plant diversity, and wildlife habitat on grasslands.



Yellow starthistle, an annual herb up to 3 feet tall, currently infests over 9 million acres of rangeland in the western US, with nearly 8 million acres in California alone. This invasive species spreads as a contaminant in agricultural seeds.

Distribution of Leafy Spurge in the Western US
By County - 1996



Leafy spurge, a federally-designated noxious weed, currently can be found in 8 of the 10 Great Plains states. First recorded in 1827, leafy spurge spread from Massachusetts to North Dakota in 80 years. This deep rooted, perennial plant forms dense stands that aggressively crowd out most other vegetation, causing a loss of plant diversity, reduction of forage, and loss of wildlife habitat. Leafy spurge can spread rapidly through seed dispersal as well as being carried by birds and other animals. It can expel its seeds to distances of 15 feet.

communities,the impacts of floods, heat waves,and other climate events is a crucial emerging issue with significant economic implications.

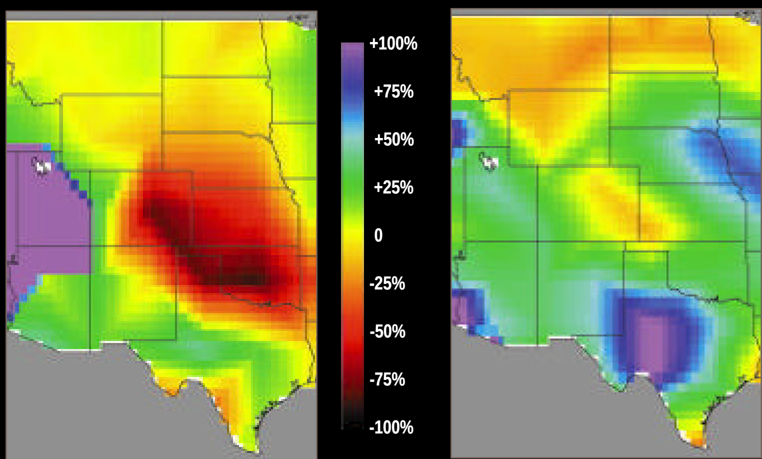
Many poorer people can not afford air conditioning,insulation,substantial housing,and other means of coping with climate extremes.

Therefore, climate change impacts will vary significantly by social and economic status.

Adaptations:Diversification within enterprises and rural communities could help to reduce risk and cope with the additional stress of climate change. Community-level dialogue is vital in identifying information needed by managers and in assessing policy options for climate change.

Summer Soil Moisture Change - 21st Century

Canadian Model | Hadley Model



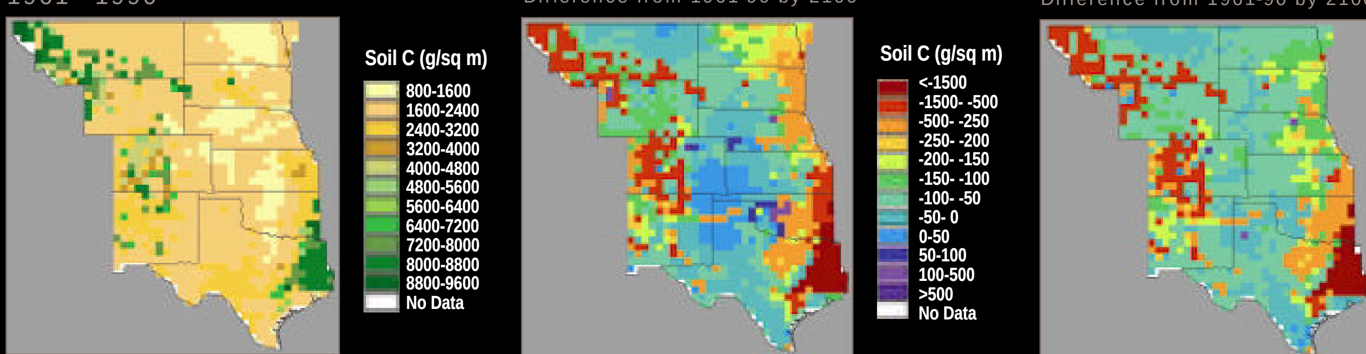
Higher air temperatures increase the rate of evaporation, removing moisture from the soil faster than it can be added by increased precipitation, resulting in net soil moisture declines for a large part of the Great Plains.

Soil carbon is vital for retaining water and nutrients. The amount of carbon stored in the soil is strongly influenced by past and present land management practices and weather patterns. Overall, soil carbon is projected to decline in response to higher temperatures in both climate scenarios. In some areas, climate changes reduce the decomposition of soil organic matter, resulting in increased soil carbon.

Soil Carbon 1961 - 1990

Canadian Model — Difference from 1961-90 by 2100

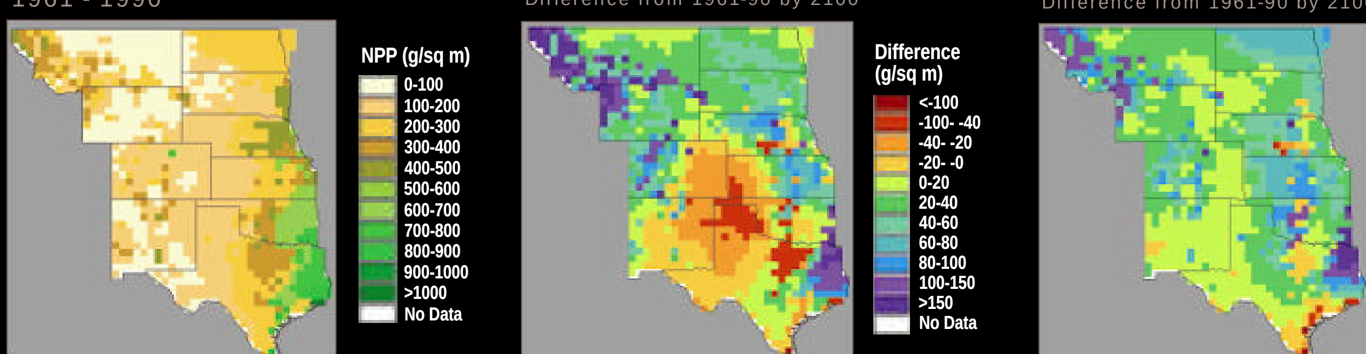
Hadley Model — Difference from 1961-90 by 2100



Net Primary Productivity (NPP) 1961 - 1990

Canadian Model — Difference from 1961-90 by 2100

Hadley Model — Difference from 1961-90 by 2100



The productivity of the Great Plains increases from west to east and from north to south, following the precipitation and the temperature gradients. Land uses are strongly influenced by productivity. Both climate scenarios increase the moisture stress in the central parts of the Great Plains and productivity declines in this region.