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Environmental Change and the Central Great Plain, Water Resources

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Environmental Change

and the Central Great Plains

Water Resources

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Introduction

Water management has been critical to transforming the semiarid central Great Plains – eastern Colorado and Wyoming, Nebraska and Kansas – into a habitable and internationally recognized agricultural landscape. Water not only sustains agriculture but a diversity of plants and animals, as well as rural and urban population centers. Balancing water quantity and quality issues while maintaining natural ecosystems is one of the greatest challenges that natural resource managers face. It becomes more daunting when considering climatic and environmental change. These changes will likely affect water resources in unanticipated ways. This fact sheet highlights some potential consequences of climate change for water resources in the central Great Plains and provides some potential adaptation strategies.

Our Water System

Whether found as groundwater in aquifers or as surface water in lakes or streams, water in the central Great Plains "begins" as precipitation – rain or snow (fig. 1). If not evaporated, the rainfall or snowmelt may infiltrate into the ground, restoring soil moisture and recharging groundwater, or it may run off into lakes and streams. Because of the greater amount of moisture in the air and the predominant air currents during the summer, the bulk of precipitation falls in those months. On an annual basis, total precipitation averages about 15 inches in eastern Colorado and Wyoming and increases to about 35 inches in southeastern Nebraska and eastern Kansas (fig. 2). This west-east gradient and seasonal variability result in some very significant and complicated water supply issues.

A thunderstorm rolls in over the Sand Hills north of Gordon in Sheridan County. Nearly all the recharge to groundwater and the runoff that feeds most of the surface water in Nebraska come from precipitation. Photo by James Swinehart, CSD.

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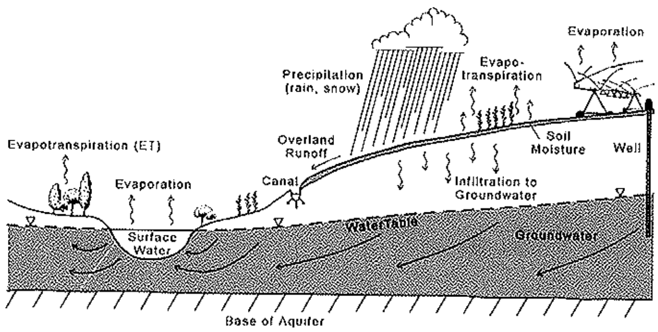
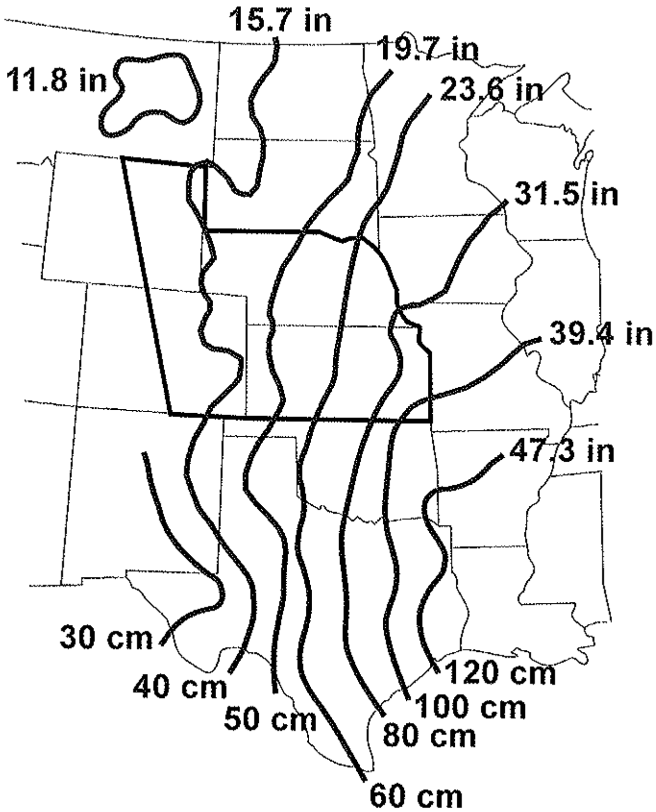
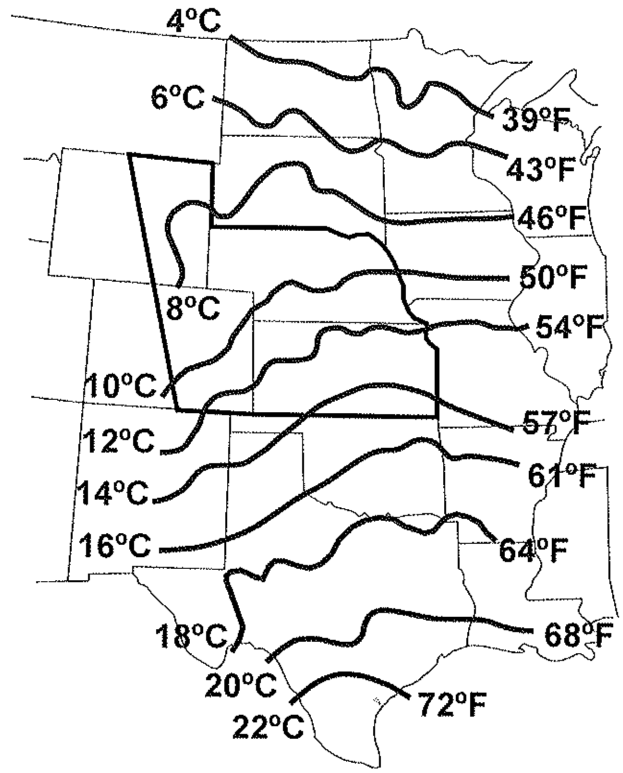


Fig. 1. The hydrologic (water) cycle.





Figs. 2 (left) and 3 (right). Gradients of mean (average) annual precipitation in inches, on left, and of mean annual temperature in degrees Celsius and Fahrenheit, on right, in the Great Plains. Central Great Plains is outlined in black (modified from Schimel and others, 1990).

Another factor important to the availability of water is consumptive use. Consumptive use is that part of the water budget that is evaporated from surface water bodies (lakes, wetlands, streams, etc.), evaporated and transpired from plants, or incorporated into products or crops. Evaporation and transpiration (evapotranspiration, or ET) move water from the earth's surface into the atmosphere. Both are related to temperature, which varies by season and follows a regional gradient from north to south (fig. 3). An increase in temperature allows more water to be transferred into the atmosphere. Currently, estimated mean annual lake evaporation ranges from 50 inches in western Kansas and eastern Colorado to 39 inches in the area from northeastern Nebraska to eastern Wyoming. Examples of crop water use in Nebraska and statewide variations, likely to be similar in other Great Plains states, are given in table 1.

Water Sources

The limited amount and seasonality of precipitation, as well as the demand for water from both natural and cropping systems require both groundwater and surface water to provide a sufficient supply for multiple uses. In Nebraska and Kansas, groundwater provides 59 and 67 percent, respectively, of the estimated total water used (table 2). The High Plains (Ogallala) aquifer, covering 63,650 and 30,500 square miles in those two states, respectively, is a primary source. This aquifer is also used to a lesser extent in Wyoming and Colorado. Extending from central Kansas northeasterly into eastern Nebraska, the Great Plains (Dakota) aquifer is another that provides water for multipurpose use. At various locations, sands and gravels are also a source of groundwater.

Ultimately, groundwater recharge comes from precipitation (fig. 1). In many areas of Kansas and Nebraska, groundwater in the High Plains aquifer is considered seasonally renewable. In other circumstances, such as in the Dakota Aquifer in northeastern Nebraska, recharge may have occurred hundreds to thousands of years ago. This type of groundwater resource is vulnerable to overuse.

Table 1. Estimated Seasonal Crop Water Use (ET) in Nebraska in inches/yr. (NebGuide G90-992-A, NU Cooperative Extension)			
Crop	**Eastern**	**Central**	**Western**
Corn	23-26	24-27	25-28
Soybeans	20-22	21-23	22-25
Sorghum	18-20	19-22	20-23
Winter Wheat	16-18	16-18	16-18
Alfalfa	31-33	32-35	34-36

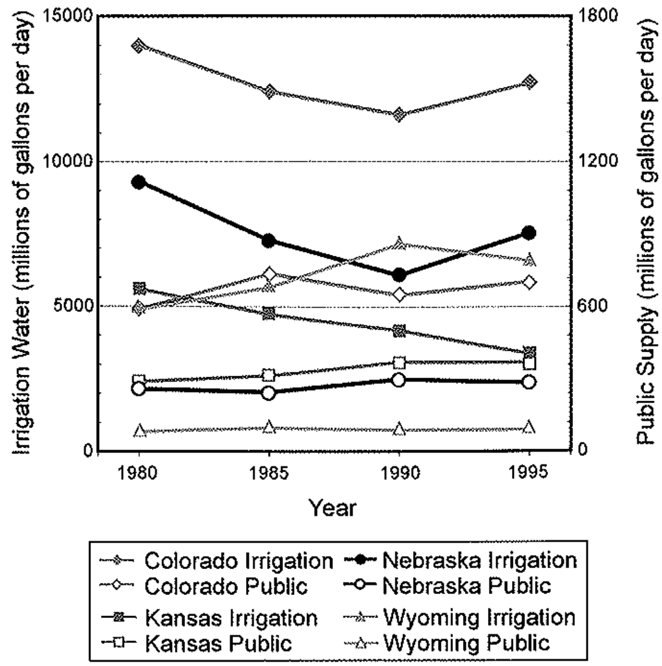


Fig. 4. Irrigation and public water use in the central Great Plains states, 1980-1995.

Surface water is the primary source of water (table 2) in eastern Colorado and Wyoming, eastern and south-central Kansas and western Nebraska. In Colorado and Wyoming, 84 and 95 percent of the water used is directly withdrawn from rivers, such as the Arkansas and Platte, or from reservoir storage (dams) and diversions (irrigation canals). These supplies are very dependent on spring snowmelt, much of which originates in the mountains of Colorado and Wyoming. In addition, spring and summer thunderstorms provide runoff for these surface water sources. Runoff from both snowmelt and rainfall are highly variable and can be scarce in some regions and in some years.

Water Use

Irrigation accounts for 65 to 94 percent of the estimated water use in the central Great Plains (table 2). Figure 4 suggests that irrigation water usage generally dropped in Kansas from 1980 to 1995. Irrigation water use has increased slightly in Wyoming, whereas in Colorado and Nebraska it has been more variable, which is likely related to climate variability.

Use of public water supplies has been relatively constant (fig. 4) since 1980 and accounts for only 1.3 to 7.1 percent of total water use (table 2; fig. 5). As would be expected, Kansas and Colorado, which have the largest populations, use the most water. Another major water use in Nebraska and Kansas is for the cooling of thermoelectric power plants. Thermoelectric use accounts for 22 to 24 percent of the water used. These three water use categories – irrigation, public supply and thermoelectric – are responsible for 96 to more than 98 percent of the water used in the four states.

Table 2. Summary of Estimated Water Sources and Water Use for the Central Great Plains States.

	Water Withdrawal by Source (million gallons per day – mgd)			Water Withdrawal by Water Use Category in mgpd (and as % of Total Water Used)		
State	Groundwater (% of Total)	Surface Water (% of Total)	Estimated Total Water Used*	Irrigation	Public Water Supply	Thermo-electric
Colorado	2,270 (16%)	11,600 (84%)	13,800	12,700 (92%)	705 (5.1%)	114 (0.83%)
Kansas	5,510 (67%)	1,720 (33%)	5,240	3,380 (65%)	370 (7.1%)	1,270 (24%)
Nebraska	6,200 (59%)	4,350 (41%)	10,500	7,550 (72%)	286 (2.7%)	2,350 (22%)
Wyoming	335 (5%)	6,720 (95%)	7,060	6,590 (94%)	90 (1.3%)	220 (3.3%)
*Figures may not add up to totals because of rounding. Source: Estimated Use of Water in the United States in 1995, USGS Circular 1200						

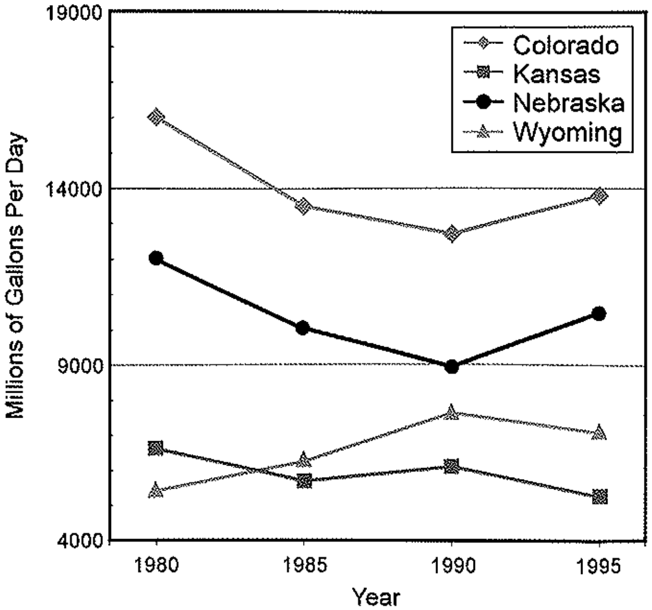


Fig. 5. Total water use in the central Great Plains, 1980-1995.

Potential Environmental Change on the Great Plains

In CSD's "Environmental Change and the Central Great Plains – Past, Present and Future," Gosselin (2001) explains that in the past 100 years temperatures have risen more than 2° F (1° C) and up to 6° F (3° C) in the region. Annual precipitation has decreased by 20 percent in western Nebraska, Wyoming and Colorado. In eastern Nebraska and Kansas, precipitation has generally risen 20 percent. These trends indicate that the environment is changing, but the direction and magnitude of the change varies across the region. According to assessments by the United Nation's Intergovernmental Panel on Climate Change (IPCC) and the United Kingdom's Hadley Centre climate model, the observed historical trends will continue: increased warming and increased precipitation for some areas. The annual average temperature may increase 2° to 5° F (1°-3° C) by 2100. The Great Plains' annual precipitation will increase by at least 10 percent. Winter precipitation should increase slightly more than summer precipitation. However, increased evaporation due to rising air temperature will surpass the increase in precipitation.

Implications for Water Resources

Under the warmer conditions of the future, precipitation during the winter in the mountains will include less snow and more rain. In addition, snowmelt will occur earlier in the spring. Higher temperatures will increase evaporation. These conditions will lead to higher streamflows in winter, earlier spring runoff and lower streamflows in the summer. These changes in the seasonal availability of water have potentially important consequences for irrigation, food production, human consumption and wildlife habitat in eastern Colorado and Wyoming, western Nebraska, and eastern and south-central Kansas.

Changes in the timing and amount of precipitation, as well as higher temperatures, will have an impact on the availability and replenishment of groundwater supplies. Precipitation is expected to increase in many areas, but higher temperatures and evaporation rates will decrease soil moisture in many parts of the central Great Plains. This, in turn, will affect the amount of water that can infiltrate to the groundwater. A recent study of the potential impacts of global warming on the High Plains (Ogallala) aquifer indicates that even under a modest increase in temperature of 2° F (1° C), recharge may decrease by as much as 20 to 25 percent. Although groundwater supplies are generally less vulnerable to short-term climate variations, long-term reductions in recharge would decrease the amount of groundwater in storage and make long-term use of this resource for irrigation potentially unsustainable. Because groundwater maintains the baseflow of streams and supplies water to lakes, the potential lowering of groundwater levels will have a negative effect on critical wildlife habitat, especially wetlands.

A center pivot creates a faint, misty rainbow with water-saving, low-pressure nozzles as it sprinkles a field of soybeans in the Platte River valley just south of Columbus last summer. This pivot, likely pumping from alluvium, was less than 200 yards away from the banks of the Platte River. Low-pressure adaptors for center-pivot sprinklers are increasingly being used to conserve water and limit evaporation. Photo by Jason Grotelueschen, CSD.

This stretch of the Platte River near Columbus is nearly dry, as of late July 1996, often remaining so at this time of year until the Loup River Canal feeds water back into it just downstream. Water users in Kansas have harbored fears of the Republican River becoming this dry due to upstream use for various purposes by Nebraskans. While the Republican rarely gets as dry as this, the state's integrated water-management law was created to help deal with such water disputes. It first came into use in the Republican basin after 1999 and might also be applied in the Platte Valley eventually. Climate change could also affect these streamflows and allocations. Photo by Jason Grotelueschen, formerly CSD.

Reducing the Human Impact on the Environment

Regardless of what perspective one takes, there are many win-win strategies that promote good stewardship and a sustainable water system. Water supply, demand, allocation, and storage are all water resources issues that currently create competition for water among the agricultural sector, natural ecosystems, and urban, industrial, and recreational users. Water resource policy-makers and managers experienced at the local and regional level are the best equipped to develop relevant water management strategies. Because these issues are closely linked to variations in climatic conditions, it would seem appropriate to develop flexible strategies and policies that allow adaptation to potential climatic changes.

Because water management has been critical to transforming the semiarid central Great Plains into an internationally recognized agricultural landscape, many types of best management practices already exist. Current strategies that will help in the future are improved soil management practices (reduced tillage, fields laying fallow, and returning crop residue to the soil) that increase organic matter which, in turn, helps soil retain moisture, reduces runoff and boosts recharge. Other options are incentives for switching to crops that use less water, improving the efficiency of water application methods, and incorporating precision farming practices. Although producers might use these practices for reasons other than concern for climate change, when used on a regional scale by many producers, they can help maintain or increase agricultural production even under changing climate conditions.

Water resource management is not just a rural issue; urban water conservation is just as important. Very little of the processed drinking water from local public water supply is used for drinking. Most goes on lawns, in washing machines, and down the drain. Implementing a simple conservation program eases the burden on water storage, purification, distribution and treatment facilities.

Conclusions

The preceding paragraphs provide only a brief summary of the complexity of the water management issue as it relates to climate change. There are many win-win strategies that promote good stewardship, reduce water usage, and are cost-

This photo of the Niobrara River shows a watercourse with plenty of streamflow. While human uses of the Niobrara are limited, compared with diversions from the other two major river systems in Nebraska, the Platte and the Republican, climate change effects could decrease rainfall and snowmelt in western Nebraska and eastern Wyoming, leading to effects on the Niobrara's streamflow. At present, in most years the Niobrara experiences adequate flows for recreation and wildlife. Photo by R.F. Diffendal, Jr., CSD.

effective, regardless of what perspective on the climate issue that one takes.

Sources of Information

Climate Change Outreach Kit - One-stop source on climate change: http://www.epa.gov/ globalwarming/publications/ outreach/ index.html#strategies

Climate Change Information for All States Website - Includes information on state greenhouse gas inventories, demonstration projects, and state action plans.

Gosselin, D.C., 2001, Environmental change and the Great Plains – Past, present and future: University of Nebraska-Lincoln, Conservation and Survey Division, Earth Science Notes No. 2, 4 p.

Great Plains Regional Center Web Site - National Institute for Global Environmental Change: http://nesen.unl.edu/nigec.

Lettenmaier, D.P., and others, 1999, Water resources implications of global warming – A U.S. regional perspective: Climatic Change, v. 43, p. 537-579.

Rosenberg, N.J. and others, 1999, Possible impacts of global warming on the hydrology of the Ogallala Aquifer region: Climatic Change, v. 42, p. 677-692.

Schimel, D.S., and others, 1990, Grassland biogeochemistry - Links to atmospheric processes: Climate Change, v. 17, p 13-25.

Solly, W. B., and others, 1998, Estimated use of water in the United States 1995: U.S. Geological Survey Circular 1200

U.S. National Assessment (USNA) Web Site - The potentia consequences of climate variability and change: http:/ www.nacc.usgcrp.gov/.

USNA Central Plains Region Web Site - http://www.nacc. usgcrp.gov/region/cgp

U.S. Environmental Protection Agency's Global Warming Website - Contains information on climate, emissions, impacts and actions.

Water Resources National Assessment Document: http:// www.gcrio.org/NationalAssessment/water/.

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