G96-1311 Global Warming: What is Known and Why Nebraska Agriculture Should Care

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Global Warming: What is Known and Why Nebraska Agriculture Should Care

The purpose of this NebGuide is to review the facts of global warming, to point out what is sheer speculation, and to suggest why Nebraska agriculture should care about global warming.

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Climatologists talk about global warming one year and the next year they talk about global cooling! Depending on the time periods involved, both views may be correct. Over the next few hundred years, the earth may undergo a general cooling trend. This trend is consistent with the regular shifts into and out of ice age conditions that have characterized the earth's climate history of the last 50,000 years. However, in the much more immediate future (100 years or less), the earth's climate may respond to the so-called "greenhouse effect," rather than the shift into cooler conditions, which may lead to warmer temperatures globally.

Some scientists say that global warming will lead to far more frequent droughts and heat waves in the Great Plains and that the major grain belts will shift northwards. Others say that, even if the climate warms, farmers will adapt so easily that no one will ever notice. The only certainty is that no one knows exactly what is going to happen to the earth's climate over the next few decades. Also, a winter that is strangely cold and snowy and followed by a summer that is cool and wet does not disprove the existence of long-term global warming. A balmy winter followed by a hot, dry summer does not prove the existence of global warming. Global warming, if it occurs, will play out over a long period of time.

The Facts about Global Warming

Fact number one is that the greenhouse effect is a natural part of the earth's climate. Without it the earth would be about 60°F colder (on average) than present and life as we know it would not exist. However, because certain gases existing in trace amounts in the atmosphere (e.g. carbon dioxide, methane, ozone) help trap and hold heat in the lower atmosphere, the earth is warm and hospitable to life. These gases are often called "greenhouse gases." The most abundant greenhouse gas is water vapor. An easy demonstration of the greenhouse effect on a local scale is the contrast in temperatures between dry clear nights versus cloudy nights. Temperatures will not drop as low on a cloudy night as they will on a cloudless night since the water vapor in the clouds traps and holds heat near the surface. This is why dry desert air is so cool at night though daytime temperatures may soar well into triple digits.

Fact number two is that greenhouse gas concentrations in the earth's atmosphere are rising at an annual rate of about half a percent per year. Measurements of carbon dioxide concentrations in the atmosphere since the 1950s confirm the rise. Rising greenhouse gas concentrations are causing the greenhouse effect to strengthen.

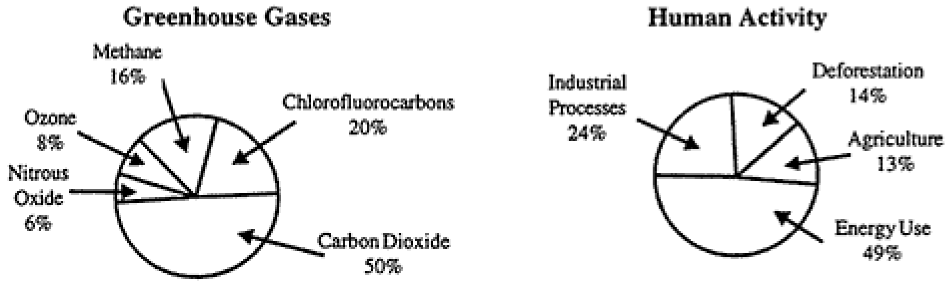

Figure 1. Composition and sources of greenhouse gasses.
Source: World Resources Institute in collaboration with the United Nations Environment Programme and the United National Development Programme. World Resources 1990-91 (Oxford University Press, New York, 1990).

Fact number three is that human activities are the major cause of the current worldwide increases in greenhouse gas concentrations. Virtually every greenhouse gas is more abundant in our atmosphere today than it was at the turn of the century. Looking at air bubbles trapped in glacial ice over thousands of years tells us that carbon dioxide concentrations in the atmosphere were remarkably steady over several centuries before the onset of the industrial revolution 200 years ago. Then the concentrations began to rise, mainly as the result of the burning of fossil fuels. *Figure 1* shows the major greenhouse gas concentrations and their human sources. Agriculture is an important source of greenhouse gases, especially chemical compounds of nitrogen.

Where the Uncertainties Begin

In a strictly controlled laboratory environment, when greenhouse gas concentrations in the atmosphere rise, so do temperatures. However, the earth's climate system is not as simple as a strictly controlled laboratory. Many factors complicate how the earth may respond to the known strengthening of the greenhouse effect. For one, water covers most of the earth. The water of the deep oceans stores large amounts of heat from the atmosphere and may act to delay or temper the atmospheric warming. Another factor is the role of clouds and aerosols (tiny airborne particles) in modifying the greenhouse effect. It is thought that the heat build-up in the atmosphere from a stronger greenhouse effect may cause more and whiter clouds to form. Depending on the shape and whiteness of the clouds, they may cause more sunlight to be reflected back to space, hence offsetting some warming, or they may further strengthen the greenhouse effect (remember clouds are composed of water vapor which is a greenhouse gas). The jury is still out on how clouds will affect temperatures.

Aerosols, particularly sulfur compounds, produced mainly by urban industrial and automotive sources are not greenhouse gases but they do reflect sunlight and may also offset greenhouse warming in and around cities. How much aerosols will offset the warming is not known. Until scientists understand these uncertainties and others, predicting how the climate will respond to a stronger greenhouse effect will be difficult.

So what can be said about the likely response of the climate to a stronger greenhouse effect? *Table I* shows the current scientific agreement on what is known about the climate response to a stronger greenhouse effect. Most climatologists are virtually certain that if greenhouse gas concentrations continue to increase, the temperature of the earth will warm. By the time the concentrations have doubled their pre-industrial revolution levels of 200 years ago (which is likely to occur sometime in the middle of the next century), the mean annual temperature of the earth is predicted to rise by 2.5° - 8.0°F. This is contrasted with the 9°F rise that has occurred since the last ice age when much of midwestern North America was covered by ice sheets.

Table I. Current scientific agreement on climate response to a stronger greenhouse effect.	
Assessment of the Predictions	
Global Climate Change	**Scientific Confidence**
Global Surface Warming	Very Probable
Acceleration by Other Gases	Very Probable
Sea Level Rise	Probable
Regional Climate Change	**Scientific Confidence**
Arctic Polar Warming	Probable
Continental Interior Drought	Uncertain
Regional Vegetation Changes	Uncertain
Source: Intergovernmental Panel on Climate Change	

Will the climate changes differ by region and season? The answer is certainly yes, but how they will differ is not clear. Scientists rely mostly on complex mathematical computer models to simulate the climate response to a strengthening greenhouse effect. There is a general agreement among the models and those who interpret them that the warming will be relatively greater with increasing distance from the equator. Therefore, the midlatitudes (where Nebraska is located) will warm more than the global average. The warming is likely to be greater in winter than in summer, but all seasons will be warmer. Nighttime temperatures are likely to increase more than daytime temperatures. The regional pattern of precipitation changes and corresponding soil moisture conditions is proving to be extremely difficult to establish. Differences in the response of summer rainfall in North America to a hypothetical doubling of the greenhouse gas concentrations are clearly evident among the major models (*Figure 2*). Most evidence suggests that the interiors of major continents like North America will get drier.

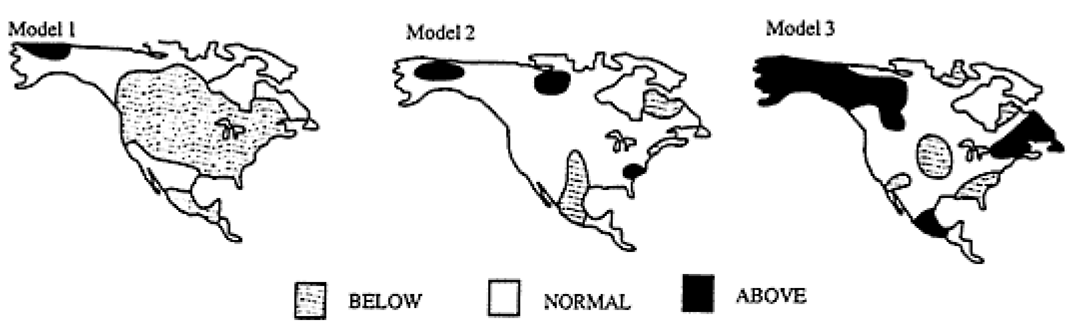

Figure 2. Response of summer rainfall in North America to a doubling of greenhouse gasses, results as indicated by three major models.

Will there be more extreme weather events like droughts, severe storms, and heat waves as the climate warms? The answer is uncertain. Globally, there will be more evaporation of water from lakes, rivers, and oceans as the climate warms because warmer air holds more water vapor than relatively cooler air. More evaporation means more precipitation (what goes up must come down), but where there may be increases in precipitation and where there may be decreases is not reliably known. Less certain still is the understanding of how the frequency and severity of droughts might change. The only certainty is that the frequency and severity *will* change. Because the global temperature will rise, there is an increased probability of periodic extreme high temperatures like heat waves, especially in summer. But, again, we don't know what parts of the world will be more susceptible to such extreme weather events.

How rapidly might the earth's climate system respond to a strengthening greenhouse effect? The rate at which the climate will change is especially important in determining how difficult the transition for agriculture will be, and probably less is known about the rate of change than any other feature of climate change. It depends partly on the rate at which greenhouse gas concentrations continue to rise--which is mostly a social and economic policy problem--and partly on the sensitivity of the climate system to a stronger greenhouse effect. If emissions of greenhouse gases continue to grow at current rates and if the climate system is "moderately" sensitive to the corresponding strengthening of the greenhouse effect, the best educated guess (and it is only a guess) is that the warming could proceed at a global average rate of between 0.5° F and 1.5°F per 10 years. That rate of warming, even on the low end, is greater than any observed over a 10-year period since the 1850s. The warmest decade on record in Nebraska was the 1930s, which averaged about 1°F warmer than the current average. After 30 years of warming, even at the low end rate of 0.5° F per decade, the high heat of the 1930s in Nebraska would seem like child's play.

Have scientists been able to detect global warming conclusively? The answer is "close, but not quite." Attempts to compile the temperature records over the entire earth for the last hundred years have had mixed results. Figure 3 shows the annual temperature difference from the 1961-90 average annual temperature of the earth over the last hundred years; it is based on temperature records from a number of sources. The data suggest that the earth has warmed about 0.9°F between the late 19th century and the present. The problem is that the data are not completely reliable. Very little information was available from the oceans until recently. Another concern is that the temperature information has been unduly influenced by the heat-generating influence of the increasing growth of cities around the observing stations. However, after accounting for these problems, scientists are convinced that the earth has indeed warmed about the amount shown in *Figure 3* since the end of the last century. Whether or not this warming is due to the strengthening greenhouse effect or to other factors is speculation. However, as scientists learn more about what to look for, they are finding more and more evidence (e.g. nighttime warming, more intense precipitation events) to support the argument that global warming is underway.

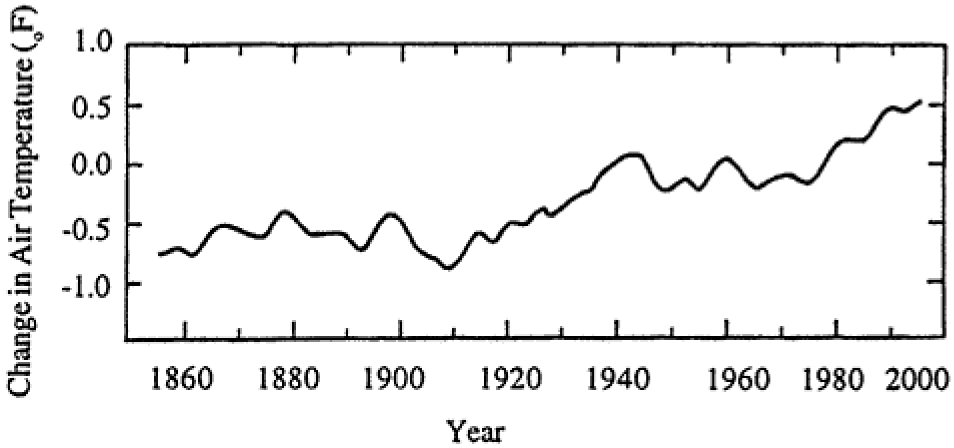

Figure 3. Annual temperature differences from the 1961-90 average annual temperature of the earth.
Source: Our Changing Planet: The FY 1997 US Global Research Program, a report by the subcommittee on Global Change Research, committee on Environmental and natural Resource of the National Science and Technology Council (Washington, DC, 1996).

Concerns for Nebraska Agriculture

No accurate "forecasts" of how the climate across Nebraska will change in response to global warming are yet available and even if they were, reliable prediction of the consequences of the resulting climate changes for Nebraska's agriculture is difficult. So, what can be said about the effects of climate change on Nebraska's agriculture?

First, certain consistencies among researchers' findings to date raise concerns that the change in Nebraska's climate may be for the worse, since most evidence suggests a change toward drier and warmer conditions than presently exist. Accordingly, by the time atmospheric greenhouse gas levels double over pre-industrial levels (about when the current generation of Nebraska's children are grandparents), the climate of Nebraska, especially in the western half of the state, may be similar to the current climate of eastern New Mexico.

Second, historical experience with past extreme weather events involving higher temperatures (the droughts of the 1930s, 1950s, and more recent, shorter-lived ones), laboratory experiments, and computer simulations of crop growth suggest that yields of most Nebraska dryland crops would decrease if farmers do not change their operations in response to the climate changes. Irrigation would help but result in higher costs. Without changes in farm operations, one study found that a recurrence of the droughts and heat of the 1930s "Dust Bowl" in Nebraska could reduce dryland corn yields by as much as 20-30 percent under current yields.

Third, a positive feature of global climate change is that rising carbon dioxide concentrations in the atmosphere are likely to benefit certain crops. Carbon dioxide is a necessary ingredient in photosynthesis and it helps plants use water more efficiently. Experiments show that certain crops like small grains and soybeans are likely to benefit greatly from increasing carbon dioxide concentrations, while others like corn and sorghum will benefit less.

Will the increased concentration of carbon dioxide offset the negative effects of a worsening climate?

Preliminary studies suggest that the negative climate changes are likely to reduce the positive consequences of rising carbon dioxide levels. Will it enhance the positive effects of an improving climate? Clearly, the answer is yes, but by how much is not known.

Could Nebraska's agriculture cope with the above changes in climatic conditions and accompanying stresses on crops? The answer depends largely on how rapidly changes occur. If changes occur swiftly, they could overwhelm the ability of farmers and the supporting research and extension community to keep up. It currently takes about 10-12 years to develop, test, and market new crop varieties that are well-adapted to the environment in which they are to be grown. Rapid climate change (0.5° F of warming per 10 years) could hinder efforts at developing new crop varieties, since the climate conditions for which varieties are being developed are constantly changing. Were the climate changes to unfold slowly and steadily, the threat to Nebraska's agriculture would be small. Many crops currently grown in Nebraska (corn and wheat, for example) are also grown successfully in climates that are warmer and drier than Nebraska. There is little question that given the time, Nebraska's farmers and ranchers could adopt operations similar to those currently used in warmer and drier locations.

One key for Nebraska agriculture is how the climate change will affect competitors elsewhere. Generally, when farm production is down everywhere, prices rise to compensate and help offset yield losses. But when drought hits one production area and conditions remain favorable in other production areas, the drought-stricken area will suffer economic hardship. Though no place on earth is likely to be untouched by climate change, agriculture is likely to be disadvantaged in some places by the change while other places (e.g. currently cold-limited regions like Canada and parts of Russia) will be helped by moderate amounts of warming. The state's agriculture will be harmed less if climate changes in competitor regions are damaging also.

What will scientists be tracking to help farmers detect the presence of global warming influences on Nebraska's climate? Long-term trends in important weather-related influences on crop production will be monitored closely. For example, trends in the lengths of frost-free periods, the intensities of precipitation events, the occurrence of runs of heat-stress days, and the warming of soil temperatures in spring will be tracked. Patterns and trends in biological markers of warming will be followed, such as the invasion of insect, pathogen, and weed pests normally found in warmer climates.

Preparing for Climate Change

Farmers often ask: What should I be doing about global warming? There are no easy answers to this question. Given the uncertainties of how the warming may take place, it is most reasonable to pursue a "no-regrets" approach to the problem. A no-regrets approach means doing things that will help reduce the impact of climate change and make sense whether there is climate change or not. Taking steps to prepare for normal climate variability (i.e. droughts, hail storms, floods) is an excellent strategy for preparing for future climate change. The following is an illustrative list of suggestions for managing climate risk:

1. **Conserving water resources.** Water for irrigation is likely to become relatively scarce over large parts of Nebraska, whether climate changes or not. Efforts to develop crop varieties that are drought-tolerant will help ensure the adequacy of irrigation water supplies as climate warming increases irrigation demand by crops. Use of more efficient irrigation equipment, proper scheduling of irrigation, and water-conserving land management practices (e.g. reduced tillage) will help.
2. **Using shelterbelts.** Recent studies show clearly that shelterbelts increase crop yields for a considerable distance downwind. Moreover, shelterbelts help offset the losses that drought and

other stressful weather cause to current crop productivity. Economic analysis suggests that the costs of installing shelterbelts are returned within a few years by the additional revenues generated by increased productivity of crops behind shelter. Simulation studies show that shelterbelt benefits to crops increase with the severity of the climate conditions.

3. **Maintaining long-term flexibility.** As climate changes become more apparent, flexibility in changing farm operations will be crucial. Flexibility is a double-edged sword. It enables Nebraska farmers to change rotations, cultural practices, and marketing strategies rapidly to take advantage of market opportunities caused by negative climate changes occurring elsewhere. It also enables farmers to deal with rapidly changing climate conditions on their own farms.
4. **Staying alert and informed.** Producers need to monitor long-term trends in aspects of their operations that are influenced directly by weather conditions. Paying attention to changes in crop-loss risk over more than a two or three year period is a good way to begin monitoring for trends associated with possible climate change. Staying informed of major trends in weather-related production conditions in other parts of the world will provide valuable planning information. Keeping in touch with information services provided by the High Plains Climate Center, the National Drought Mitigation Center, and the Great Plains Regional Center for Global Environmental Change at the University of Nebraska-Lincoln will help keep producers informed of important changes in climate conditions here and abroad.

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