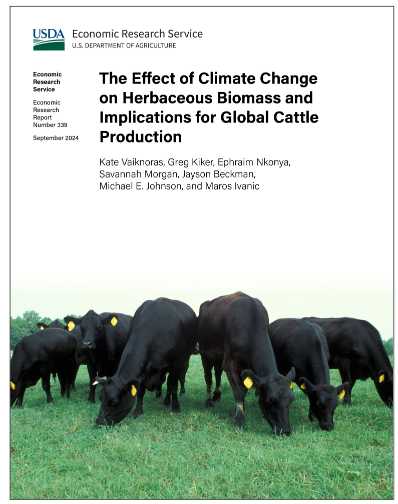
USDA Economic Research Service
U.S. DEPARTMENT OF AGRICULTURE

A report summary from the Economic Research Service — *September 2024*

The Effect of Climate Change on Herbaceous Biomass and Implications for Global Cattle Production

Kate Vaiknoras, Greg Kiker, Ephraim Nkonya, Savannah Morgan, Jayson Beckman, Michael E. Johnson, and Maros Ivanic



What Is the Issue?

Climate change may affect plant growth, including grasses that cattle and other livestock feed on—ultimately affecting livestock production. This development has the potential to affect livestock producers and consumers of animal products around the world. This report used G-Range (a simulation model) to estimate changes in herbaceous biomass on rangelands by 2050 under a high-greenhouse gas concentration climate change scenario. Increased carbon dioxide (CO_2) concentrations promote growth in some plants by increasing the rate of photosynthesis, a process known as carbon fertilization. Because there is scientific uncertainty about how plant growth may respond in a sustained way to increased atmospheric carbon dioxide, this report simulated results that considered a positive carbon fertilization effect on plant growth in rangelands and results with no such effect. We then used productivity equations to estimate how these changes in herbaceous biomass could affect beef and milk production. Climate change may affect livestock production in other ways, such as causing heat stress for animals, reducing water availability, and promoting pathogens. Thus, this report does not capture all potential effects of climate change on livestock.

What Did the Study Find?

This study estimated a 4-percent decline in total global herbaceous biomass on rangelands by 2050 under a climate scenario of high greenhouse gas concentrations (Representative Concentration Pathway (RCP) 8.5) if there was no positive carbon fertilization effect. Results for the effect of climate on herbaceous biomass varied widely by region.

- This estimate represents a loss in food availability for cattle and dairy cows that rely on grasslands as forage.
- In Africa, every subregion experienced a loss in herbaceous biomass. Western Africa had the largest losses: Around 34 percent of its herbaceous biomass was lost without carbon fertilization. Several other regions would lose herbaceous biomass as well, such as South and Central America.

ERS is a primary source of economic research and analysis from the U.S. Department of Agriculture, providing timely information on economic and policy issues related to agriculture, food, the environment, and rural America.

- Some regions, particularly those with cooler climates such as North America and Northern Europe, would gain herbaceous biomass as warming temperatures and/or changes in rainfall facilitated plant growth. Even within gaining regions, however, some areas would lose herbaceous biomass.

If herbaceous plants respond positively to increased atmospheric carbon dioxide, global losses would be more than offset. It was estimated that herbaceous biomass would increase by 7 percent under RCP 8.5.

- If carbon fertilization leads to increased plant growth, more regions would see gains in herbaceous biomass, including East Africa, Australia, and New Zealand.

This report also estimated changes in potential beef and milk production stemming from changes in herbaceous biomass availability in rangeland areas with at least one cow per grid square (55 kilometers by 55 kilometers). In general, regions that lost herbaceous biomass would lose meat and milk production, while regions that gained in biomass would gain in production. Some regions that gained herbaceous biomass, particularly North America, had widespread and highly productive beef and milk production: Gains in these regions offset losses in other regions. As a result, we estimated that globally, without carbon fertilization, potential beef production by cattle fed with rangeland herbaceous biomass would remain about the same, and milk production would fall by 1 percent. With carbon fertilization, potential beef and milk production would expand by 12 percent and 11 percent, respectively, as a result of increased biomass availability.

How Was the Study Conducted?

This report used a global, gridded ecosystem model called G-Range to simulate the effects of climate change scenarios on global mean herbaceous biomass. We focused our analysis on herbaceous (grass) biomass because this is the type of biomass that is grazed by cattle. The change in herbaceous biomass globally and regionally was estimated from 2017 to 2050. The simulations assumed a climate scenario under a relatively high level of future greenhouse gas concentrations called RCP 8.5; although, in the time frame examined, there was little variation among RCP scenarios. Seven different sets of climate data were used to account for uncertainty in future weather patterns under RCP 8.5; the results are an average of these seven. There was also uncertainty in how plants would respond to increased carbon dioxide in the atmosphere, so the results were estimated for different assumptions regarding plant responses under RCP 8.5.

To determine how climate change effects on herbaceous biomass affect beef and milk production, the herbaceous biomass results were entered into productivity equations that included regionally specific parameters representing the importance of herbaceous biomass in animal diets, meat and milk productivity, and more. The areas modeled were also restricted to those with cattle present, according to the most recently available data (2015). This study is the first to our knowledge to combine a formal productivity analysis with simulated herbaceous biomass changes, allowing us to translate changes in herbaceous biomass due to climate change into changes in beef and milk production. Thus, the total changes in beef and milk production on rangelands were calculated by region in 2050 and compared to 2017.