



Sustaining rangelands in the 21st century

By Nathan F. Sayre

On the Ground

- The major threats to sustaining rangelands in the 21st century are climate and land-use change, both of which originate outside of rangelands themselves.
- Society's demands on rangelands have shifted away from livestock production and toward services and disservices such as climate mitigation and greenhouse gas emissions.
- Sustaining rangelands in the United States depends on sustainability of the larger beef production system, including crop agriculture, feeding, and finishing.
- Understanding the history of the beef system helps identify strategies and priorities for sustaining rangelands and meeting society's evolving demands.

Keywords: sustainability, beef production, climate change, land-use change, feedlots.

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Sustaining rangelands has been central to the mission of SRM from its foundation nearly 75 years ago. But the meaning of sustainability has evolved with changes in our knowledge, in rangelands, and in society's concerns and demands. Historically, the primary focus was on uses and products such as forage, water, wildlife, forestry, and recreation. This prioritized the art and science of range management, applied on rangelands, with livestock grazing as a core concern in most cases. If sustainability were still just a question of how to manage livestock grazing, I think we could say we know how to do that pretty well by now. It's not easy, but it's also not a mystery—and it is still important. Society's concerns continue to evolve, however, and many people now see the value

of rangelands through the lens of global issues such as biodiversity, energy, and climate. This is not just a demand for different products. Rather, people are asking about services and disservices—how rangelands contribute to global problems and needs.¹

This effectively means sustaining rangelands in the 21st century depends on what happens in other places. The biggest threats to rangelands (and the services they provide) are climate and land-use change, both of which originate elsewhere.^{2,3} Modern society has long seen rangelands as a reserve supply of “under-employed” land available for other uses as they arise; livestock grazing, on this view, is just a placeholder until something more lucrative or urgent comes along. Simply put, land-use change is lucrative and climate change is urgent; the recent rapid expansion of solar and wind energy production on rangelands is evidence of both.⁴

Sustaining rangelands thus poses a dilemma. On one hand, livestock grazing is still the activity that stands the best chance of preventing land-use change on extensive grazing lands while supporting people in the face of a changing climate. On the other hand, there is widespread belief, at least in the wealthier parts of the world today, that livestock production is inherently unsustainable due to greenhouse gas (GHG) emissions and other environmental impacts. A growing chorus of environmentalists, scientists, philanthropists, and entrepreneurs is demanding radical transformation—or outright elimination—of animal-based meat production as a whole.^{5,6} Notably, the art and science of range management is largely irrelevant to these demands. How should range scientists and the SRM respond?

In the face of this dilemma, sustaining rangelands depends on the sustainability of beef production as a whole, because the beef system determines both the economic viability of livestock production and how rangelands are framed in climate debates. Rangelands are only one piece of this system, which also encompasses sown pastures and croplands producing various feedstuffs and byproducts that cattle consume; the feedlots and processing plants where cattle are finished and slaughtered; and the supply chains and infrastructures supporting the whole system. Notably, much of the land involved is former rangeland. Unfortunately, very little literature spans rangelands and the rest of the beef system.^{7,8}

I explore the interdependency of rangelands and the beef system to draw out lessons for the present century. At the

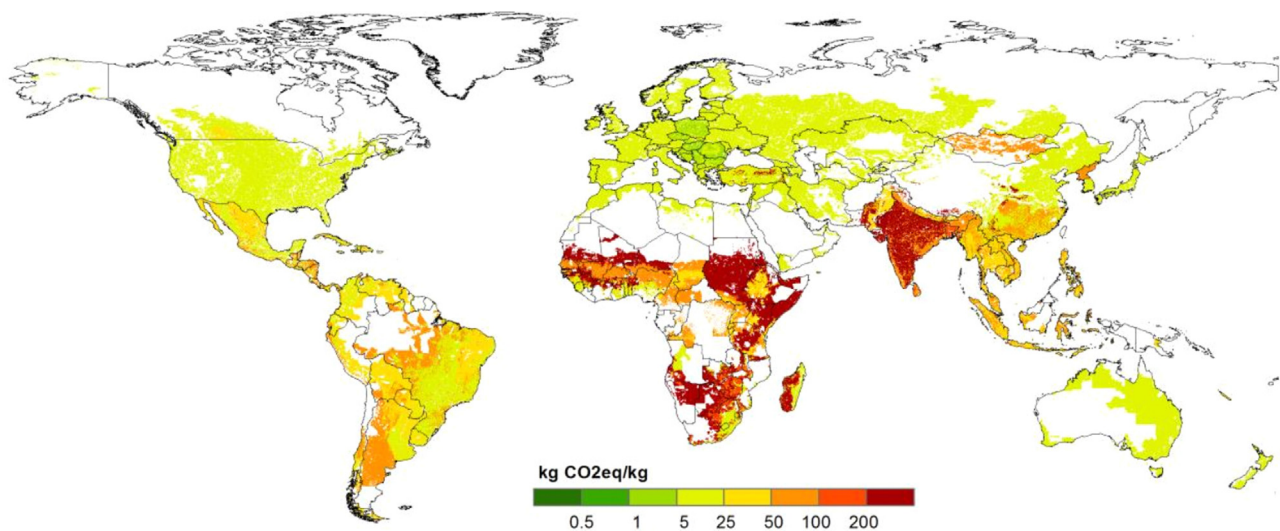


Figure 1. Greenhouse gas efficiency of bovine meat production in the year 2000, expressed in kg CO₂eq/kg product.⁸ Emissions per unit of meat vary widely, largely due to lifespans; cattle in the developed world grow more quickly and are slaughtered at a younger age.

center of the story is the feedlot and the practice of fattening (or “finishing”) livestock on grains such as corn or other crop-based feeds. The feedlot is the quintessence of modern livestock production: a marvel of industrial efficiency for supporters and the embodiment of its ills for detractors. Where did the feedlot originate? How has it affected rangelands and range livestock production? What can be learned from this history? Although my focus is primarily the United States, the answers to these questions are also relevant to rangelands in other parts of the world.

Both globally and in the United States, beef production is extraordinarily varied and complex, with environmental impacts as diverse as the landscapes, breeds, and production systems involved.^{9,10} Averaged worldwide, producing 100 g of beef protein results in 25 kg of CO₂ equivalent, but this masks more than an order of magnitude difference between the 10th percentile (9 kg CO₂eq) and the 90th (105 kg).¹¹ More so than for other foods, GHG emissions per unit of output varies widely between countries and regions (Fig. 1), and even between firms in the same country. Other impacts of beef production are geographically uneven as well. Brazilian beef is exported primarily to the Middle East and Asia, for example; very little of it goes to North America. Thus, if Americans stopped eating beef, it would have virtually no effect on Amazonian deforestation.¹²

Livestock production in the developed world actually reduced its GHG emissions from 1960 to 2010, and the United States is among the lowest intensity producers in the world.¹³ The primary reasons are high-quality forages and feeds, livestock breeds that optimize these feeds, and high reproduction and growth rates. Taken together, these factors reduce the average lifespan of beef cattle, maximize output per unit of biomass, water and time, and thereby minimize emissions. How this came about holds a number of important lessons for sustaining rangelands in the 21st century.

Modern, industrial-scale feedlots developed after World War II, but their predecessors date back to the early 1800s

when Euro-American settlers colonized the rich farm lands of the Ohio River Valley. Their fields yielded bountiful harvests when planted with corn, a cultivar adopted from Native Americans. But transportation was too expensive to justify hauling their crops to markets over the Appalachians to the east or far downriver to New Orleans. Instead, they fed the corn to pigs and cattle, which could carry themselves to market.

The feedlot was invented on these Ohio Valley farms. Mature corn plants—stalks, leaves, and ears-in-the-husk—were cut and piled into stacks, called “shocks,” that dotted the fields after harvest. As historical geographer John Hudson¹⁴ explains:

A ten-acre cornfield was the basic unit, supporting one hundred head of cattle in the late fall fattening season. Twelve to sixteen hills of corn were gathered to provide one shock; one-half bushel of shock corn per head per day was fed from early November to February, when the drive to market began. For each field there were two or three of like size adjoining it, filled with the same arrangement of corn in the shock, through which the animals were changed to fresh lots at every feed, morning and evening. Each lot of one hundred head was fed together and then driven to market together. (p.71)

The key innovation was feeding the animals in the fields, where their manure would replenish the fertility of the soil:

Feedlots eliminated cattle barns. The considerable amount of corn that passes whole through a steer becomes unusable waste when produced by an animal fed in a barn stall, but in a feedlot that corn becomes accessible feed for hogs. Between one hundred and two hundred hogs cleaning up after corn-fed steers could be fattened simply on the waste. The manure produced both by cattle and hogs enriched the soil of the series of fields through which they were rotated in the feeding season, providing nutrients for the next year's crop. (p.71)

By 1840, pig processing had become a major industry in Cincinnati, Ohio, giving rise to some of the world's first large-scale slaughterhouses. After the Civil War, the center of meat processing shifted from Cincinnati to Chicago, linked via the railroads to markets in the East, and the feedlot model expanded to encompass a vastly larger geography. Pioneer cattleman and booster Joseph McCoy¹⁵ wrote in 1873 that, "Central Illinois has become universally wealthy by corn raising and hog and cattle feeding, or, in other words, making the live stock product of other regions fit for eastern markets and consumption" (p.166). Settlers borrowed money to buy and improve land, and as land values rose, farmers planted ever more corn to cover their debts; as more and more land was plowed, cattle were pushed further west.¹⁶ Thus, a gigantic geographical division of labor was established between the Union Stock Yards in Chicago, farms in the emerging Corn and Wheat Belts, and ranches on the semiarid rangelands of the High Plains and Southwest.

With demand for beef booming at home and abroad, the last third of the 19th century witnessed breakneck change on the Great Plains. Bison (*Bison bison*) were hunted nearly to extinction, Native Americans were dispossessed and confined to reservations, and vast areas of prairie were plowed up and converted to croplands. Productivity gains in agriculture were huge, but industrialization produced even greater gains in the rest of the economy, so farmers and ranchers prospered. Historian Richard White¹⁷ explains:

In this new economic world of increased demand and increased production a seeming miracle occurred: western farmers received a higher real price for their wheat even as eastern consumers paid less for it. The price of wheat on the world market fell during the late nineteenth century, but in real terms (that is, in terms of actual buying power) farmers received more for their crop than ever before. The source of this seeming paradox lay in declining transportation costs, declining production costs, and declines in the prices of goods purchased by farmers. (p.245)

The advent of feedlots had significant ramifications for rangelands.¹⁶ As already suggested, profits from corn feeding drove conversion of prairies from rangelands into croplands (more on this below). Feeding also gave ranchers a reliable outlet for their animals, allowing them to destock for the winter or when range forage was depleted. Most importantly, feedlots helped drive a change in the livestock themselves. British livestock breeds, such as the Shorthorn, Durham, Hereford, and Angus, had been bred specifically for rapid growth when fed on fodder crops and sown pastures, and their meat fetched a premium for its higher fat content and marbling. From the 1870s onward, under pressure from farmer-feeders (who were responding to pressure from meat-packers), cattle producers began crossing British breeds with the Longhorns that had spread from Texas in the famous cattle drives. The newer breeds were not well suited to the dry rangelands of the West, but they thrived on corn when transferred to Midwestern farms.

Range science, and the system of public land tenure and administration we associate with the Western Range, was

conceived in response to this period of breakneck change, in particular the devastation that resulted when severe winter storms and droughts in the 1880s and 1890s led to massive cattle die-offs and overgrazing (probably made worse by the shift to British breeds). Not surprisingly, range science focused on the range portion of the production cycle, leaving the rest to other disciplines such as agronomy and animal science.¹⁸ This has obscured the fact that ranching, corn farming, and grain-finishing coevolved together. In a very real sense, there has never been ranching in the United States without corn feeding as the next step in the production of beef.

To put this history in a longer-term perspective, I should note that in 1492 there were an estimated 405 million hectares (1 billion acres) of rangeland in what is now the United States. Since then, a little more than one-third of that area (139 million hectares [343 million acres]) has been converted to other land cover types and thereby lost as rangelands (Fig. 2).¹⁹ These figures are probably under-estimates. There is evidence that significant savannas were found east of the Mississippi: bison were found as far east as New York, for example, and the long-leaf pine (*Pinus palustris*) forests of the southeastern coastal plains were savannas at the time of contact. It is now recognized that Native Americans produced these savannas, which have largely filled in with trees due to the removal of Indigenous burning.²⁰ Historians also note that when Europeans first landed in North America, from New England to the Gulf of Mexico, they remarked on the abundance of pastures suitable for their cattle and other livestock, which were instrumental to the success of colonization and settlement throughout the Americas.²¹

Because homesteaders gravitated toward the more productive areas—generally those best suited to cultivation—these are now primarily private lands, and the most productive are no longer rangelands at all.²² An estimated 98% of the tall grass prairie and 67% of the midgrass prairie is gone.²³ The Palouse prairie of the Pacific Northwest is almost entirely cropped, as are large parts of the San Joaquin, Salinas, and Imperial valleys in California. Conversion of private rangelands to cultivated agriculture continues to this day—a little more than 810,000 hectares (2 million acres) in 12 midwestern states between 2008 and 2016.²⁴ Private rangelands are susceptible to conversion to other uses, as well, such as residential or energy development. This is important not only for rangeland ecosystems and their biota, but also for climate change. Rangelands contain approximately 30% of the world's soil carbon, and an estimated 45% of cattle-related GHG emissions worldwide are attributable to land-use change (e.g., Amazonian deforestation). Restoring cultivated lands to rangeland would sequester significant amounts of carbon, and avoiding the loss of carbon from rangeland soils is probably the most effective strategy for climate change mitigation involving rangelands going forward.²⁵⁻²⁷

In other words, anyone concerned about the sustainability of rangelands today needs to be concerned about former rangelands as well as those that remain. US beef production is

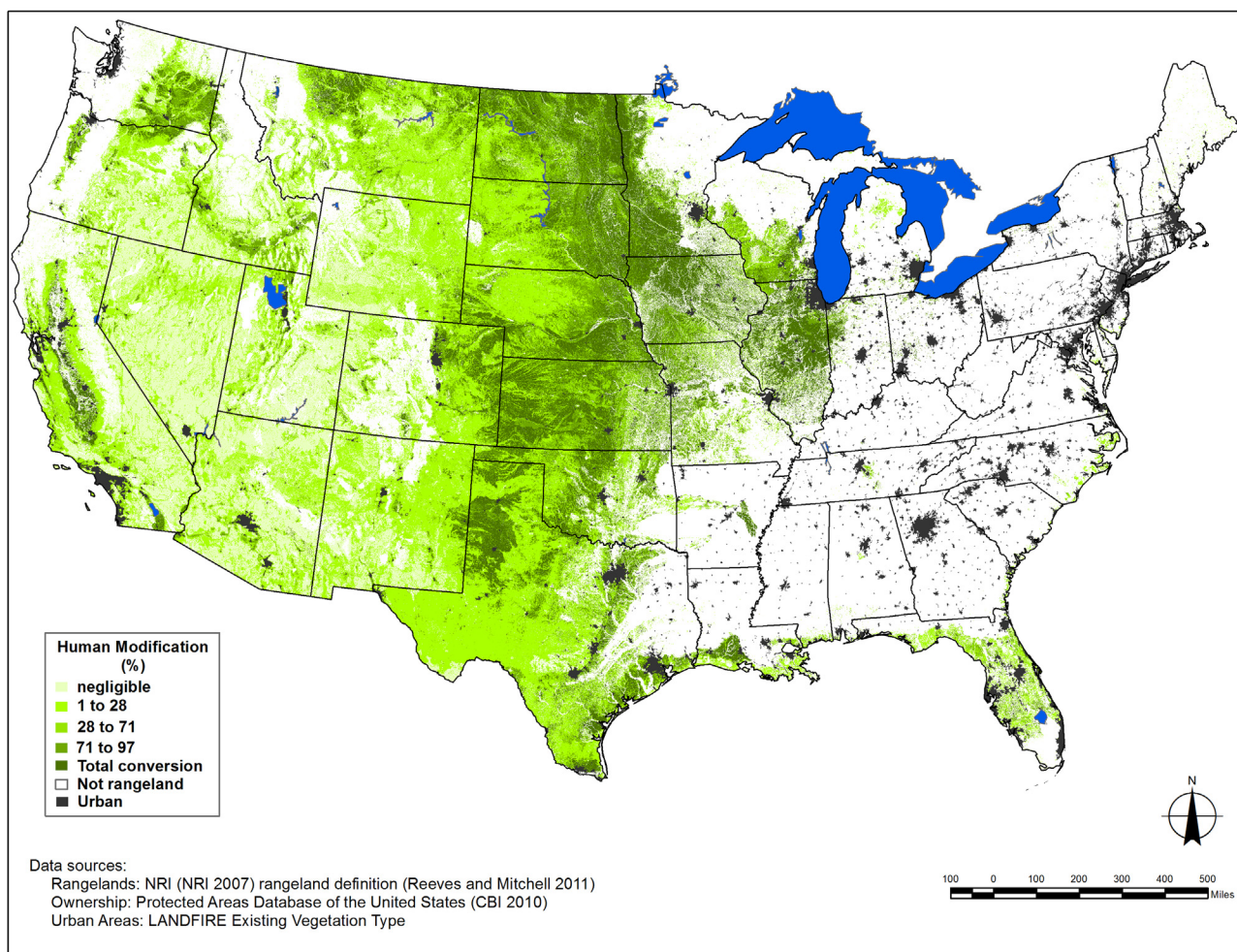


Figure 2. Extent and magnitude of human-modified land cover in the United States, displayed at a resolution of 90 m.¹⁶ Roughly one-third of all rangelands circa 1500 is no longer rangelands, primarily due to conversion to crop agriculture, and many of the resulting crops (especially corn) are used to feed livestock in confined animal feeding operations.

so efficient because it tightly integrates ranching with farms, feedlots, and the processing industry. Events since World War II reinforced this overall pattern, even as the center of gravity of the industry shifted to the Southern Plains. Feedlots expanded to become confined animal feeding operations, and slaughterhouses decamped from Chicago and other cities for rural areas with cheaper nonunion labor and closer proximity to feedlots. As the scale and intensity of production have increased, however, a number of important changes have occurred. Beef production has increasingly abandoned the very thing enabling the success of the feedlot in the first place: the synergistic relationship between livestock and crop production, mediated by manure and soil fertility. Farms rely instead on synthetic fertilizers, and cattle and hogs are fed in confinement instead of in fields.²⁸ Additionally, corn production has grown well beyond what is needed for livestock feed. Large amounts are used to produce ethanol, sweeteners, and countless other products.

Today, the Corn Belt encompasses our most fertile land, has the highest rates of soil erosion and nutrient run-off, and receives higher levels of government farm payments than the

rest of the country.²⁹ And it has become, arguably, too efficient. Productivity gains in US agriculture have exceeded those in industry and services, inverting the 19th century economic “miracle” for farmers and replacing it with a vicious cycle of rising output and declining profits. For all US farm households, rates of return are negative for small operations and modest for mid-sized operations.²⁸ Either you get bigger and bigger, or you turn to off-farm income to stay afloat. Or you subdivide: nationally, exurban development (1 home/0.4-16 hectares [1-40 acres]) increased from 5% to 25% of the lower 48 states from 1950 to 2000.³⁰

Efficiency has been achieved largely by economies of scale. Nearly every segment of the US meat industry has become more consolidated since the 1980s—that is, the number of firms has declined and their average size has grown. The sales midpoint for feedlots (the size of the firm where half the national herd is on larger, and half on smaller, feedlots) has more than doubled since the 1980s, and consolidation in the processing sector has reached levels not seen since the early 20th century.²⁸ Interestingly, some economists say today’s Big Four packers—JBS, Cargill, Tyson, and National Beef—do not ad-

Sustaining rangelands in the 21st century will depend heavily on livestock and meat producers' social license to operate, or what Machen et al.³² term the "Social Acceptability of Food & Fiber Production." Ranching currently is the strongest exhibit in support of social acceptability, both for its cultural values and for the expansive landscapes it helps to conserve. But its power to offset criticisms of the rest of the beef system is threatened by political and economic forces relegating rangelands to the margins of power. To succeed, rangeland advocates need to understand and engage with the entire beef production system, which paradoxically holds both promise and peril for the rangelands we have lost as well as for those we continue to enjoy today.

Declaration of Competing Interest

The author declares the following financial interests/personal relationships which may be considered as potential competing interests. The author certifies that he has no financial interest in the subject matter discussed in the manuscript.

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