tion. It is felt that achieving these goals will maximize the benefits to all users of these public lands.

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Assessing the Long-term Availability of Forage from the Nation's Forest and Rangelands

Linda A. Joyce, Lane Eskew, and Edward Schlatterer

Concern for the long-term availability of resources from forest and rangelands motivated Congress in 1974 to require the Forest Service to analyze "present and anticipated uses, demand for, and supply of the renewable resources of forest, range, and other associated lands." Rangelands are being used for a wide variety of resources. Forest and rangeland now feed over 70 million cattle, nearly 8 million sheep, 45,000 wild horses and burros, 20 million deer, 400,000 elk, 600,000 antelope, and small numbers of goats, bison, wild sheep, and moose. Range vegetation provides grains, nuts, fruits, vegetables, medicines, range forage, fuelwood, firewood, specialty wood products, oil, rubber, and drought-adapted plants for agriculture, land reclamation, and landscaping. Some resources are sold in markets and while other such as wilderness experiences are harder to value monetarily.

The 1989 Range Assessment compiles the current scientific understanding of the ecology and the economics of rangelands to project the future use, demand for, and supply of rangeland resources 50 years into the future. The Assessment examines the biological, economic, and social factors affecting the use of rangelands and how those factors might change over time (USDA Forest Service 1989, Joyce 1989). These analyses show potential problems in the long-term availability of rangeland resources and the need for a careful consideration of present and future management options for the nation's forest and rangelands.

Projecting Future Supply/Demand

Because the law requires an analysis of the supply and demand of rangeland resources, early Range Assessments in 1975 and 1980 focused on products bought and traded in an observable market: livestock and meat. Forage produced on rangelands and forests is rarely traded in an observable market and so the available data were, and still are, insufficient to quantify a true supply estimate of range forage. Earlier analyses used an agricultural model developed by the Economic Research Service to estimate the future demand for meat and for livestock. In the 1989 Assessment, this economic model was used again to estimate the future demand for meat and livestock. Forage demand was derived from the demand for meat and livestock. In contrast to these earlier analyses, however, an attempt was made to examine the potential ability of regions across the United States to supply this demand and what the consequences of supplying this demand might be on other rangeland resources.

Conversion of rangeland to other uses and management decisions made by private landowners and by public land managers influence the supply of forage. On private land, owners determine forage produced within their operation based on the availability and the cost of land (their land, leased land, and public grazing) and technology. On public lands, public policy and multiple resource objectives influence forage availability through permits. We project factors that influence range forage production—land availability and technology—by using

This paper summarizes a more detailed and in-depth analysis titled *An Analysis of the Range Forage Situation in the United States: 1989-2040* by Linda Joyce. Readers interested in the technical background and references should consult this document.

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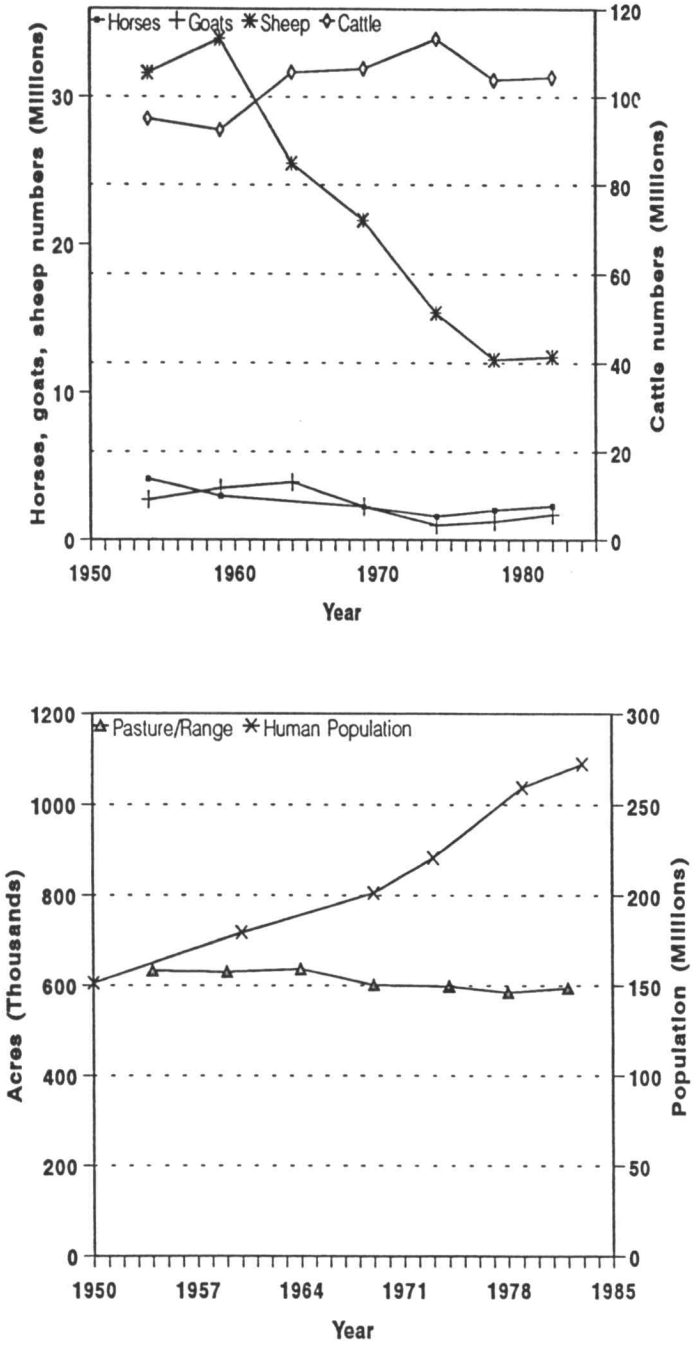
historical trends in rangeland availability and the implementation of range improvements.

How Land Use Affects the Supply of Forage

Between 1969 and 1982, the area of improved pasture and rangeland declined nearly 8% (Fig. 1). This decline resulted from long-term forces—such as an increasing population's need for urban and recreational land—and from short-term forces, such as crop prices. For example, the rapid conversion of rangeland to cropland during the late 1970's was related to disincentives within the livestock sector such as poor cattle prices and cash-flow problems that encouraged ranch sales, and incentives within agriculture such as high wheat profits, credit availability on cropland, higher cropland prices, and government programs and tax provisions that enhanced the profitability of conversions. Forecasting how land use will change involves projecting the location of human population growth, the growth of agricultural markets, and the development of agricultural and natural resource government programs.



Source: Animal data: USDC [various years], Census of Agriculture
Land area: ERS; Population: Bureau of Census

Fig.1 . *Number of livestock on farms, pasture and rangeland area, and human population in the United States.*

Projections by the Bureau of Census suggest that human population growth over the next 50 years will be most rapid along the Pacific Coast, in the South, and in some areas within the Rocky Mountain region. Minimal growth in population is projected for the Great Plains. Urbanization of rangeland is not likely to have a national impact, although areas in the West, such as the Front Range of Colorado, Las Vegas, Phoenix, and Tucson will see the conversion of rangeland into cities and towns. Because population growth will be in predominately forested or agricultural areas, in the 1989 Assessment we assume minimal conversion of rangeland into urban land.

In contrast to the 1980 Assessment, the future demand for cropland in the 1989 Assessment is projected to be low because of the less favorable cost/price relationships, lower agricultural exports, changes in the federal tax code, and county and state restrictions of plowing fragile rangelands. The projected decline in irrigated cropland in the West also reduces the demand for converting rangeland to cropland. Projected increased growth efficiencies in feed grains and livestock will reduce the land needed for feed grain production (USDA SCS 1987). Improvements in animal feed efficiency and productivity could result in a decline of 3 to 10 million acres of feed grains and roughages crops.

Government crop-acreage control legislation has and will continue to have a significant impact on the use of rangelands. In the most recent program, the Conservation Reserve Program, 45 million acres of highly erodible cropland have been enrolled with about 85% of the acreage planted to grasses. If, at the end of this 10-year program, this cropland remains in permanent cover (native or introduced grasses), land for forage production could increase by 30 million acres. While previous set-aside programs did not keep land out of crop production, other features of the Food Security Act suggest that high erodible land may remain in permanent vegetation and be converted to other uses such as grazing.

Because government programs converting lands into the wildlife parks and reserves often carries a provision for continued domestic grazing, we assume that the conversion to parks and refuges will have little impact on the availability of land for livestock grazing. A large percent of public lands have traditionally been managed for grazing. Strong guidelines for multiple resource management are given in the extensive environmental legislation of the 1960's and 1970's, and the demands on public rangeland

Fig. 2. *The side effects of the urbanization of rangeland.*

for other uses have expanded. Given these pressures, the supply of permitted animal unit months (AUMs) on National Forest System lands is projected to rise only slightly over the 1986 level by 2040. Other sources of public forage, such as BLM-administered lands, are assumed to remain at 1980 levels.

Given these future forces on rangeland use, we project a slight increase of 5% in nonfederal rangeland area by 2040. We assume no change in federal land area available for grazing. The supply of grazing from all public lands is assumed to rise less than 1% by 2040.

The Influence of Technology on Range Productivity

Currently available technologies could dramatically improve forage production on rangelands according to an Office of Technology Assessment report (U.S. Congress, Office of Technology Assessment 1986). While developing technologies such as improved water-use efficiency through recombinant DNA could enhance forage production, the development of plant technologies lags behind animal technologies. The future demand for forage would be most affected by animal technologies which increase the efficiency of feed conversion into weight gain.

The implementation of currently available technology on most rangelands is lacking, particularly for capital-intensive improvements and on areas of low return (woody rangelands). The depressed livestock market of the early 1980's did not foster a profitable implementation of many range improvement practices (Pope and Wagstaff 1987).

For this analysis, we assume that only currently available range improvements would be used, and that this implementation would increase the productivity of range forage at only 0.7% per year over the 1985–2040 period. For comparison, productivity of crops in the agricultural sector is projected to grow at 1.6% per year, with productivity of feed grains increasing 1.2 to 1.7% over the 1990 to 2030 period (USDA SCS 1987).

The Demand for Meat and the Derived Demand for Forage

Demand for meat depends on exports and domestic consumption. Exports from the United States were less than 1.5% of total U.S. meat supplies in 1985, and 2.3% in 1986 and 1987. While the world consumption of meat is projected to grow 1% a year, increases in meat consumption in developing countries will likely be met with intensive poultry and pork production or pasture-based ruminant production in those countries. Thus, the future demand for meat will depend primarily on domestic consumption.

Domestic demand for meat is related to population size, disposable income, the relative prices of alternative foods, and consumer preferences. Future population growth rates are projected to decline annually. While disposable per capita income is estimated to increase 2.5 times the 1986 level by 2040, this increase in spending power will minimally affect meat consumption. Sociological factors, such as a more health-conscious public, appear to interact with factors, such as the large supplies of inexpensive meats in the supermarket case, resulting in a shift in consumer preferences for type of meat. Per capita beef and veal consumption rose 140% from 1950 to 1980 but poultry consumption rose 279%. Some of this increase reflects the increase in total meat consumption of 165% from 1950 levels. We do not expect these dra-

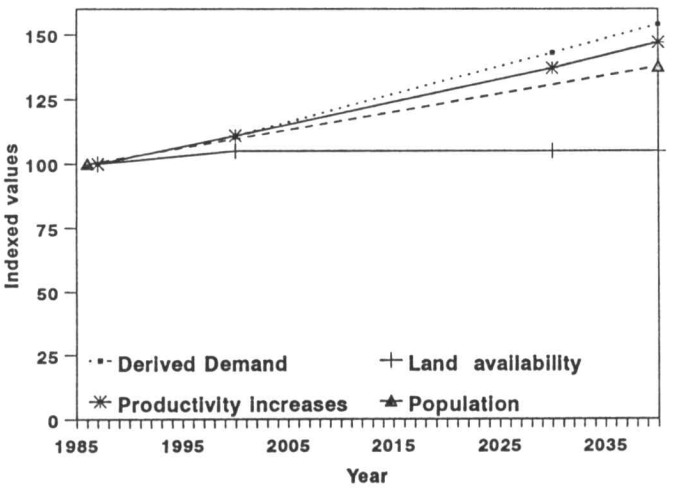


Fig. 3. *Projections of forage production, forage demand, and human population, indexed to 1987.*

matic increases in meat consumption to continue, and the comparative advantage of poultry will decline. Per capita consumption of meat is assumed to remain at the consumption levels of the mid-1980's. For beef and veal, we project per capita consumption to remain at 110 pounds (carcass weight) and for lamb and mutton, 2 pounds (carcass weight).

Using the above social and economic assumptions, meat supply/demand projections to 2040 were computed using an econometric model of the agricultural sector that analyzes meat production as a function of feed inputs. Beef cow inventories in the year 2040 are projected to be 55 million, a 56% increase over 1985 inventories. Beef cow numbers are not expected to exceed the historical peak of 1975 until after the year 2000, and the 2040 inventory is only 21% above the 1975 peak. Breeding ewe numbers were projected to be 8.5 million by 2040, a slight increase over the 1985 inventory of 7.2 million.

The demand for forage, based on regional historical patterns of grazed forage consumption, was derived from these demands for livestock for meat production (Gee and others 1992). By 2040, total forage demand will increase 54% over the 1985 demands.

Implications of the Future Supply/Demand Projections for Forage

Rangeland area increases coupled with increased productivity imply that total forage productivity will increase some 52% by 2040 (Fig. 3). Demand for forage based on the likely future demand for meat is projected to rise 54% over the next 55 years. Thus, grazed forage supplies will probably meet the projected demand for forage.

The distribution of grazed forages, however, will probably vary from this historical pattern. The largest source of grazed forages for beef cattle within all regions is deeded nonirrigated land which includes nonfederal rangeland. The three other sources of forage (public grazing, irrigated pasture, and crop residue) may be the only available sources of feed during certain periods of the year and their availability for grazing influence the use of the nonirrigated land. The slight increase in public forage and the probable decline in irrigated forage suggest intensified management on nonirrigated grazingland, including rangeland, to meet forage demand. The average area of nonfederal grazingland per grazing animal in the western United States is lower than other parts of the United States only because of the high productivity of irrigated pasture and the accessibility of public grazing. Increasing costs of irrigating and the flat projected supply of public grazing will result in herd reductions on those enterprises unable to implement necessary technology to improve forage production on their remaining land.

This analysis rests on several critical assumptions that could be changed to examine their implications. For example, one such assumption is the retention of 30 million acres of highly erodible former cropland in permanent cover and the availability of such land to grazing use. Projections without this assumption suggested that rangeland area will remain the same or increase by 1%, with most of the increase occurring in regions where feed grain production is reduced, such as the Northern Great Plains. With limited capacity to expand on public lands, this alternative future suggests an even greater intensification of forage management on nonfederal rangelands.

When these forage supply/demand projections are compared to projections for other grazers such as wildlife, increased competition between domestic and wild grazers is suggested. Big game numbers (elk, deer, and antelope) are projected to increase 19% over 1985 inventories in the West by the year 2040 (Flather and Hoekstra 1989). Livestock numbers are projected to increase 32% over the same period in the West, suggesting that the grazing pressure from both wildlife and livestock will increase. Social pressure to remove livestock from public lands coupled with an increased demand for recreation and wildlife from public lands may separate wildlife and domestic grazing spatially. But, while fewer livestock operations may be associated with public lands, increased recreation on public lands as well as increasing subdivision of ranches surrounding prime public land wildlife habitat will affect the quality of wildlife habitat on both public and nonfederal lands.

The fragmentation of rangelands and the consequences of this fragmentation has received little examination and, yet these analyses suggest, future demands for both wildlife and domestic grazing will increase, requiring healthy and sustainable habitat. Although this analysis examined land use shifts in the aggregate, we know that at a finer scale the irreversible conversion of rangeland to urban developments, vacation homes, and roads occurs as a break-up of large areas of rangeland into increasingly smaller parcels. For example, over the 1974 to 1982 period, the number of small farms (from 1 to 9 cows) doubled in New Mexico, Oklahoma, and nearly doubled in Texas. This fragmentation of the rangeland landscape and the expansion of the urban-wildland interface may diminish the commercial viability of forage production on

these smaller parcels, restrict management activities, create barriers to wildlife migration, and increase sediment losses. The subtle effects of zoning, taxes, regulations, and population growth on the productivity and use of rangelands is not well-understood locally and the potential is there to affect the long-term availability of rangeland resources.

These analyses and others (Flather and Hoekstra 1989, Guildin 1989, Cordell 1989) have described a future in which there are increasing demands for recreation, clean water, wildlife habitat, wild horse and burro habitat, and habitat for threatened and endangered plants and animals. Recent reviews say that rangeland condition is improving; however, a future in which resource use intensifies may mean that our nation's ecosystems will not improve in condition or productivity unless management intensifies also.

The Role of Strategic Planning within the Forest Service

There is a need to examine the potential future forces on the rangeland landscape and to identify future problems and the management needs to create the desired future for the nation's rangelands. This assessment represents the most current available information on land use changes, demand for meat, and agricultural sector dynamics, and reflects an evolution in the analytical processes used to project rangeland resources.

As in the earlier Assessment analyses, factors influencing the supply and demand for rangeland resources have changed and continue to change since the 1989 Range Assessment. In 1980, the major concern was the rapidly increasing demand for meat and increasing demands for cropland. By 1989, per capita meat consumption was declining and crop productivity, particularly in developed countries, was such that domestic cropland acreage was projected as an increasing surplus, lessening the demand for the conversion of rangeland. Environmental concerns were the main issue in 1989.

Because the factors that influence rangeland use and rangeland resources are dynamic, the Forest Service is required by law to examine these forces every 10 years. The next assessment will re-visit many of the issues examined in the 1989 report, in addition to new issues, such as the potential for climate change.

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