National Planning
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Agricultural Research
Policy Advisory Committee

RANGE AND FORAGE RESEARCH NEEDS FOR RED MEAT PRODUCTION

U. S. Department of Agriculture
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A Report to the National
Planning Committee of the
Agricultural Research Policy
Advisory Committee

A National Review of RANGE AND FORAGE RESEARCH NEEDS FOR RED MEAT PRODUCTION

A Joint Study Conducted by National
and Regional Representatives of the
National Association of State Universities
and Land Grant Colleges and the
U. S. Department of Agriculture

PREFACE

The National Planning Committee[1/] authorized the development of a national report on Range and Forage Research Needs for Red Meat Production. This report was developed on a regional basis with each Region appointing a task force and developing a report within the guidelines designated by the national ad hoc task force. Each regional task force had co-chairmen, one USDA and one SAES designated by their respective Regional Research Planning Committees. The eight regional co-chairmen and the national co-chairmen comprised the National Task Force.

The national report identifies major researchable problems mentioned in one or more of the four regional reports. Researchable problems vary in specificity but include for the most part critical issues that must be resolved in order to take full advantage of range and forage crops in red meat production. Readers are referred to individual regional reports for details.

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1/ A committee of the Agricultural Research Policy Advisory Committee jointly sponsored by the U. S. Department of Agriculture and the National Association of State Universities and Land Grant Colleges

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SUMMARY

World concern for food supplies and the alleviation of hunger requires the livestock industry to assess its future role as a supplier of human food. The grain-livestock issue is believed by some to be simply one of feeding less grain to livestock and using the grain to feed more humans. The issue is much more complex, however, and requires rational decisions, recognizing agricultural economies as well as moral obligations. Forage-consuming animals are not direct competitors for human food. Instead, they supply red meat which is not only a preferred food item but one which supplies high quality proteins, essential minerals and vitamins, and significant amounts of food energy for the nourishment of man. Grains are fed to cattle and sheep in significant amounts only when world supplies and prices are such that it is economically feasible to do so. However, it remains clear that decreased use of grain in livestock feeding requires increased use of high quality forage.

In the struggle to feed an ever increasing world population, much emphasis has been given to the increased production of cereal grains and other foods which can be consumed directly by man. However, the contributions which forages and livestock which consume them have made and can continue to make have been largely neglected. The dollar value of forages, expressed in terms of their contribution to human food of animal origin, exceeds the value of any other crop. However, forage technology is many years behind that of most grain crops due to a lack of adequate funding for range and forage research. This may have occurred because range and most forages are considered to have low economic value. Much of the true value of forages is not realized until they are marketed through livestock.

Great potential exists to provide higher proportions of forage feeds in the diets of cattle and sheep, thereby conserving grain for other uses. This can be attained through the development of new technology which will provide greater productivity from lands devoted to range and forage crops, improve herbage quality, provide greater use of corn and other silages, and expand recovery and use of grain crop residues. Human food supplies from increased forage production can be further enhanced through improved efficiencies of ruminant animals in reproductive performance, breeding, management systems, forage digestibility, and disease control.

Research Needs:

Range, forage, and livestock research is complex, time-consuming, and expansive. Most past research has focused on component parts of the complex, range-forage-livestock system, but future efforts will require a much greater emphasis on an interdisciplinary approach. A number of researchable problems are identified in this report. Solutions to these problems would dramatically increase red meat production from range and forage. Specific research needs are listed in the following general categories.

A. Improving Grasses and Legumes for Range and Forage Use.

Develop cultivars with improved yield, quality, pest resistance, seed production, and low levels of toxic constituents; collect, evaluate, and maintain germplasm; and develop cultivars to efficiently utilize commercial fertilizer and water and those adapted to areas with severe resource limitations.

B. Improving Management of Range and Forage Crops.

Improve productive capacity of soils; develop improved revegetation, management, utilization, multiple use, grazing, harvesting, and storing practices; and develop systems to increase off-season production and utilize annual forages.

C. Reducing Limiting Factors in Range and Forage Production.

Increase production by use of nitrogen fixing plants; improve efficiency of fossil-fuel energy use; reduce losses from disease, insects, weeds, and poisonous plants; and improve plant, soil, and water conservation and mechanization of harvesting, handling, and processing forages.

D. Improving Management of Livestock on Range and Forage.

Coordinate beef cattle and sheep management systems with efficient range, pasture, and forage utilization; integrate animal species, season of breeding, weaning, and grazing with multiple range and pasture use; produce finished slaughter animals primarily from forage; and model total production systems with input-output relationships.

E. Reducing Limiting Factors in Range and Forage-Based Livestock Production Systems.

Improve reproductive rate and genetic adaptability of forage-consuming animals; control diseases, parasites, and predators of cattle and sheep; improve digestibility of forages, especially those of low quality; and develop rapid, accurate, in-field measures of forage quality.

Recommendations:

High priority should be given to more adequate funding of existing range-forage-livestock research programs. There is an immediate need for an additional 64 Scientist Years (SY's) and a long-term need for an additional 224 SY's to solve the complex researchable problems identified in this report which are associated with range and forage use for red meat production. Current (1975) and recommended SY support by Research Problem Areas are presented in Appendix Table 1. The level of research in 1967 is included in Table 1 for comparison with current and projected needs.

Comment

In the eight year interval from 1967 to 1975, the emphasis devoted to range and forage research for red meat production declined from 674 to 639 SY's. Although there was either a modest increase or essentially no change in many RPA's (Research Problems Areas), there was a substantial decline in the RPA's that have a direct input to improving range and forage resources. Thus, support for RPA 112, Improvement of Range Resources, decreased from 139.4 to 92.0; RPA 307, Improve Biological Efficiency of Field Crops, from 249.2 to 204.3; and RPA 313, Production Management Systems for Livestock, from 9.1 to 4.9 SY's.

INTRODUCTION

Why is this an opportune time to review range and forage research needs for red meat production? Consider these recent events and their consequences. In 1972, world production of grain fell by 35 million tons. In 1973, world grain production increased substantially, but did not replenish depleted stocks from the 1972 shortfall. In 1974, the U.S. experienced a poor corn crop causing a steep rise in feed prices. Since 1972, several countries have become importing rather than exporting countries, particularly the USSR. These events signal the approach of the long-predicted point where the world's population will increase faster than concomitant increases in food production. Immediate trends may be obscured, however, by sharp fluctuations in the supply of grain and other agricultural commodities resulting from variations in climatic conditions, as well as in the cost and availability of commercial fertilizer and other inputs. Nevertheless, the trend toward increased pressures on world food supplies appear inevitable.

In 1974, uncertainties over the food situation resulted in the organization of a World Food Conference in Rome to discuss projected shortages. Public debate of alternatives in the media publicized statements such as "If Americans would decrease the meat they eat by 10 percent, it would release enough grain to feed 60 million people." This and similar statements put the livestock industry in a position of assessing and defending its role in supplying food nutrients for humans. The grain-livestock issue is poorly understood by the media and the public. Rangelands, pastures, and forage croplands provide the major portion of feed for beef and sheep production in the U.S. Contrary to popular opinion, most beef and lamb are produced on forages which cannot be used by humans and might otherwise be wasted. During the 1972/73 crop year for example, some grain for finishing was fed to 97 percent of the steers and heifers slaughtered, but almost 75 percent of the total feed for beef cattle was provided by forages and range. At a slaughter weight of 1,050 pounds, a steer has received only three pounds of grain per pound of live weight gain; the remainder coming from roughage and forage. References to the 10 pounds of grain per pound of live weight gain, often cited and inserted into equations to incriminate livestock feeding, are grossly overstated.

Even though grain can be reduced further in cattle rations, the feed grains saved would consist of corn, grain sorghum, barley, and oats. Wheat and rice are the predominant cereal grains in human diets and insignificant amounts of these food grains are used for livestock feed. However, increased forage and decreased feed grain in livestock rations could free more of these grains for export. Ten-year projections by USDA show world consumption of feed grains growing more rapidly than food grains, and indicate increased imports of feed grains by developed countries.

The current disorder in world economics concerning food and energy has staggering implications. Population is growing rapidly, inflation is rampant, and food needs expand with population growth. Since the U.S. is the major food exporting nation, American agriculture plays a unique and important role in the world economy. Even under these conditions, U.S. farmers, especially livestock farmers, are subject to serious fluctuations in price-cost relationships.

It is evident that agricultural research must explore alternative food production systems so that adjustments can be made to economic realities and the market place. Research should be expanded on all major components of the food production system. Breakthroughs from new research as well as extension and adaptation of present knowledge should be the building blocks for developing efficient food production systems that can be integrated into changing economic situations.

The four regions of the U.S. have similarities as well as distinct differences in forage, range-livestock enterprises.

The Northeastern Region encompasses areas of intensive agriculture, major urban centers, and extensive forests and woodlands. More than one-quarter of the Nation's people live in the area. More than 25 percent of the 127.5 million acres of land is in farms, and animal agriculture is dominant. Of this farm acreage, 51.9 percent is committed to forage and pasture production. The forage-feed units derived from the hay, silage, green chop, and pastures in the region are valued at 724.8 million dollars annually. Improvements in quality and yield of forage plants would allow forages to supply a larger proportion of the total livestock ration. It is estimated that approximately 25 million acres of non-forested land in the Northeast are presently not contributing to the agricultural economy. Most of the livestock operations in the Northeast, particularly beef and sheep, are small in size compared with those in other regions. Although these operations are relatively small in size, they account for a large proportion of the presently productive land.

In 1976, the North Central Region maintained 17 million beef cows and replacement females. The importance of this regional contribution to the beef producing enterprise in the nation is particularly significant since the region comprises slightly more than one-third of the land mass of the country and contributes significantly to the national output of numerous other farm commodities. The 1976 calf crop in the North Central Region, including calves from dairy herds was in excess of 19 million head. The productivity of the region in terms of forage production is illustrated by the fact that beef cow numbers more than doubled between 1960 and 1976. In addition to the large beef cow enterprise, some 11 million head of fed cattle are marketed from the region annually. Recognition that approximately 75 percent of the feeds going into finished cattle are represented by roughages emphasizes the importance of forages in the total beef producing program of the region.

About three-fourths of the land area of the West produces range forage which represents wealth to local communities, to the States, and to the Nation when properly grazed by livestock and big game animals. Grazing of livestock, in spite of some views, is compatible with other land resource uses properly planned and administered. About 10 million beef cows and replacement females and 6.7 million stock sheep are found in the 17 Western States. These animals are maintained on range and forages from other sources. With the increased need to supply red meat for our increasing population, the farmlands and rangelands of the Western Region will become more and better integrated in their uses.

The number of cattle in the 13 Southern States has increased 61 percent or 6,954,000 cows since 1960, and the Southern Region now contains 45 percent of the total beef cow herd in the 48 contiguous States. Research has shown that many areas in the South have the capacity to produce large quantities of a variety of forage crops in support of these animals. However, these forages vary greatly in their concentration of digestible nutrients, and there are great differences in animal response to grazing on the species grown.

Land use in the future should be based upon either suitability or adaptability to specific uses and needs. The variety of demands placed on the same land is rapidly becoming a major problem in the allocation of land resources. Research must present factual information for land resource management that will counter emotional and irrelevant issues.

The evaluation of additional range-forage-livestock research needs includes those research problem areas identified under the CRIS (Current Research Information System) commodity codes of 0700 range, 1400 corn for silage only, 1900 pasture, and 2000 forage. In developing the national report, however, it became necessary to estimate the amount of forage related research in certain RPA's (Research Problem Areas) that are not classified under the commodity codes selected for consideration. These RPA's are as follows: 102 Soil, plant, water, nutrient relationships; 212 Control of internal parasites of livestock, poultry, and other animals; 213 Protect livestock, poultry, and other animals from toxic chemicals, poisonous plants, and other hazards; 310 Reproductive performance of livestock, poultry, and other animals; 311 Improvement of biological efficiency in production of livestock, poultry, and other animals; and 313 Production management systems for livestock, poultry, and other animals. (Appendix Tables 2, 3, 4, 5)

RESEARCHABLE PROBLEMS

A. Improving Grasses and Legumes for Range and Forage Use

Comment

Crested wheatgrass, coastal bermudagrass, tall fescue, and pest-resistant alfalfas are but a few examples of research contributions to the development of improved forage resources. Conversely, the use of many potentially valuable species is limited by the lack of persistence, susceptibility to pests, and inferior herbage quality. For example, the contribution of tall fescue to animal agriculture could be increased many-fold by new cultivars possessing superior nutritional quality, improved acceptability, and no evidence of toxicity to livestock. Also, there is the need to protect grasses and legumes from such threats as that posed by the newly discovered verticillium wilt of alfalfa.

1. Collect, evaluate, and maintain germplasm of range and forage species.

There is an urgent need to accelerate efforts to increase the diversity of germplasm available to plant breeders, and to intensify current work on the collection of new species and accessions for evaluation in range and forage plantings. The world's native grasslands represent a rich storehouse of potentially valuable species, many of which grow on sites similar to critical problem areas in the United States. Changing agricultural patterns in or near the centers of origin for many species are diminishing the natural germplasm reservoirs where new genes can be located. It is imperative that this valuable germplasm be collected, evaluated, and preserved while relatively undisturbed natural habitats are available for exploration. Major needs include (1) systematic exploration of natural habitats to assemble accessions for either immediate use or for incorporation in long-term breeding programs; (2) evaluating and characterizing all collections for adaptation and for their potential value in breeding programs; and (3) developing an effective system for the permanent preservation of germplasm with emphasis on accessibility of genes of importance in breeding programs.

Appropriate RPA's -- 112, 207, 208, and 307

2. Develop new approaches to improving range and forage species.

Species used for range and forage are characterized by unique reproductive systems, complex cytogenetic behavior, and small perfect flowers. Limitations to the application of conventional breeding methods may be imposed by one or all of the following: apomixis, cleistogamy, polyploidy, chromosome irregularity, lack of understanding of taxonomic relationships, and minute flowers that preclude mass emasculation and controlled hybridization. Intensive cytogenetic and cytotaxonomic investigations are essential to identify reproductive problems, establish relationships among species and genera, and develop more effective breeding techniques. New approaches are needed to capitalize on the potential advantages of heterosis in grass and legume cultivars. Male sterile and maintainer lines offer promise in the production of hybrid forage grasses and efforts to identify and isolate these stocks must be intensified. Although apomixis poses problems in grass breeding, it offers promise of fixing a high level of hybrid vigor in true breeding cultivars. Control and manipulation of obligate apomixis and the suppression of sexuality in facultative apomicts is of high priority. Similarly, information is needed on the potential value of interspecific and intergeneric hybridization, mutation breeding, haploidy, and the inheritance of important characteristics. New breeding methods are required for the development of improved cultivars that exhibit wide adaptation and high yields of herbage, and possess both a broad genetic base and minimal levels of genetic vulnerability. Major needs include (1) development of detailed cytogenetic information for important grasses and legumes; (2) clarification of taxonomic relationships and establishing the potential for progress through interspecific and intergeneric hybridization; (3) initiation or expansion of efforts to identify male sterile lines, isolate male sterility maintainers, and clarify self-incompatibility systems, as approaches to the development of superior hybrid cultivars; (4) clarification of the nature and genetic control of apomictic mechanisms to facilitate the manipulation of apomixis in fixing the genotype of F_1 hybrids and to transfer genes for mode of reproduction in intra- and interspecific hybrids; and (5) development of germplasm pools and evaluating genetic gain under various selection methods and progeny evaluation techniques.

Appropriate RPA's -- 112 and 307

3. Develop germplasm and cultivars with multiple pest resistance.

Diseases, insect pests, and nematodes reduce herbage yields and herbage quality in all growing areas. Pests damage new stands, contribute to the loss of leaves, and shorten the productive life of perennial species. Tolerance or resistance to pests achieved through breeding is important in the grasses and legumes because of the high cost to average benefit ratios for chemical pest control on extensively grown crops. Also, genetic

control is preferable to chemicals because of the possibility of residues entering the crop-animal-human food chain. A knowledge of the identification, biology, life history, and ecology of insect pests is essential to breeding for resistance and to establishment of alternative control practices. Similarly, knowledge of the taxonomy, ecology, genetics, physiology, and modes of pathogenesis of many pathogens is inadequate for either the development of sound breeding procedures or integrated control measures. Major needs include (1) identification of pests, establishing host range and studying physiology, genetics, and ecology; (2) assessing the extent of injury to forage and range plants from diseases, insect pests and nematodes; (3) developing effective techniques for screening germplasm for tolerance or resistance to specific pests; and (4) incorporating tolerance and resistance to major diseases, insect pests, and nematodes in plant populations characterized by a broad genetic base.

Appropriate RPA's -- 112, 207, 208, and 307

4. Develop germplasm and cultivars with improved herbage quality

Optimum use of forages in feeding systems will necessitate increased efforts to develop forages with high feeding value, as measured by improved intake and digestibility, higher energy content, and better mineral balance. Research on comparatively few species indicate that large gains in quality are possible. There is good expectation of developing grasses and legumes as well as forbs and shrubs better suited to intensive management regimes that result in high quality forage. Breeding improved legumes can increase persistence and their contribution to herbage mixtures, thereby improving quality through higher protein content and herbage intake. Since the improvement of quality in a particular forage represents a clear economic gain with little or no additional cost input, efforts to improve quality through breeding and management deserves high priority. Major needs include (1) developing rapid, reliable techniques for assessing forage quality; (2) identifying and evaluating chemical, anatomical, and morphological characteristics of forages that affect digestibility, animal intake, selective grazing, and nutrition; (3) determining the heritability of characters associated with quality, (4) combining quality factors with multiple pest resistance and increased yield in cultivars with genetic potential to produce optimum yields of digestible nutrients per unit of land; and (5) developing annual forage crops, specifically corn, forage sorghum and millets, for improved silage quality and for increased digestibility of stover.

Appropriate RPA's -- 112, 307, 405, 207, and 208

5. Develop germplasm and cultivars with low levels of anti-quality constituents.

The use of several herbage and browse plants that exhibit good adaptation and other desirable characteristics is limited because of poor utilization by livestock. Mineral deposits and various chemical constituents, such as alkaloids, phenols, glycosides, and tannins, contribute to reduced intake, and under certain conditions reach near-lethal or lethal levels in herbage. Breeding efforts to reduce levels of antiquality substances look promising, but information is lacking on the heritability of these factors and on alternative methods for substantially altering their presence in plant tissue. It appears certain, however, that the acceptance and value of less desirable species can be changed through research. Similarly, the elimination of bloat problems in desirable legume species, either through breeding or management, would constitute a major advance in forage utilization. Major needs include (1) the identification and clarification of the inheritance of specific constituents in forages that reduce intake and animal performance; and (2) the development of rapid, reliable screening techniques to eliminate or reduce antiquality constituents in improved germplasm and cultivars.

Appropriate RPA's -- 213, 307, and 405

6. Develop germplasm and cultivars to improve efficiency in the use of finite resources--commercial fertilizer, water, and land.

Total forage production is dependent on photosynthesis, translocation, nutrient uptake, and efficient water use. Greater knowledge of these and other growth processes is essential for the delineation of breeding objectives. Environmental concerns over the use of fertilizer and increased fertilizer costs due to energy requirements are important reasons for developing forages with high fertilizer use efficiency. It is obvious that the diversity of climate, soils, and animal production systems impose special requirements on herbage plants that cannot be met by relying on a limited number of species and cultivars. Major needs include (1) identification of physiological factors that limit the growth and yield of forage and range plants; (2) development of rapid, reliable screening and evaluation techniques for various components of biological efficiency; and (3) development of cultivars that make full use of the growing season by virtue of their growth patterns, rooting habit, efficiency of water and fertilizer use, as well as their tolerance to pest damage and environmental stress.

Appropriate RPA's -- 102, 112, and 307

7. Develop cultivars with improved seed yield potential.

Seed production of forage and range plants is uniquely different from cereal, fiber, and oil crops, in which seed is a by-product of crop production. Most forage crops are grown for their vegetative parts and are grazed or harvested prior to development of mature seed. Forage seed production is a separate operation with large quantities produced outside the intended area of usage. Most seed of cool-season grasses and legumes is produced by specialized seed growers in non-humid growing areas of the Western United States. In the Western Region, forage seed production competes directly with other crop alternatives that are increasing rapidly in value per unit area of land. Improved cultivars cannot be increased and reach potential users unless seed production is economically favorable. Major needs include (1) identification of factors that limit seed set and seed yield in forage and range plants; (2) development of screening and evaluation techniques and programs to isolate genotypes with high seed yield potential; and (3) development of cultivars and specific management practices for native and introduced species that will ensure optimum yields of high quality seed.

Appropriate RPA's -- 112, 307, 207, 208, and 209

8. Develop cultivars adapted for use in areas with severe resource limitations.

All regions of the country have extensive areas of agricultural land that are suited to the perennial grasses and legumes, but are restricted for economic production of grains or other intensively managed crops by climate, topography, or soil characteristics. In addition, the yield and persistence of forage and range plants may be restricted by a variety of stress factors on specific sites and over extensive areas. Principal limiting factors include drought, temperature extremes, aluminum and manganese toxicity in acid soils, soil salinity, inadequate drainage, and various pollutants. Under these circumstances, there is often a critical demand to meet the specific needs posed by wild game populations, conservation, reclamation, and enrichment of the environment. Major needs include (1) development of basic understanding of factors which contribute to susceptibility and tolerance to stress phenomena; (2) devising reliable techniques for isolating tolerant germplasm, and for determining the heritability of these characteristics; (3) intensification of breeding work where it has been clearly shown that cultivars can be developed with tolerance to aluminum and manganese toxicity, and other factors; and (4) screening germplasm resources and selections from intensive breeding programs for their potential value and contribution to soil

and water conservation, reclamation, use by wild game animals, and enchancement of the environment.

Appropriate RPA's -- 102, 112, and 307

B. Improving Management of Range and Forage Crops

Comment

Research on management practices has contributed significantly to increasing the reliability of establishment, to increasing herbage yields, persistence, and quality, and to furnish better guidelines for stocking rangelands and pastures. Major gains can be realized from research on extending the grazing season, on developing better approaches to renovating deteriorated grasslands, on integrating the use of grasslands and croplands, and on optimizing the production of animal products while ensuring the protection of soil and water resources.

1. Improve the productive capacity of soils utilized for forage production.

Forage crops are frequently produced on soils that have major limitations for the production of grain and fiber crops. There are, therefore, major research needs relating to the chemical and physical nature of interrelationships among soils, water, soil nutrients, soil and water conservation, and forage crop production. In many cases, production of feed for livestock in the form of perennial forage crops is the most efficient use of soils which are located in regions of limited precipitation, have limited water-holding capacity and are susceptible to erosion. A better understanding of interrelationships is essential to utilize these lands most efficiently and in a manner that is consistent with maintaining the soil resource base and protecting the environment. Major needs include (1) obtaining fundamental information which will improve root development and depth of rooting; (2) developing optimum fertilization programs utilizing animal, industrial, and municipal waste as sources of plant nutrients; (3) developing soil management systems to improve seedling establishment and maintenance; and (4) obtaining fundamental information relative to physical, chemical, and biological properties of soils as related to forage production.

Appropriate RPA's -- 102 and 307

2. Develop guidelines for improved utilization of pasture and range resources.

Forage production is subject to extreme fluctuations within and among years because the amount and seasonal distribution of precipitation is the primary determinant of production. This great variability in herbage production leads alternately to over and under utilization of the resource. The quantity and quality of forage determines livestock performance, proper stocking rate and seasons of use. Forage quality is most important in optimizing and integrating different forage resources (as between seeded and native, or among different sites) into seasonal patterns of grazing. With any single forage resource, management decisions must be based largely on the quantity of forage (the standing crop of forage species), because that quantity includes the source of herbage growth (photosynthetic tissue), provides sustenance for livestock, protects the soil, and nourishes soil microflora, which perform a vital role in nutrient cycling. When the standing crop is overgrazed, plant growth and persistence decrease, soils erode, and livestock performance deteriorates. These concepts are useful in management even though quantitative data are inadequate. Ultimate development of quantitative relations among forage conditions, stocking rates, and livestock performance require mathematical models of plant growth, forage consumptiom, herbage disappearance, and livestock performance. The extrapolation of results from research areas to typical extensive pasture and range conditions present additional problems, because over and under utilization occur simultaneously. Grazing is not distributed uniformly and is a very complex problem of species preference, site and habitat preference, topography, accessibility, weather, class or species of animal, and distance from water. Some of these factors are static and others are seasonally dynamic. The challenge is to define the biological relations and impacts in a useful and quantitative way. Major needs include (1) developing improved methods of measuring digestibility and intake of forage by grazing animals; (2) developing improved methods and equipment for measuring the standing crop of forage plants; (3) determining animal-forage relations through all seasons of the year on important range sites in each vegetation type; (4) developing mathematical models of plant growth, herbage disappearance, forage consumption, and animal performance; and (5) developing guidelines for determining the type(s) of operation (cow-calf, steer, all ages, mixed class) that provides greatest flexibility, consistent with economic stability, in adjusting for grazing stress brought about by fluctuating forage production from season to season and year to year.

Appropriate RPA's -- 112, 307, 311, and 313

3. Develop improved systems for the multiple use of range and forage resources.

The production of range and forage crops for livestock represents one alternative in the use of land and other resources. Population growth, advances in agricultural technology, changing domestic consumer demands, increased world demand for food and feed grains, increased recreational demands, and other factors result in altered demands upon the fixed supply of land available in the USA. These factors, along with increasing concern for protecting the soil resource base for food production require that major research consideration be given to the role of range-forage-livestock production in the joint goals of conserving natural resources and the optimum use of these resources in food production and for wildlife, watershed development and recreation. Improved knowledge of the potential for alternative uses of land resources will lead to multiple resource management and assignment of use based upon the greatest economic and social benefits. The effective use of grasslands will enhance the quality of the countryside for future generations. Major needs include (1) developing methods for an appropriate inventory of land resources for alternative uses; (2) determining the plant species which best meet the needs for multiple use of range, pasture and forage producing land; (3) evaluating alternative uses of land resources and their potential improvement and management for harmonious use by livestock, wildlife, and man, as well as for watershed production and recreation; and (4) evaluating the impact of multiple use on all associated resources.

Appropriate RPA's -- 102, 107, 110, 112, and 207

4. Develop improved management practices based on physiological characteristics of range and forage plants.

Forage crops have one or more growth cycles in every season of production. The triggering mechanisms for growth initiation and cessation in spring and in autumn, for vegetative and reproduction cycles and for regrowth after harvest are critical to forage growth patterns and potential production. Total forage production is crucially dependent upon functions such as photosynthesis, translocation, nutrient uptake, and efficient water utilization. Greater knowledge of how these systems operate would optimize the use of soil and climate resources through improved management. Major needs include (1) determination of optimum regrowth intervals between harvests; (2) best intensity of defoliation; (3) most effective time and rate of fertilizer application; and (4) integration of those practices

that favor maintenance of stands, high forage production, and superior quality of forage.

Appropriate RPA's -- 112 and 307

5. Develop improved revegetation practices to restore, protect, and enhance rangeland productivity.

Millions of acres of rangeland have been and are being disturbed or deteriorated by plowing, mining, building of roads, drought, and poor grazing management. After severe disturbances, annual plant species are first to colonize the site. Unfortunately, the natural succession of species is very slow, and may be prevented entirely by irreversible changes or losses of soil. For this reason, a most urgent research need is for the technology required to obtain prompt revegetation of disturbed areas for conservation of the soil resource and beef production. Technology must be based on knowledge of soils, climate, range sites, plant species adapted to those sites, mechanical and chemical methods of seedbed preparation, methods and seasons of seeding, methods of conserving soil moisture, seed and seedling characteristics and requirements, and management requirements after seeding. Major needs include (1) development of guidelines for identifying site potential to justify revegetation; (2) determining microenvironmental requirements for seed germination, seedling emergence, and seedling establishment of adapted species; (3) development of seed harvesting and quality testing procedures for plants used to revegetate rangelands; (4) development of methods and equipment for soil improvement, renovation, seedbed preparation, mulching, planting, interseeding, and sodding; and (5) development of systems to integrate seeded and native rangeland for the improvement of multiple-use benefits and obtain data for cost benefit analysis.

Appropriate RPA's -- 102, 107, 112, and 209

6. Improve establishment practices for grasses and legumes in humid regions.

Establishment of desirable forage species is a critical problem in much of the Nation. Stand failure is one of the greatest sources of economic loss. Development of dependable methods for establishing new stands will reduce production costs, provide for more efficient use of the land resource and result in a significant increase in the production of animal products. There is a need for better information on techniques of stand establishment, weed control in new stands, and equipment effective for seeding under diverse conditions. Major needs include (1) improving reliability of grass and legume seedling establishment by seedbed modification, innovative approaches to seed placement, and improved seed quality; (2) developing machinery for improved seeding

methods; (3) defining soil and microclimatic parameters affecting seedling germination and emergence with emphasis on modifying these variables; (4) determining the relationship between establishment and genotypic characters, such as seed size and ability to germinate at variable temperatures and soil moisture conditions; (5) improving the successful establishment of vegetatively propagated grasses; and (6) developing machines for the successful establishment of vegetatively propagated grasses on an economical, commercial scale.

Appropriate RPA's -- 102, 107, 209, and 307

7. Develop techniques for introducing perennial forage crops into existing stands.

Forage crops are ideally suited to lands that cannot or should not be tilled; but development of these lands has been limited by lack of equipment, cost of establishment, and low probability of success in establishing forage crops. Conventional methods of tillage and seeding are often expensive and cannot be used because of inaccessibility or erosion problems. Techniques for killing existing vegetation and equipment for establishing forages with minimum tillage have been developed. However, these techniques must be improved and adapted to a wider range of soil types and species. Major needs include (1) developing interseeding, equipment, and techniques; (2) identifying most successful species for interseeding; and developing appropriate weed and pest control practices to enhance establishment.

Appropriate RPA's -- 102, 107, 112, 207, 208, 209, 307, and 308

8. Develop systems to increase off-season forage production.

Cool-season perennial species are the primary forages used by grazing animals in many sections of the nation. Most of these undergo a reduction in growth rate during mid-summer which results in reduced animal gains and carrying capacity, and requires supplementation of permanent pastures with other sources of forage. Overgrazing and stand deterioration of desired species frequently results. Conversely, in regions that rely on warm-season perennial species, the length of the grazing season can be increased by the use of appropriate cool-season perennials and annuals. Major needs include (1) determining adaptation of warm- and cool-season forage species for incorporation into stable grazing production programs; and (2) development of systems to increase carrying capacity of grazing lands by increasing off-season forage supplies.

Appropriate RPA's -- 307, 308, and 309

9. Develop improved methods for using annual forages in livestock production.

Annual crops such as pearl millet, sudangrass, and small grain species can be used to optimize forage production efficiency in situations where acreage is limited. Where the availability of pasture is important, extended grazing is possible in areas that depend primarily on either warm- or cool-season species by using small grains to extend the grazing season for the warm-season perennials and pearl millet or sudangrass to supply summer grazing when cool-season species make little growth. Major needs include (1) evaluation of species, cultivars, costs, and management limitations; and (2) developing appropriate combinations for different areas and adapting them to the appropriate livestock production system.

Appropriate RPA's -- 112, 307, and 313

10. Develop harvesting, storing, and feeding systems to optimize feeding value and efficiency.

Maintenance of quality is a challenging problem. Losses of forage quantity and quality from harvesting to feeding have been reported as high as 25 percent. Top quality forage, as measured by content and availability of energy, protein and mineral constituents, is required for maximum production by ruminants. Many variables can affect these forage characteristics, such as fertilization, botanical composition, cultivar characteristics, stage of maturity, and processing and storage methods. The interrelationships among these variables are not well known. Major needs include (1) determining the interaction of chemical, biological, and mechanical processes in harvesting, handling, and storage and their effects on feed quality of silages; (2) determining the effects of chopping, crushing, and compression on the biological activity, type of fermentation, feeding value, and acceptability of silage; (3) developing improved methods for the rapid determination of forage dry matter content under field drying conditions for hay and wilted silage; (4) establishing standards for nutrition research, farm feeding programs, and related equipment design and manufacture based on the chemical and physical parameters of forages; and (5) developing alternative harvesting and feeding systems adapted to different ruminant species and herd size.

Appropriate RPA's -- 307, 308, 309, 313, 405, and 407

C. Reducing Limiting Factors in Range and Forage Production

Comment

Important advances have been made in weed and brush control and in reducing losses from plant pests, poisonous plants, and other limiting factors. However, progress has fallen far short of what is needed to ensure stability and to meet future requirements for livestock production. There is a particularly urgent need for research to capitalize fully on biological nitrogen fixation to increase yield and quality of the Nation's grasslands, to make forage production a reality on extensive areas characterized by severe site and soil limitations, and to reduce the tremendous losses associated with the harvesting and storage of forages.

1. Develop improved conservation and water use on rangelands

Rangeland watersheds are the source of much water stored in surface reservoirs and used for municipal, industrial, and irrigation purposes. Management decisions must be made both in terms of livestock and wildlife needs as well as off-site requirements. Livestock grazing systems may affect water yield and quality as well as forage production. Rangelands that have been overgrazed produce runoff water with heavy loads of suspended sediment that is detrimental to bulk water supplies for off-site use. Likewise, undesirable brush and weeds use water that otherwise would be available for increased forage production and off-site water needs. Major needs include (1) developing improved methods for increasing water intake and storage and reducing water loss; (2) determining the impact of livestock grazing systems on erosion, water yield, and quality; (3) determining the water requirement of various species under grazing in different climatic and soil situations; (4) determining effect of vegetation management practices and land treatments in optimizing water storage and/or water yield and quality consistent with optimum forage-red meat production; (5) determining the most effective way to utilize conserved water supplies in range forage production systems; and (6) developing mathematical models as a guide to improving the management of vegetation in relation to ground water recharge, streamflow, erosion, sedimentation, and water quality.

Appropriate PDA's -- 102, 107, 112, 209, and 308

2. Reduce losses in yield and feeding value of range and forage crops caused by disease, nematode, and insect pests.

Disease, nematode, and insect pests annually cause millions of dollars damage to forages in the United States. The reduced yield, lower quality, and shorter stand life caused by pests increases the costs of forage crop production and limits their use in livestock production. Available chemical control methods are often expensive and may pose hazards to the environment. Genetic resistance is the most desirable method of controlling most forage pests. When genetic resistance is not available, other forms of biological control or use of environmentally acceptable chemicals are preferable to indiscriminate spraying with numerous pesticides. Major needs include (1) providing more accurate assessments of disease and insect losses and development of innovative approaches to pest control; (2) devising control measures based on more complete knowledge of genetic resistance, biological control, harvest management, and chemical pesticides; and (3) developing sound integrated pest management systems for forage crops, especially for legumes and silage corn.

Appropriate RPA's -- 207 and 208

3. Reduce losses from weeds and other hazards in range and forage production.

Information on weed control, as well as control of brush, noxious plants and destructive rodents and pests in pastures and rangelands, has not kept pace with progress attained in cultivated crop production. Methods available for controlling many problem weeds on range are ineffective, inadequate, or not economical. Weed infestations pose a serious threat to stand establishment, reduce the productivity of land devoted to forage crops, and reduce the acceptability of herbage to livestock. Some weeds have value as forage, but most of them are considered inferior in quality to the forages they replace. Major needs include (1) developing more effective and less hazardous herbicides for forage crops with particular emphasis on establishment of new seedlings; (2) developing more effective and safer methods for herbicide application; (3) developing improved cultural practices for the establishment of new seedlings; (4) developing integrated control methods for eliminating weeds and brush in established stands; (5) determining the effects of different species of weeds and brush on herbage quality, intake, and animal performance, including potential toxic effects; (6) developing effective methods for the control of rodents damaging range and forage crops; and (7) obtaining information on impact of control measures on non-target species.

Appropriate RPA -- 209

4. Reduce losses from poisonous plants in range and forage production.

Each year, 3 to 5 percent of all cattle, sheep, and horses on range are killed from ingestion of poisonous plants. Additional losses, frequently overlooked, result from sublethal doses of plant toxins that retard or inhibit growth and production in livestock. In terms of red meat production, these losses represent an unmet demand for meat, a waste of forage, and less efficient production. Losses from livestock poisoning are largely eliminated when range is in good condition and livestock and range are properly managed. Most ranges are not in sufficiently good condition, or managed well enough, to eliminate the opportunity for livestock poisoning and until they are, the problem will continue to exist. Major needs include (1) determining the conditions (seasonal, climatic, grazing) under which poisonous plants are grazed; (2) characterizing the behavior of animals that influence grazing of poisonous plants; (3) determining the effects (abortion, scouring, loss in physiological efficiency) and measure losses (physical and economic) of sublethal doses of plant toxins on livestock; (4) developing grazing schemes and supplementation programs that will prevent plant poisoning in animals; (5) developing methods for the utilization of plants which are valuable forage species but potentially poisonous to livestock; and (6) developing more effective methods of diagnosing the danger and types of poisoning from plants and more effective treatments of poisoned animals.

Appropriate RPA -- 213

5. Increase forage production by the use of nitrogen fixing plants in range and forage production programs.

Relatively low priced nitrogen fertilizer, readily available selective herbicides, and ease of management of mono-cultures has led to an increase in nitrogen fertilized grass production. Research on grass-legume mixtures has received relatively little attention in recent years. Today, increasing costs of fertilizer, decreasing supplies of fossil fuels, and the increased demand for high quality forage to produce quality beef, has emphasized the need for research on grass-legumes mixtures. Nitrogen-fixation by legume symbiosis has always been important in production of forage and pasture crops under humid conditions, but there has been little emphasis on rangelands. Many species of leguminous shrubs exist on arid rangelands, but there is little evidence they function effectively in symbiotic nitrogen-fixation. Non-legume nitrogen fixing symbiosis has been known to occur under several shrubby genera common to rangelands. Only recently has the nitrogen-fixation potential among other genera and

their effectiveness been explored. Recent research has shown that appreciable nitrogen fixation occurs in the various tropical grasses and several dicotyledonous plants. These findings offer promise of explaining the variety specific occurrence on non-symbiotic rhizosphere organisms and stress conditions which limit their nitrogen fixing activities. Major needs include (1) determining the nitrogen fixing potential by symbiotic and non-symbiotic organisms in native and introduced species (legumes and non-legumes); (2) developing efficient methods for increasing the persistence of balanced legume-grass mixtures; (3) increasing the nitrogen fixing potential of legumes; and (4) determining the amount of nitrogen fixation tnat presently occurs in the rhizosphere and roots of different grasses, isolating efficient nitrogen fixing organisms, and developing practical means of enhancing nitrogen fixation in selected grass species.

Appropriate RAP's -- 102, 112, and 307

6. Develop systems to improve the efficiency of forage-livestock production on land not now effectively utilized because of soil and site limitations.

Substantial acreages of land in the United States are under-utilized for crop production because of site or soil limitations. Much of this acreage in the past has been cultivated, but limitations, such as poor soil drainage, droughtiness, soil erodibility, and low soil fertility led to removal from crop production. Some of these areas are utilized for grazing, hay production, or have reverted to brush and woodland. Other areas have been drastically disturbed by strip mining and need revegetation. Forage crops are likely plants for this revegetation. The grass sods are excellent for soil conservation. Current and future production systems of forage crops have to be economically sound and require extensive research inputs to develop improved methodology. New technology may require different cultivars, fertilizer and pesticide may be reduced, and minimum till seeding methods and less intensive harvesting methods may be necessary. Grazing of forage may be the most important consideration in developing a management system. Major needs include (1) evaluation of improved cultivars of perennial grasses and legumes for different soil and site situations; (2) development of systems of seeding and fertilization which require minimum energy inputs; (3) development of economically feasible control methods for weeds and brush; and (4) development of integrated management systems which produce adequate forage of suitable nutritive value throughout the year for grazing and confined feeding of livestock.

Appropriate RPA's -- 102, 112, 209, 307, and 313

7. Improve mechanization for harvesting, handling, and processing forage crops.

Mechanization research is needed to increase efficiency in the production of forage and pasture crops. An important consideration in the production of these feed materials is the requirement for timeliness in accomplishing certain operations from seeding through harvesting and handling of the harvested crop. Research objectives in this area relate to improved equipment which minimizes cost as well as possible hazards in harvesting and processing of forages, and for development of forage cultivars which have high adaptation to mechanized harvesting. Major needs include (1) development of improved equipment for harvesting and handling of forage crops and crop residues; (2) development of cultivars and cropping systems with improved adaptation to mechanization; and (3) development of methods which will increase efficiency in harvesting forages, reduce fuel (power) and labor, and maintain forage quality.

Appropriate RPA's -- 307, 308, and 405

8. Increase the efficiency of energy use in red meat production from range and forage.

Energy from fossil fuels is used in the production of forage for livestock on the farm as well as in the manufacture of products utilized in plant and animal production, such as fertilizers and pesticides. Mechanical power for forage harvesting, transport, handling, and feeding represent major expenses. Farm operations vary greatly from energy-intensive corn silage production to less intensive grazing management. Rangelands have no alternative use for food production except through grazing. They are an efficient means of converting solar energy to red meat and wise use of such lands will greatly enhance our capacity for food production in the future. Major needs include (1) determining total fossil fuel use and categorize the various energy use components, such as forage establishment, fertilization, pest management, weed control, harvesting, storage, feeding, care of livestock, and marketing of final product; (2) developing and testing systems of forage and livestock management to minimize fossil fuel input and maximize production; (3) developing alternative energy sources, such as conversion of plant biomass to fuel, to reduce fossil fuel use; (4) developing methods for the effective use of solar radiation in the field drying of hay and wilted silage and in farm drying of moist hay using unheated air; and (4) developing range and forage crop feeding programs that minimize inputs of fossil fuel.

Appropriate RPA's -- 112, 307, 308, and 309

D. Improving Management of Livestock on Range and Forage

Comment

Researchable problems with livestock include management systems for beef or sheep and for the two species in dual-use systems coordinated with efficient range, pasture and forage utilization. Selected areas of research that require new initiatives and increased emphasis to reduce costs and optimize production of red meat include: Integration of animal species, season of breeding, calving, weaning, and grazing with multiple range and pasture use; production of finished slaughter animals primarily from forage; and modeling total systems with input-output relationships.

1. Develop range livestock systems for red meat production.

Range management plans are not always compatible with maximum livestock production. On Federal ranges, the impetus for achieving optimum red meat production must be tempered by recognition of their multiple resource values. Within these natural and social constraints there are opportunities to improve livestock management and realize increased red meat production. The various tradeoffs in range and livestock production plans on public and private ranges must be evaluated to insure that livestock will still contribute to a maximum extent possible in meeting the demand for high quality food and still maintain a productive range resource. A combination of grazing animal species often yields a greater amount of usable product than a single animal type. Mature, pregnant, non-lactating animals have the lowest nutrient requirements of all classes of animals and greater use of the range by these animals would be expected. Livestock production patterns may need to be changed, including season of calving as well as season of use. Modification of use by various livestock classes may be initiated by early weaning of suckling animals which could greatly modify existing management plans and problems. The consequences of such actions may improve reproductive performance substantially. Major needs include (1) evaluating livestock production and range utilization with different seasons of use by range livestock; (2) determining the consequences of early weaning, combinations of grazing animals and related management systems on maintenance and reproduction by range livestock; (3) evaluating various grazing plans, i.e., rest rotation, deferred grazing, season of grazing, and integrated pasture and range

on livestock performance and range improvement; and (4) evaluating the competitive or complementary use of cattle, sheep, game, and equine species on range areas.

Appropriate RPA's -- 112, 310, 311, and 313

2. Develop beef-cow management systems to optimize range and forage use.

Nutrient content of forages vary with species, stage of maturity, season of the year, and geographic location. Also, nutrient requirements of a beef breeding herd vary with stage of production, i.e., dry cows, gestation, lactation, etc. Forage growth varies with season and total feed requirements vary with number and size of calves in the herd. Additional research is needed to most efficiently match herd requirements with quantity and quality of forage produced in various areas of the country. At what season of the year should breeding and subsequent calving occur? One of the highest requirement periods for nutrient content is during rebreeding of lactating cows. This is often attempted when quality of forage is declining. At what age and weight should calves be weaned? The greatest need for quantity of forage is just prior to weaning when the calves are large and rapid gains are desirable. Maximum, seasonal forage production often does not coincide with maximum herd needs. Beef cattle management systems should be developed to most effectively utilize the forage production systems best suited to different geographic areas. Major needs include (1) determining the season of breeding and subsequent calving which will best match herd needs with range and forage production in different regions; and (2) determining the age and weight of calf at weaning which will most effectively utilize available feed supplies by the total breeding herd.

Appropriate RPA's -- 112, 307, 313

3. Develop superior systems for finishing beef on pasture and range.

With the advent of large, commercial feed lots, fewer numbers of cattle have been finished on farms. A number of advantages can be cited for feeding cattle on pasture. Primary among these are facility costs and manure disposal. High quality forages provide protein and other nutrients which must be included in the diet of dry-lot fed cattle. To provide maximum gains and the most desired degree of finish in a reasonable time, supplemental energy in the form of feed grains is needed. This need varies with the quantity and quality of forage produced which varies with seasons. Self-feeding is the most efficient method of providing grain on pasture but, dependent upon relative costs,

some method of limiting grain intake may be desirable. Research has shown that this may be accomplished by incorporating salt, fat, and other materials in the grain mix. However, the amounts needed will vary with pasture conditions and some presently untried materials may be more effective. Further research is needed to fully develop this system of beef production to maximize forage and minimize feed grain utilization. Major needs include (1) identifying safe, inexpensive materials which will limit the consumption of grain when self-fed on pastures; and (2) developing pasture supplementation systems that will optimize red meat production and minimize production costs.

Appropriate RPA's -- 112, 307, and 313

4. Develop computer models for beef production systems.

Block beef suitable for steaks and roasts can be produced exclusively from roughages. However, to reach a desirable degree of finish without feed grains, beef cattle must be kept to ages more nearly approaching maturity. Feeding slaughter cattle from a given forage supply for extended periods markedly decreases the number of breeding animals which can be maintained and thus reduces total beef supplies. Feed grain supplies vary with weather conditions during the growing season and prices vary with supplies and export demand. Carcass beef prices of the various grades also vary with cattle numbers which tend to follow fairly definite cycles. Nutrient content of many forages and feed grains and nutrient requirements for maintenance and gain of cattle are known. This information, with anticipated cattle numbers and feed supplies, could be used to simulate those programs which would be the most profitable under a wide variety of conditions. Major needs include (1) developing an adequate data base for various regions and areas; and (2) developing models that integrate all inputs and outputs in order to improve the planning and management of forage-grain-livestock operations.

Appropriate RPA -- 313

5. Develop improved systems to produce young beef exclusively from range and forage.

One of the most feasible systems of producing beef without the use of feed grains may be through the production of fat, slaughter calves. Such a system will require a combination of cattle types, management systems and high quality forage production. Young animals are efficient converters of feed to beef when gaining rapidly. Maximum growth of large, suckling calves is dependent upon liberal milk production by their dams. Cow types capable of high milk production require ample amounts of high quality forage, especially if they are to breed

regularly. Calving season would need to be timed such that calves could make maximum use of high quality forage. Major needs include (1) developing forage production systems that reflect the nutrient requirements of livestock; and (2) developing the most appropriate combination of cattle dam and sire types and seasons of calving that will produce the most desirable grade of beef without the use of feed grains.

Appropriate RPA's -- 112, 212, 307, 310, 311, and 313

6. Develop forage-based feeding programs for the efficient production of beef from dairy calves.

Large numbers of dairy calves are produced annually which are excess to the requirements for herd replacements. Growing and finishing rations for these calves have contained high proportions of concentrates, and essentially no forages. From the standpoint of meat quality, grain-fed dairy calves result in higher carcass grades and are more predictable in performance than calves fed rations high in forage. Although a certain amount of grain will continue to be needed in rations with this class of livestock, efforts should be directed toward minimizing grain inputs. Major needs include (1) developing procedures for producing, harvesting, and processing high-quality forages to optimize nutritive intake and simultaneously decrease the amounts of grain and fed-milk required; and (2) developing improved feeding regimes to insure good carcass quality.

Appropriate RPA's -- 212, 307, 308, 309, 311, 313, and 405

7. Increase sheep production from range and forage to improve red meat supplies.

Sheep are notably efficient utilizers of range and forage plants. In total production systems, they have traditionally required smaller percentages of feed grains than any of the farm animals. However, sheep numbers and production have declined steadily for many years. All of the reasons for this decline are difficult to establish. A lack of specialized labor, predators, high fencing costs, and parasites are some of the factors most frequently mentioned. Major needs include (1) development of systems for partial or total confinement rearing; (2) development of improved mechanization for use in harvesting and feeding; (3) development of systems of production and genetic types best suited to these systems; and (4) development of improved methods for parasite and predator control.

Appropriate RPA's -- 212, 213, 308, 310, 311, and 313

8. Develop beef cattle and sheep production systems applicable to part-time farmers.

Due to low daily, routine labor requirements and minimal equipment investment, livestock programs based on forage utilization are well adapted to the small, part-time farmer. A very significant number of beef cattle and sheep are produced on such farms. Some of these may be classified as hobby farms; however, most owners are concerned with net income and all contribute to the food supply. Production inputs on these small farms may not be greatly different from larger commercial operations. However, timeliness of labor, machinery, and capital availability and other factors may not be compatible with maximum production. Major needs include (1) developing specialized equipment for harvesting, storing, and feeding forages for small herds and flocks; (2) determining levels of production that will optimize net income; and (3) developing appropriate forage production systems and coordinated livestock operations that will increase the efficiency and net income of part-time operators.

Appropriate RPA's -- 212, 307, 210, and 313

9. Determine the economic worth of alternative range-forage-livestock production adjustments.

Production adjustment research provides a basis for farm business management. Technical coefficients can be developed for prediction of farm and ranch organizational strategies and output-income results. By monitoring results from range, forage, and livestock research, models can be constructed. These economic models permit evaluation of crop production alternatives associated with fuel conservation, environmental impact, range, forage, and grain feeding systems, herbage quality, feed additives, and production and harvest systems. The results would be beneficial in indicating the effect of technological changes on farm output and net farm income. The models would be useful in measuring the impact of an intensified forage program on the competitive position of ranches and farms. Representative models would permit clear decision on value of forage substitution for concentrates, the aggregate supply and demand for feed grains and land use policy. Major needs include (1) developing price inputs for all major components of grassland-livestock enterprises; (2) developing price information for livestock sales alternatives; and (3) integrating input-output costs into models for evaluating coefficients and management alternatives for best profit.

Appropriate RPA's -- 112, 307, 313, and 509

E. Reducing Limiting Factors in Range and Forage Based Livestock Production Systems

Comment

Improving reproductive rate and genetic adaptability of forage-consuming animals; and controlling diseases, parasites, and predators of cattle and sheep would markedly increase red meat production from range and forage. Also, the efficiency of animal production would benefit in direct proportion to research advances in developing rapid, accurate, in-field measures of forage quality, and improving digestibility of forages, especially those of low quality, such as grain crop residues.

1. Develop field methods for rapidly determining the feeding value of range and forage plants.

Research on the improvement of the nutritional quality of forage crops has been hampered by laborious, expensive, and imprecise methods of evaluation. There is a pressing need for a method, or combination of methods, that is comparable in accuracy to using the live animal to determine the feeding value of range and forage crops, grown alone and in mixtures, and subjected to various management, harvesting, and storage practices. A rapid field test is needed to aid in making managerial decisions that could mean the difference between profit or loss. Major needs include (1) developing physical, chemical, and microbiological methods that closely parallel the performance of animals in feeding trials; and (2) devising a rapid, reliable test or combination of tests that can be used to measure forage quality under field conditions.

Appropriate RPA's -- 112, 307, and 405

2. Improve feeding value of low quality forages.

Large tonnages of crop residues, waste products, late cut hay, and other high fiber materials are produced annually. Because of their low digestibility, they must be limited to a small percentage of the total diet or used primarily for animal maintenance. These sources of feed energy have long been recognized and research has been conducted in an effort to improve their feeding value. Practices such as ensiling, fine grinding and pelleting have been found to increase animal performance. Similarly, treatments with alkalis, moisture, and pressure may

increase digestibility. A tremendous potential exists for increasing human food through livestock systems based in part on low quality forages. Major needs include (1) development of improved equipment and systems for collecting and storing low quality forages; and (2) development of inexpensive treatments that can be applied to large volumes of material to increase both intake and animal performance.

Appropriate RPA's -- 308, 311, and 407

3. Determine the relationship of mineral status in range and forage plants to animal performance.

A frequent cause of "unexplained" deaths of ruminants receiving high-forage rations is related to mineral deficiencies and imbalances. An unknown number of animals produce at less than their genetic potential because of borderline levels of certain essential nutrients. These and related problems, particularly those involving mineral nutrition, are not restricted to low- or moderate-producing animals but tend to be more frequently observed in higher-producing herds. Forage management practices, cultivars with multiple pest resistance, and cultivars adapted to problem soils may result in changes in plant constituents. Major needs include (1) determining the nutrient-supplying characteristics of the soil; (2) determining the processes and genetics of uptake and translocation of minerals in plants; (3) determining the compositional requirements of different classes of livestock; (4) determining the interrelationship of different minerals in the animal's feed and within the animal, and their possible effects on health, reproductive efficiency, growth rate, and production level; and (5) determining the effectiveness of different methods of direct mineral supplementation.

Appropriate RPA's -- 102, 112, 307, and 311

4. Control parasites and animal diseases associated with forage utilization.

A wide array of animal diseases and parasites reduce food production and livestock income. Prevention and control of those associated with ruminants would markedly increase returns from pasture and forages. Improved forages, fertilization, and adequate rainfall or irrigation water all produce pastures with high carrying capacity. High animal density may lead to increased parasite infestation. Grazing systems should be developed to minimize parasitic problems which may be associated with the maximum use of pastured forages. Bloat and grass tetany are specific maladies most commonly encountered with productive pastures. Many diseases are not specifically associated with forage utilization; however, any that reduce performance reduce human food production. Death losses are the most obvious but chronic diseases can be more costly. Major needs include

(1) developing improved parasite detection, prevention, and control methods to increase returns from pasture and forage; and (2) developing cultivars, management practices, and improved treatments to reduce losses from bloat and grass tetany.

Appropriate RPA's -- 102, 212, 213, 307, and 311

5. Increase the utilization of range and forage plants by enhancing the efficiency of rumen organisms.

The ability of ruminant animals to digest cellulosic and other complex constituents is well known. This digestion is dependent upon the microbial population in the rumen. The contribution of microbial populations is not only in digestion but also in the synthesis of vitamins and microbial protein that can be used by the host animal. The makeup of the rumen microbial flora is extremely complex and variable, and includes a multitude of different bacterial and protozoal species which vary with the type and quality of the diet fed to host animals. Numerous species have been isolated and their nutrient requirements and end products of fermentation identified. Major needs include (1) determining the effect of the total microbial population on the rate of digestion and passage, and thus, on the rate of forage intake by the host animal; and (2) determining the interrelationships which exist among forage types, forage quality, and optimum rumen fermentation.

Appropriate RPA -- 307, 311, and 405

6. Improve reproductive efficiency of beef cattle and sheep.

The most rapid increase in net efficiency of beef and sheep production could be achieved through improvements in reproductive performance. The average annual calf crop is about 80 percent. At this rate, well over two-thirds of the total feed energy consumed by beef cattle is required by breeding herds. Breeding herds are maintained largely on forages, hence, any small increase in beef cow reproduction would markedly improve net efficiency and forage utilization. Major needs include (1) determination of factors that influence ovulation, conception, and embryo survival; (2) development of improved methods of estrus control to simplify artificial insemination under pasture and range conditions; and (3) development through breeding or other procedures sharp reductions in dystocia and death losses at calving.

Appropriate RPA -- 310

7. Increase total beef production by early marketing of non-breeders.

A high proportion of total range forage production is presently utilized to maintain mature, beef-breeding females. Once a cow is mature, all she can produce is a calf. However, replacement heifers can be grown on good quality herbage and will reproduce prior to maturity. Until maturity is reached, heifers will produce cow beef as well as a calf. A number of large fast-service food chains have developed a strong demand for this grade of beef. More effort should be expanded in producing such beef rather than merely considering it as a by-product of feeder-calf production. Due to the high, nonproductive, feed requirements for maintenance, any mature cow which is neither carrying and/or nursing a calf should be marketed for beef. Major needs include (1) determining the physiology and nutrient requirements of heifers that will contribute to reducing the age of first breeding; (2) developing practical methods for early diagnosis of pregnancy; and (3) developing forage production systems that will provide high quality feed for heifers bred before maturity.

Appropriate RPA's -- 112, 307, 310, 507, and 509

8. Develop beef cattle breeding and selection procedures to optimize range and forage use.

In recent years, beef cattle selection procedures have placed much emphasis upon rate of gain. This has led to larger type animals and the introduction of many new breeds which are presently used for beef production. These and older types, including a number of dairy breeds, provide a broad genetic base from which specific selections may be made. The many breed types available are known to vary, not only in mature size and rate of gain but also in rate of maturing or ease of finishing. Preliminary data suggest that there are differences among types in feed consumption per unit of body weight, and hence interactions may exist among cattle types and available feed supplies or management systems. These differences have been more intensively studied post-weaning and primarily under feed-lot conditions. Major needs include (1) breeding cattle types best adapted to the utilization of forages; (2) developing cross-breeding systems which use these types and include the advantages of heterosis; and (3) developing production systems which will most effectively combine cattle types and breeding systems with range and forage production.

Appropriate RPA's -- 112, 307, 310, and 311

9. Reduce livestock losses from predators.

There is no doubt that the explosion of predator populations constitutes a most important constraint on livestock production on

ranges. In 1974, an estimated 1.2 million sheep and lambs were killed by predators. The problem is becoming more serious and being extended to cattle with the recent suspension by government of the more effective control procedures. If predator populations continue to increase, they will almost certainly reduce populations of wild animals constituting their "natural" food supply and turn increasingly to livestock. A major need is to develop innovative approaches to reducing the populations of important predator species.

Appropriate RPA -- 213

10. Determine market quality, acceptability and value of meat from animals finished on different combinations of forages and concentrates.

Emphasis on energy conservation and on world food supplies will cause ruminants, used for meat, to be fed rations higher in forage and fewer will reach the choice grade. This lower grading meat is commonly believed to be drier, less tender, and less flavorful. The low fat content of meat may also present problems with packaging and shelf life. Major needs include (1) developing methods to improve postmortem tenderness, shelf life, nutritional composition (protein, lipid, mineral, and vitamin), consumer acceptance and palatability of beef produced under different forage-concentrate feeding systems; (2) improving meat animal products through research on processing and meat cookery; and (3) developing better packaging and distribution systems to maintain acceptable quality of meat animal products.

Appropriate RPA's -- 503 and 507

11. Develop methods of waste handling and utilization for forage-livestock production systems.

Agricultural wastes have value as sources of plant and animal nutrients and are potential soil, water, and air pollutants. The nitrogen content of animal manures is approximately two-thirds that of the fertilizer nitrogen used in the United States. However, nearly one-half of this is lost before it can be used for crop production. Forage crops are among the most efficient in utilizing nitrogen in that up to 70 percent of applied nitrogen is removed by the crop. In the United States, domestic animals produce over one billion tons of fecal waste annually. Other waste products, such as whey and other by-products of the human food industry, which contribute to air and water pollution, require in-depth studies as to their potential as animal feeds and sources of plant nutrients. In addition to agricultural waste materials, attention is also being focused on using agricultural land to recycle several types of municipal and industrial wastes. Such disposal and

recycling methods must be monitored carefully to safeguard the environment and assure that plant and animal products produced from waste recycling are safe and wholesome for consumption by man and animals. Major needs include (1) utilization of animal wastes and other processing by-products as fertilizer and as a means of disposal in forage production systems; (2) measuring the value of the manures from alternative disposal systems since nutrient recovery may vary among systems; (3) determining the value and possible deleterious effects of municipal and industrial wastes on forage fed to livestock; and (4) determining the value of other agricultural wastes, such as those from food processing and plant residues, as either soil amendments or livestock feed.

Appropriate RPA's -- 102, 214, and 313

RECOMMENDATIONS

Scientist year projections for range-forage-livestock research have been summarized on a national basis (Summary Table). A 10 percent increase in SY's is shown for 1980, with recommended scientist year allocations for 1985 given at a level judged to provide near optimum effectiveness of the research effort. Researchable problems could not be assigned a national priority except for the need to provide adequate funding for existing range-forage-livestock research programs. This is because a significant problem in one region may be of little consequence in another.

Specific recommendations for research effort in the various RPA's are included in each of the four regional reports. Recommendations highlighting priority research needs are as follows:

(1) There is a critical need to provide more adequate funding for maintaining the effectiveness of current range-forage-livestock research programs. Range and forage technology is estimated to be as much as 25 years behind that of cereal crops because of inadequate funding. This deficiency in technology is, by itself, strong justification to increase funding in order to optimize all facets of agricultural production.

(2) Collect, evaluate, utilize, and maintain germplasm of grasses, legumes, forbs, and shrubs for current and future use in improving range and forage resources.

(3) Develop through genetic and physiological research new cultivars of grasses, legumes, forbs, and shrubs high in protein, digestibility, palatability and intake, having multiple resistance to insects, diseases, and nematodes, more tolerance to stress conditions, greater persistence, freedom from problem constituents, greater compatibility in forage mixtures, and improved biological efficiency and yield.

(4) Develop integrated pest management systems for optimum use of resistant cultivars and new and improved methods for chemical, cultural, and biological control of weeds, insects, diseases, nematodes, and rodents infesting range and forages.

(5) Develop improved energy-conserving methods for seeding, producing, harvesting, storing, modifying, transporting, and feeding of forages that reduce costs, preserve nutritional quality, improve efficiency, and provide more uniformity in quality and quantity throughout the year.

(6) Develop improved livestock grazing management programs and improved forage production practices, including tillage and seeding methods, fertilization, renovation, cropping systems, water conservation and erosion control, pest control, cutting frequency and intensity, irrigation regimes, maintenance of pure stands or a proper balance of grasses, legumes, forbs, and shrubs, and the introduction of improved cultivars into existing stands.

(7) Determine potentials of symbiotic and nonsymbiotic nitrogen-fixing microorganisms associated with grasses and legumes.

(8) Increase human food production from range and forage through improved efficiencies of beef cattle and sheep in reproductive performance, selective breeding, management systems, disease and parasite control, and by increasing intake, digestibility, and utilization of range and pasture, harvested forages and crop residues.

(9) Provide information on the interaction and integration of forage production and animal management systems to improve reproductive efficiency and productivity of forage sources and animals. Integrate all facets of research and producer experience dealing with forages and livestock into systems that provide maximum return on investment.

APPENDIX

Appendix Table 1

Summary of 1967, 1975, and Future Recommended Allocation of Scientist Year (SY's) to Range and Forage Research by Research Problem Areas (RPA's)

Research Problem Area		Recommended			
No.	Name	1967	1975	1980	1985
102 1/	Soil, Plant, Water, Nutrient Relationships	22.0	19.2	21.2	32
107	Watershed Protection and Management	*	2.0	3.0	4
110	Appraisal of Forest and Range Resources	6.0	5.4	5.4	8
112	Improvement of Range Resources	189.4	92.0	103.0	125
203	Prevention and Control of Forest & Range Fires	*	1.8	1.8	3
207 2/	Control of Insects Affecting Field Crops & Range	50.7	59.1	65.1	75
208 2/	Control of Diseases of Field Crops and Range	35.7	38.9	41.9	50
209 2/	Control of Weeds of Field Crops and Range	16.4	33.0	37.0	50
212 3/	Control of Internal Parasites of Livestock	41.2	23.7	24.7	29
213 4/	Protect Livestock from Toxic Chemicals, Poisonous Plants, and Other Hazards	6.3	14.4	15.4	17
214	Protection of Plants and Animals from Pollution	0.4	1.5	1.5	3
307 2/	Improve Biological Efficiency of Field Crops	249.2	204.3	218.3	260
308 2/	Mechanization of Production of Field Crops	16.1	10.9	12.9	20
309 2/	Production Management Systems for Field Crops	2.8	12.0	13.0	15
310 5/	Reproductive Performance of Livestock	24.6	41.6	45.6	55
311 6/	Improve Biological Efficiency of Livestock	26.1	27.3	30.3	35
313 6/	Production Management Systems for Livestock	9.1	4.9	11.9	22
405	Production of Field Crops with Improved Acceptability	2.9	15.3	16.3	20
407	New and Improved Products from Field Crops	11.3	19.2	20.2	22
408, 501, 503, 506, 507 509, 604, 701, 702 708, 808, 901, 903	Other Range and Forage Related	13.8	12.5	14.5	18
	Totals	674.0	639.0	703.0	863.0

1/ 10 percent of total research estimated to be range and forage related.
2/ 10 percent of research conducted on corn included in these RPA's as an estimate of corn used for silage.
3/ 100 percent of beef and sheep research included.
4/ 50 percnet of beef and sheep research included.
5/ 50 percent of beef and sheep and 10 percent of dairy cattle research included.
6/ 10 percent of beef, sheep, and dairy cattle research included as an estimate of that related to range and forage for meat production.
* Not available.

Appendix Table 2

Research Effort (SY) 1975

0700 - Range (SAES includes Forestry Schools)

RPA	NE			NC			S			W			TOTAL		
	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL
107. Watershed										.3	1.7	2.0	.3	1.7	2.0
110. Appraisal				.2		.2	.7		.7	2.9	1.5	4.4	3.9	1.5	5.4
112. Improve				5.7	5.4	11.1	11.7		11.7	26.1	43.2	69.3	43.4	48.6	92.0
203. Fire									.1	.3	1.5	1.8	.3	1.5	1.8
207. Pests	.4		.4	1.3		1.3	.1			4.9	4.3	9.2	6.7	4.3	11.0
208. Diseases				.5	.4	.9					.4	.4	.5	.9	1.4
209. Weeds					.2	.2	.8		.8	2.6	9.6	2.6	3.4	10.4	13.7 1/
903. Multi-use	.1		.1							.4	.3	.7	.5	.3	.8
Totals	.5		.5	7.7	6.0	13.7	13.3		13.3	37.5	52.9	90.4	59.0	69.2	128.1

1/ USDA total includes .5 foreign

Appendix Table 3
Research Effort (SY) 1975

1900 - Pasture (NE includes District of Columbia)

RPA	NE			NC			S			W			TOTAL		
	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL
207. Pests	.1		.1	.2		.2	1.4	.3	1.7	.2		.2	1.8	.3	2.0
208. Diseases				.2		.2	2.1		2.1	.1		.1	2.4		2.4
209. Weeds		1.0	1.0	.1	2.4	2.5	1.9	1.4	3.3	.3		.3	2.4	5.3	7.6 1/
307. Biological Effic.	.7		.7	7.3	1.1	8.4	22.2	.4	22.6	5.0	.1	5.1	35.3	1.6	36.9
308. Mechanization		.3	.3								.3	.3		.6	.6
309. Management				.4		.4	2.9	.2	3.1	.1		.1	3.4	.2	3.6
405. Impr. Accept.		.2	.2				.1		.1	.1		.1	.2	.2	.4
407. New & Impr. Non-Food	.1		.1	.1		.1							.2		.2
506. Supply and Demand		.2	.2											.2	.2
808. Government Programs				.1		.1							.1		.1
Total	.9	1.7	2.6	8.4	3.5	11.9	30.6	2.3	32.9	5.8	.4	6.2	45.8	8.4	54.2

1/ USDA total includes .5 foreign

Appendix Table 4

Research Effort (SY) 1975

2000 Forage Crops (NE includes District of Columbia)

	RPA	NE			NC			S			W			TOTAL			
		SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	SAES	USDA	TOTAL	
207.	Pests	3.4	3.6	7.0	11.0	2.7	13.7	4.3	3.9	8.2	11.3	.8	12.1	30.0	10.8	40.8	
208.	Diseases	2.7	5.0	7.7	4.9	1.9	6.8	6.1	3.4	9.5	4.5	2.3	6.8	18.2	12.5	30.6	
209.	Weeds	1.2	1.4	2.6	1.9	.3	2.2	1.8	1.0	2.8	2.2	1.4	3.6	7.1	4.1	11.2	
214.	Pollution	.6			.3			.4			.3			1.5		1.5	
307.	Biological Efficiency	14.8	7.6	22.4	27.6	7.3	34.9	54.4	11.8	66.2	25.3	9.8	35.1	122.1	37.9	160.0	1/
308.	Mechanization	1.4	.3	1.7	2.6		2.6	.5	2.3	2.8	1.2	1.7	2.9	5.6	4.2	9.8	
309.	Management	.9		.9	2.7		2.7	2.6	.2	2.8	.6	1.0	1.6	6.7	1.2	7.9	
405.	Impr. Accept.		.4	.4	3.8	1.0	4.8	5.4	1.1	6.5	2.6	.6	3.2	11.8	3.1	14.9	
406.	New and Impr. Food							.1		.1		2.3	2.3	.1	2.3	2.4	
407.	New & Impr. Non-Fed.	.2		.2	.8		.8	.6	7.2	7.8		10.2	10.2	1.6	17.4	19.0	
408.	Mkt. Qual.	1.1		1.1	.2		.2							1.4		1.4	
501.	Grades & Std.					.1	.1				.1		.1	.1	.1	.2	
503.	Marketing Efficiency										.3		.3	.3		.3	
506.	Supply and Demand		1.1	1.1		.3	.3				.3		.3	.3	1.4	1.7	
507.	Compet. Relation					.6	.6				.1		.1	.1	.6	.7	
509.	Perf.Mkt.Sys.					.5	.5								.5	.5	
604.	Foreign Mkt.											.8	.8		.8	.8	
701.	Toxic Residues	.6		.6	.1		.1	.2	.1	.3	1.5		1.5	2.4	.1	2.5	
702.	Prot.Toxins					.2	.2	.3		.3	.3		.3	.5	.2	.7	
708.	Human Nutr.							.5		.5				.5		.5	
901.	Pollution				.3		.3	.5	.1	.6	.3	.9	1.2	1.1	1.0	2.1	
	Totals	26.9	19.4	45.7	56.2	14.9	70,7	77.7	31.1	108.4	50.9	31.8	82.4	211.5	98.2	309.7	

1/ USDA total includes 1.4 foreign

Appendix Table 5

Additional RPA's Considered in Report

Research Effort (51)1975

RPA		NE		NC		S		W		TOTAL		
		SAES	USDA	SAES	USDA	SAES	USDA	SAES	USDA	SAES	USDA	TOTAL
102	Soil	12.7	16.8	37.6	10.1	50.0	12.7	33.4	18.9	133.8	58.3	192.1
212	Livestock Parasit.											
	Beef	0	6.0	0.8	0	4.6	3.3	1.9	0	7.4	9.3	16.7
	Sheep	.2	3.8	0.7	0	1.2	0	1.2	0	3.2	3.8	7.0
213	Protect Livestock											
	Beef	0	0.2	0.4	3.5	3.5	6.0	1.5	2.0	5.3	11.7	17.0
	Sheep	0	1.6	0.2	0.4	0.8	1.5	1.5	5.9	2.5	9.3	11.8
310	Reproduction											
	Beef	1.4	0.9	4.9	1.9	23.6	1.9	14.1	2.7	44.0	7.5	51.4
	Sheep	1.0	2.0	4.0	1.8	4.1	0	9.1	1.5	18.2	5.3	23.5
	Dairy	4.4	5.7	9.5	0	14.6	0	7.8	0	36.4	5.7	42.1
311	Biol. Eff.											
	Beef	4.4	5.1	43.4	5.0	62.9	3.5	30.6	2.6	141.3	16.3	157.6
	Sheep	2.6	0.6	9.1	1.7	8.1	0	6.5	1.5	26.2	3.8	30.0
	Dairy	18.5	13.0	3.3	0.1	35.2	2.2	11.5	2.0	68.5	17.3	85.80
313	Manag. Systems											
	Beef	0.2	0.0	4.4	0.7	16.1	0	5.8	0.3	26.5	1.0	27.5
	Sheep	0	0	2.4	0.1	1.8	0	2.0	0.1	6.1	0.2	6.3
	Dairy	4.1	0.8	4.4	0	5.9	0	0.4	0	14.8	0.8	15.6
	Totals	49.5	56.5	125.1	25.3	232.4	31.1	127.3	37.5	534.2	150.3	684.5

* U.S. GOVERNMENT PRINTING OFFICE : 1977 0-241-461/SEC-54