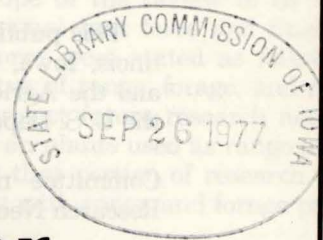


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Range and Forage Research Needs for Red Meat Production in the North Central Region

Edited by S. A. Ewing and Herman J. Gorz

**Agricultural Experiment Stations of
Alaska, Illinois, Indiana,
Iowa, Kansas,
Michigan, Minnesota, Missouri, Nebraska,
North Dakota, Ohio, South Dakota, and
Wisconsin, and
the U. S. Department of
Agriculture cooperating.**

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Ames, Iowa
June 1977

FOREWORD

The North Central ad hoc task force reporting herein was established under authorization by the National Planning Committee (NPC) as a part of a national effort to review range and forage research needs for red meat production. The directive issued by NPC Cochairmen Robert W. Long and Orville G. Bentley established the National Task Force on Range and Forage Research Needs for Red Meat Production, which was to be made up of cochairpersons representing four regional task forces for the Northeast, North Central, Southern, and Western regions. The national task force was to be cochaired by appointments from the U. S. Department of Agriculture (USDA) and state agricultural experiment stations (SAES). Correspondingly, the regional task forces were to be cochaired by appointments from USDA and the SAES.

The North Central Task Force was appointed by Richard R. Davis and Kenneth Farrell, Cochairmen of the North Central Research Planning Committee, with advice and approval of USDA and SAES ad-

ministrators within the region. Representation on the task force included appointments from USDA and SAES in accordance with guidelines of the North Central Research Planning Committee.

The purpose and scope of the review to be accomplished by each regional task force and finally by the national task force were stated as follows: Review the current status of range, forage, and red meat production, and project future research needs in terms of all research on plants used as range and forage by livestock and that portion of research on red meat that interfaces with range and forage production.

The report provided results from the North Central Task Force response to this charge and includes recommendations as to areas of major research emphasis within the Research Problem Areas (RPA's) considered as germane to the review and recommendations as to increases in Science Year effort that should be allocated to each RPA at two levels of increased funding.

R. R. Davis
Administrative Advisor

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SUMMARY

1. The North Central Region encompasses some of the most productive forage land in the world. This is represented by 33 million acres of cropland used for rotation pastures, 95 million acres of grassland pasture and range, and 19 million acres of forest land used for pasture and range. These acreages represent more than 16 percent of all land devoted to such uses in the United States. Present indications are that these lands have a productive potential ranging from two to five times that presently experienced. Within the region, there are massive quantities of forage materials that can be gained through more complete usage of grain crop residues such as corn and sorghum stalks.

The North Central Region also encompasses a very large livestock resource heavily based on forage production. The region maintains 41 percent of the nation's cattle and calves and 34 percent of the beef cows, and it produces 39 percent of the total calf crop from beef and dairy herds.

Great potential exists within the region to provide relatively higher amounts of forage feeds in the diets of cattle and sheep, thereby conserving grain resources for other uses if it is economically feasible to do so. This can be attained through the development of new technology that will provide greater productivity of lands devoted to forage crops, improved forage quality, greater use of corn and

sorghum silage, and expanded recovery of grain crop residues.

2. The dollar value of forages, expressed in terms of their contribution to human food of animal origin, exceeds the value of any other crop. Forage technology, however, is many years behind that of most grain crops because of a lack of adequate funding for forage research, perhaps because most forages are considered to have low economic value as a cash crop since their true value is not realized until marketed through livestock. Forage research is complex, time consuming, and expensive. Most past research has focused on component parts of the forage-livestock system, but future efforts will require a much greater emphasis on an interdisciplinary approach.

3. High priority should be given to more adequate funding of existing forage-livestock research programs to achieve maximum effectiveness of current scientific personnel. Present Science Year allocations to the Research Problem Areas considered in this report total 329.3. The committee recommends an expansion of this number to 364.3 by 1980, and to 550.3 by 1985. In addition to an expansion of scientific personnel, the committee recommends that greater emphasis be placed on research dealing with integrated forage-livestock systems.

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Range and Forage Research Needs for Red Meat Production in the North Central Region¹

Edited by S. A. Ewing and Herman J. Gorz

Geography, Climate, and Soils of the North Central Region

The 12 contiguous states of the North Central Region constitute one of the most productive agricultural areas in the world. Before the region was settled, vegetation consisted primarily of forest in the east, grasses in the west, and an intermingling of grass and forest in the central portions. Although the region contains a high proportion of productive soils, there are great differences within the region in soils, as well as in climate, vegetation, and geology. The short-grass soils in the western areas are higher in pH, lighter in color, and thinner than the tall-grass soils in the central and west-central areas, which have thick, dark surface horizons. The more strongly leached soils of the eastern humid forested areas are more acid and have thin, dark surface (A) horizons and light-colored subsurface horizons, which are mixed when cultivated. Approximately 75% of all soils in the region is derived from glacial till and loess. A large proportion of the deposits of glacial origin was derived locally from underlying bedrock or from material laid down during previous glaciations. Most of these deposits range from a few to tens of feet thick, but occasionally are several hundred feet thick. Loess deposits deeper than 4 feet cover large areas of Illinois, Iowa, Missouri, Kansas, and Nebraska. There also are extensive areas where shallow loess deposits cover the land surface.

Large areas of nearly level to gently rolling plains are a dominant characteristic of the topography of the North Central Region. From central Ohio to the Black Hills in South Dakota and from Kansas to the Canadian border, this smooth relief is interrupted only occasionally by strips or relatively small areas of land with steeper slopes.

Cold to warm temperate, semiarid to humid continental climates characterize the North Central Region. A greater proportion of the rainfall occurs during the spring and summer seasons, particularly in western parts of the region, with much smaller seasonal differences in the east and southeast. The

western part of the region, where precipitation averages 15 to 20 inches or less, is considerably drier than the eastern part and is classed as semiarid or subhumid. Precipitation increases to the east and southeast and attains annual average values of 45 inches or more along the southeastern border. The climate of the central and eastern parts of the region is humid. The western and central parts, and especially the southwestern portion, have a drier atmosphere and are subject to higher potential losses of moisture into the atmosphere than the rest of the region.

Along the northern border of the region, the climate is cold. Here, the annual temperature averages below 40°F, and the average frost-free period is less than 120 days. Both the average temperature and length of frost-free period increase in a southerly direction, with values of 55°F and 200 days being common along the southern border. The frost-free period along the Great Lakes borders, particularly to the leeward, is somewhat longer than for the adjoining inland areas owing to the ameliorating effect of these large bodies of fresh water on air temperatures. Wide differences between winter and summer temperatures are common to the region. These differences are especially pronounced in the northernmost part of the region and tend to decrease in a southerly direction. The prevalence of low winter temperatures in the northern part of the region results in much greater frost penetration than in the southern part. Soil temperatures average appreciably lower in the northern part of the region.

Land, Crop, and Ruminant Animal Resources in the North Central Region

Land and Crop Resources—The land resource in the North Central Region consists of 844 million acres. Land-use classification of this vast land area

Table 1. Land Use Classification, North Central Region (millions of acres)^a

	Crop-land	Pasture and Range	Forest Land	Total Land Area
Lake States -----	44.3	6.2	52.5	122.0
Corn Belt -----	102.0	14.0	31.1	165.0
Northern Plains ----	107.2	72.9	4.5	194.0
Alaska -----	--	1.6	118.3	362.5
Total NC Region ----	253.5	94.7	206.4	843.5
Total U.S. -----	472.1	603.6	722.7	2263.6
NC Region as % of U.S. -----	53.7	15.7	28.6	37.3

^aU.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report 247, 1969.

¹Prepared by a joint Agricultural Research Service, U. S. Department of Agriculture, and state agricultural experiment station task force for the North Central Region as authorized by the National Planning Committee.

Acknowledgment: The participation and assistance of Dr. Douglas Kenealy, Department of Animal Science, Iowa State University, is appreciated as recorder of task force activities and participant in preparation of the text.

Table 2. Land Use by Harvested Crops in States Within the North Central Region (1000 Acres)^a

State	Corn for Grain	Corn for Silage & Forage	Sorghum for Grain	Sorghum for Silage & Forage	All Hay	Soybeans	Small Grains ^b
AK -----	--	-- ^c	--	--	14	--	2
IL -----	10,710	270	60	19	1,270	8,220	2,241
IN -----	5,630	202	18	7	945	3,530	1,734
IA -----	12,130	910	26	13	2,450	6,970	1,580
KA -----	1,640	270	3,430	570	2,280	1,080	12,385
MI -----	1,910	380	--	--	1,300	610	1,420
MN -----	5,820	1,112	--	--	3,210	3,570	5,803
MO -----	2,700	265	490	78	3,400	4,470	1,632
NE -----	5,920	510	1,880	120	4,050	1,230	3,695
ND -----	132	335	--	--	3,450	149	13,722
OH -----	3,490	235	--	--	1,535	3,100	2,279
SD -----	2,250	1,280	237	147	4,770	337	5,755
WI -----	2,390	1,060	--	--	3,970	191	1,543
NC Region Total --	54,722	6,829	6,141	954	32,644	33,557	53,791
U.S. Total -----	66,905	10,315	15,484	1,607	61,863	53,606	92,832
NC Region as % of U.S.-----	81.8	66.2	39.7	59.4	52.8	62.6	57.9

^aU.S. Department of Agriculture. 1975 Annual Summary of Crop Production, Crop Reporting Board, Jan. 15, 1976.

^bTotal of barley, oats, rye, and wheat.

^cAlaska--all silages: 2.8

Table 3. Pasture and Range by Type^a in the North Central Region (1000 acres)^b

	Cropland ^c Pasture	Grassland Pasture and Range	Forest Land Pasture & Range	Total
Lake States -----	5,293	6,175	4,735	16,203
Corn Belt -----	16,886	13,948	11,975	42,809
Northern Plains ---	11,273	72,940	2,358	86,571
Alaska -----	3	1,624	111	1,738
NC Region Total ---	33,455	94,687	19,179	147,321
U.S. Total -----	88,220	603,615	198,043	889,878
NC Region as % of U.S. -----	37.9	15.7	9.7	16.6

^aExcludes cropland used for pasture.

^bU.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report 247, 1969.

^cCropland in rotation.

Table 4. Pasture and Range by Type^a and by State in the North Central Region (1000 acres)^b

	Cropland ^c Pasture	Grassland Pasture and Range	Forest Land Pasture and Range	Total
AK -----	3	1,624	111	1,738
IL -----	2,179	2,614	1,251	6,044
IN -----	1,572	2,038	945	4,555
IA -----	4,008	2,089	1,602	7,699
KS -----	3,925	15,453	537	19,915
MI -----	1,091	1,338	653	3,082
MN -----	2,101	2,311	1,872	6,284
MO -----	7,401	4,833	7,081	19,315
NE -----	2,461	22,179	631	25,271
ND -----	1,889	11,278	264	13,431
OH -----	1,726	2,374	1,096	5,196
SD -----	2,998	24,030	926	27,954
WI -----	2,101	2,526	2,210	6,837
Total NC Region ---	33,455	94,687	19,179	147,321
Total U.S. -----	88,220	603,615	198,043	889,878
NC Region as % of U.S. -----	37.9	15.7	9.7	16.6

^aExcludes cropland used for pasture.

^bU.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report 247, 1969.

^cCropland in rotation.

indicates that respective percentages of land in cropland, pasture and range, forest land, and other are 30, 11, 24, and 34. Actual acreage values for classified land use are shown in Table 1.

Tables 2, 3, and 4 reflect land inventory and use patterns within the North Central Region. Of the land area in the North Central Region, approximately 147 million acres are devoted to pasture and range crops. This represents 17 percent of the U. S total in this classification, and this region contains vast quantities of the most productive forage lands in the world. The soil and climatic conditions that make such productivity possible within the region contribute to the very large potential of the area to respond to improved forage and livestock production technology.

Ruminant Animal Resources for Red Meat Production—As of January 1, 1976, the North Central Region maintained 17 million beef cows and replacement females. This represents 33 percent of the beef-cow herd in the United States. The importance of this regional contribution to the beef-producing enterprise in the nation is particularly significant since the region composes only slightly more than one-third of the land mass of the country and, from this, also contributes significantly to the national output of numerous other farm commodities. The 1975 calf crop in the North Central Region, including calves from dairy herds, was in excess of 19 million head, which represented 38 percent of the U. S. total. 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,

Table 5. Cattle and Calf Crop Numbers and Calf Crop by States in the North Central Region, January 1976 (1000 head)^a

	All Cattle and Calves	Beef Cows 2 Yrs & Older	Replacement Females	Calf Crop (1975) ^b
AK -----	8.5	2.5	0.5	3.5
ND -----	2,380	1,150	140	1,300
SD -----	4,500	1,905	225	2,100
NE -----	6,550	2,142	275	2,190
KS -----	6,450	1,757	238	1,880
MN -----	4,430	751	152	1,596
IA -----	7,500	1,931	225	2,200
MO -----	6,600	2,700	421	2,840
WI -----	4,550	350	91	2,100
IL -----	3,400	842	139	1,020
MI -----	1,650	195	33	590
OH -----	2,305	500	101	800
IN -----	2,225	617	96	780
Total NC	52,548	14,842	2,136	19,400
Total U.S.	127,976	43,743	7,197	50,426
NC Region as % of U.S.	41.1	33.9	29.7	38.5

^aU.S. Department of Agriculture, Statistical Reporting Service, Crop Reporting Board, LvGn 1 (2-76), Washington, D.C.

^bIncludes calf crop from both beef and dairy cows.

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 is represented by roughages emphasizes the importance of forages in the total beef-producing program of the region.

The dairy herd in the North Central Region, including replacements in 1976, was 7.2 million head. This herd would produce approximately 4 million calves annually. Of this calf crop, 3 million or more calves would be utilized for beef production.

The North Central Region markets approximately 3.5 million sheep annually. The number of lambs born annually within the region is in excess of 3.2 million head.

Table 5 reflects cattle inventory data for the North Central Region.

Need and Justification for Forage-Livestock Research in the North Central Region

Forages from pasture, range, and harvested crop materials, including crop residues, represent a very large base for red meat production in the North Central Region. Current research indicates the existence of vast potential for improving the productivity of forage crops used for grazing, as well as for harvested feeds. Estimates of this potential range

from two- to five-fold that experienced presently on large areas of the region. The development of new technology in forage production and use is essential to make the most efficient use of this potentially large feed resource.

Greatly increased support of research on forages and ruminant livestock would be of direct benefit and interest to most Americans. An increasing dependence on foods of animal origin and the increasing dependence of ruminant animals on forages strongly suggests that a larger proportion of the nation's agricultural research funds should be devoted to the forage-livestock complex. Problems associated with forage-meat animal production systems are complex, requiring a multidisciplinary approach. Most research conducted in the past has focused on component parts of the beef-forage system. Future research will require a continuation of effort on individual system components, but much greater emphasis must be placed on the interaction of the plant and animal systems, which will require a fully integrated, interdisciplinary approach to forage-animal production problems. This may require redirection of some existing research programs plus substantial strengthening of these programs in terms of maintenance funds and technical assistance.

Forage research is difficult, time consuming, and expensive. Factors responsible for making it complex and challenging include: The large number of annual and perennial species of both grasses and legumes used for forage, range, and pasture; the high chromosome number and complicated behavior of most forages; the desirability of having perennial species, which requires adequate winterhardiness and yield; the difficulty of establishment and seed production; the wide range of management practices to which they are subjected; the diverse and often rigorous environmental conditions under which they are grown; the time required for and the complexity of evaluating perennial species and management practices; the need to relate forage characteristics to animal performance; and the fact that, in general, forage value is not realized until marketed through livestock. Increased efficiency in forage production has not kept pace with that in grain crops, partly because research effort on forage production has been inadequate. For forage production to attain the degree of efficiency characteristic of grain production, greater efforts in research and producer educational programs will be essential.

GENERAL RECOMMENDATIONS

The committee recommends that high priority be given to providing more adequate funding for operational needs of existing forage-livestock programs in the North Central Region. Forage technology is estimated to be as much as 25 years behind that of cereal crops because of a lack of adequate funding for forage research. This deficiency in technology is,

by itself, sufficient justification for urgent additional funding to optimize all facets of agricultural production.

In considering additional forage-livestock research needs for the region, all Research Problem Areas (RPA's) applicable to the forage-livestock interface were considered. Recommendations for in-

creased research effort are for a 10-percent increase by 1980. Recommended Science Year allocations are also made for 1985 at a level judged to provide maximum effectiveness of the research effort. These recommendations are summarized in the Summary Table that follows this section.

Specific committee recommendations for research effort in the various RPA's are detailed in statements for each RPA considered in the following final section. Recommendations highlighting priority research needs are:

1. Collect, evaluate, utilize, and maintain germ plasm of grasses and legumes for current and future use in improving forage crops.

2. Develop new varieties of grasses and legumes high in protein, digestibility, palatability, and intake and having multiple resistance to insects, diseases and nematodes, more tolerance to stresses, greater persistence, freedom from problem components, and greater compatibility in forage mixtures.

3. Develop integrated pest management systems for optimum use of resistant varieties, and develop new and improved methods for chemical, cultural, and biological control of weeds, insects, diseases, nematodes, and rodents infesting forages.

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

5. Develop improved forage management 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 and legumes, and the introduction of improved grasses and legumes into permanent sod.

6. Develop potentials of symbiotic and nonsymbiotic nitrogen-fixing microorganisms associated with grasses and legumes.

7. Develop more effective breeding procedures to improve biological efficiency and yield.

8. Determine physiological characteristics of forage plants, increase photosynthetic efficiency as well as the efficiency of water use and of mineral element uptake and use, and develop procedures for rapid screening of forage plants for tolerance or resistance to various environmental stresses.

9. Improve efficiency of beef production from forages by increasing intake, digestibility, and utilization of pasture, harvested forages, and residues in reproducing and growing-finishing beef cattle.

10. Provide information on the effects of chemicals, plant toxins, mycotoxins, and other pollutants on animal health and safety of animal products. Develop methods of reducing the levels and effects of these pollutants in forages and on the animals consuming them.

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

SUMMARY TABLE Showing Recommended Allocation of Scientist Years (SY's) to Research Problem Areas.

Research Problem Area	No.	Allocation of SY's In North Central Region		
		Present (1974)	Recommended ^a	
Name			1980	1985
Soil, Plant, Water, and Nutrient Relationships -----	102	38.5 ^b	38.5	41.5
Alternative Uses of Land -----	104	11.7 ^b	11.7	13.7
Conservation and Efficient Use of Water-----	105	23.1 ^b	23.1	25.1
Efficient Drainage and Irrigation Systems and Facilities -----	106	11.6 ^b	11.6	12.6
Watershed Protection and Management -----	107	36.2 ^b	36.2	38.2
Appraisal of Forest and Range Resources -----	110	0.3	1.3	4.3
Improvement of Range Resources -----	112	12.7	16.7	30.7
Control of Insects and Pests of Field Crops and Range -----	207	15.3	16.3	23.3
Control of Diseases and Nematodes of Field Crops and Range ---	208	7.6	8.6	19.6
Control of Weeds and Other Hazards of Field Crops and Range --	209	4.0	6.0	12.0
Control of Internal Parasites of Livestock -----	212	1.1 ^b	3.1	6.1
Protect Livestock from Toxic Chemicals and Plants -----	213	1.2 ^b	3.2	6.2
Protection from Harmful Effects of Pollution -----	214	0.3	1.3	5.3
Improvement of Biological Efficiency of Field Crops -----	307	45.2	46.2	60.2
Mechanization of Production of Field Crops -----	308	2.8	5.8	7.8
Production Management Systems for Field Crops -----	309	2.7	4.7	12.7
Reproductive Performance of Livestock -----	310	5.8 ^b	6.8	14.8
Improvement of Biological Efficiency of Livestock -----	311	44.9 ^b	46.9	74.9
Production Management Systems for Livestock -----	313	3.8 ^b	5.8	9.8
Bees and Other Pollinating Insects -----	314	6.5 ^b	6.5	7.5
Farm Business Management -----	316	15.9 ^b	15.9	19.9
Mechanization and Structures in Production of Livestock -----	317	1.2 ^b	3.2	6.2
Noncommodity-Oriented Biological Technology and Biometry -----	318	---	---	5.0
Production of Field Crops with Improved Acceptability -----	405	4.2	5.2	9.2
New and Improved Feed, Textile, and Industrial Products -----	407	0.8	0.8	3.8
Quality Maintenance in Storing and Marketing Field Crops -----	408	0.2	1.2	3.2
Production of Animal Products with Improved Acceptability ----	409	6.7	6.7	9.7
Improve Grades and Standards -- Crop and Animal Products -----	501	0.1	1.1	2.1
Efficiency in Marketing Agricultural Products and Inputs -----	503	3.1	4.1	7.1
Supply, Demand, and Price Analysis -- Crop and Animal Products	506	0.4	0.4	2.4
Competitive Interrelationships in Agriculture -----	507	0.7	0.7	4.7
Group Action and Market Power -----	510	---	---	2.0
Technical Assistance to Developing Countries -----	603	---	---	4.0
Insure Food Free of Toxic Contaminants and Residues -----	701	0.2	0.2	5.2
Protect Food and Feed From Harmful Microorganisms and Toxins	702	0.2	2.2	5.2
Soil, Water, and Air Pollution and Waste Disposal -----	901	0.2	1.2	7.2
Multiple-Use Potential of Forest Land -----	903	---	---	2.0
Fish, Fur-Bearing Animals, and Other Wildlife -----	904	20.1 ^b	21.1	25.1
TOTAL -----		329.3	364.3	550.3

^a Projected SY's for FY 1980 were restricted to an increase of approximately 10 percent; projections for FY 1985 represent committee recommendations for maximum effectiveness of research effort.

^b The value shown represents the total SY's for the RPA without regard to the proportion dealing with forages (no information was available on the number of forage-related SY's). All other SY's represent forage-related research.

STATEMENTS AND RECOMMENDATIONS FOR SPECIFIC RESEARCH PROBLEM AREAS

In the statements and recommendations that follow, each Research Problem Area (RPA) considered is identified by number and title. The figures given at the beginning of each statement show the number of Science Years of effort devoted to the RPA in 1974 and those recommended for fiscal years 1980 and 1985. Increases, if any, for 1980 were broadly restricted to 10 percent, although there are individual exceptions among the specific RPA's. The Science Years of effort recommended for fiscal year 1985 are those judged by the task force to provide maximum effectiveness of the research effort in each of the RPA's.

RPA 102 SOIL, PLANT, WATER, NUTRIENT RELATIONSHIPS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
38.5	38.5	41.5

Problem situation in the industry and justification for research in this RPA:

Forage crops are commonly produced on soils that have major limitations for the production of grain and fiber crops. Thus, there are major research needs relating to the chemical and physical relationships among soils, water, soil nutrients, soil and water conservation, and forage crop production. Often production of feed for livestock in the form of perennial forage crops is the most efficient use of soils that 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 use these lands most efficiently and in a manner consistent with maintaining the soil-resource base and protecting the environment. The major objectives in this research area are to improve, maintain, or restore the productive capacity of soils used continuously or rotationally in forage production.

Objectives and (or) research approaches:

1. Develop fundamental information that will provide a base for improving root development and depth of rooting in forage and pasture crops.
2. Develop techniques for reducing the effect of tillage pans and other soil-related restrictions on root penetration.
3. Develop optimum fertilization programs considering both macro and micro nutrients and the utilization of animal, industrial, and municipal waste as sources of plant nutrients.
4. Develop and evaluate soil-management systems to improve conditions for seeding, seedling establishment, and maintenance of the stand in a productive state through improved tillage and water regime.
5. Develop fundamental information relative to physical, chemical, and biological properties of soils in relationship to factors influencing forage production.
6. Determine the effectiveness of surface-applied nitrogen, phosphorus, potassium, and lime in long-term pasture systems.

Potential benefit from research:

Preservation of our soil and water for future generations

will be enhanced through proper management of soil, plant, and water resources on rolling lands and problem soils, to allow optimum production of forage for livestock use with a minimum of soil loss through erosion and surface-water pollution from sedimentation.

RPA 104 ALTERNATIVE USES OF LAND

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
11.7	11.7	13.7

Problem situation in the industry and justification for research in this RPA:

The production of forages and the associated production of livestock exists as one alternative in the use of land and other resources. It is essential that this alternative be carefully evaluated along with others to determine those land-use alternatives that provide the greatest social and economic benefits. Population growth, advances in agricultural technology, changing domestic consumer demands, increased world demand for food and feed grains, urban and suburban growth, increased recreational demands, and other factors result in altered demand upon the fixed supply of land available in the North Central Region. 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 forage-livestock production in the joint goals of conserving natural resources and maintaining optimum use of these resources in food production. Approximately twice as much area is suitable to production of cellulose as is suitable for the production of edible carbohydrates for monogastrics. The capability of ruminants to convert this cellulose material to high-quality human food is an asset that needs to be developed to the maximum if human food needs are to be more adequately met.

Objectives and (or) research approaches:

1. Provide appropriate inventory of land resources to permit models for land-use planning.
2. Evaluate alternative uses of land resources to determine those likely to provide the greatest short-range and long-range social and economic benefits.
3. Determine the amount of land likely to be available for forage production and the animal-unit capacity of such available lands under different economic and social restraints.
4. Determine the forage species that best meet the needs of the intended or multiple use of range, open, and grazing lands.
5. Develop techniques for the reclamation of wasted and scarred lands so that they may be returned to active and productive use.

Potential benefit from research:

Increased vegetative cover will assist in soil stabilization and water retention. This retains the productivity of the soil, decreases sediment in streams and rivers, lessens the severity and frequency of flooding downstream, increases recycling of water-borne salts through plants, and improves the quality of ground water. Through better and more efficient use of open and grazing lands, the output of useful (to man) products will be increased. Effective land-

use planning will help to preserve, enhance, and develop the esthetic quality of the countryside for the physical and visual enjoyment of the public.

RPA 105 CONSERVATION AND EFFICIENT USE OF WATER

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
23.1	23.1	25.1

Problem situation in the industry and justification for research in this RPA:

With the exception of the Plains States, forage-production areas in the North Central Region are characterized by reasonably adequate rainfall levels. All areas within the region, however, can be subjected to periods of critical water shortages. Such periods can be extremely disruptive to livestock programs, which inherently require stability over an extended period if available technology and other management techniques are to be used most efficiently. Because of this, it is extremely important that research be conducted that will lead to improved genetic materials for water conservation as well as cultural practices used in the forage-production enterprise. The major objectives in this area of research relate to the production of drought resistant varieties of forage crops, the development of water-conserving cultural practices, the conservation of surface and subsurface water, and in the more arid areas of the North Central Region, the development of improved management techniques to conserve water used for irrigation of forage crops.

Objectives and (or) research approaches:

1. Develop crop and soil management practices to optimize efficiency in the use of water by forage crops.
2. Develop improved varieties of grasses and legumes that are more drought tolerant and more efficient in use of available water.
3. Determine soil management and forage production and grazing management practices that enhance water infiltration, transmission, and availability to the plant.
4. Develop systems for minimizing water loss through evaporation and runoff in irrigated forage production.

Potential benefit from research:

Conservation of water will effectively increase the productivity of grassland. This will be accomplished by increasing soil water-storage capacity and absorption rate to decrease runoff. Reduction of runoff will reduce flooding and the amount of silt in waterways, thereby also giving longer life to water reservoirs. Increased percolation of water through the topsoil will alleviate the root zone problems with sodium, calcium, magnesium, and other salts.

RPA 106 EFFICIENT DRAINAGE AND IRRIGATION SYSTEMS AND FACILITIES

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
11.6	11.6	12.6

Problem situation in the industry and justification for research in this RPA:

The diverse climate and soil conditions existing within the North Central Region result in excessive amounts of water on some lands, hence the need for efficient drainage systems for optimum crop production. In the more arid areas within the region, irrigation may be a viable means to in-

crease forage production on lands where continuous or intermittent forage production is a desirable land-use alternative. Both drainage and irrigation facilities are expensive; thus, it is important to maintain research programs dealing with the development of low cost, efficient systems to meet these needs. The major objective of research work in this area would relate to seeking those facility designs that would optimize the use of land, water, and capital resources in areas requiring drainage and (or) irrigation.

Objectives and (or) research approaches:

1. Develop methods to improve efficiency of water use in irrigated forage production through reduced evaporation and runoff.
2. Provide necessary input data to permit the development of economic models to more clearly define land, water, plant, and livestock value conditions important in the decision to produce irrigated forage crops utilizing resources having alternative crop potential or commercial use.

Potential benefit from research:

The minimum use of water for irrigation lowers production expense, saves water for other competing needs, and minimizes the leaching of soluble salts from the soil and into the ground and surface water supplies. Proper drainage of wetlands and irrigation of dry lands will enlarge the productive land area of the North Central Region. The use of recycled drainage water will permit maximum use of dissolved soil nutrients in the drainage water and thereby reduce the presence of nutrients in surface watercourses.

RPA 107 WATERSHED PROTECTION AND MANAGEMENT

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
36.2	36.2	38.2

Problem situation in the industry and justification for research in this RPA:

In many instances, forage crops provide the most effective erosion control needed to protect the productive capacity of land. Sediment control is needed to prevent unwanted deposition of eroded materials in reservoirs, harbors, stream channels, streets, highways, and floodplain lands. Sediment in streams can damage recreational values, and such materials must be removed from domestic and industrial water supplies. Therefore, it is important that land-use programs consider cropping alternatives that minimize the loss of soil resources. In many instances, forage crops are not the most attractive short-run economic alternative for the use of lands subject to erosion. Research is needed to improve the productive capacity of forage crops to make them a more competitive alternative for the use of such lands. The major objective of research in this area is to define the role of forage crops of various types in watershed protection and management and to develop efficient management practices relating to the mix of land, water, and crops that effectively protects the soil-resource base.

Objectives and (or) research approaches:

1. Develop more efficient laboratory and field techniques for evaluating the effect of crop alternatives on water and sediment loss.
2. Develop improved mathematical models for determining water and sediment loss under different cropping alternatives.
3. Determine optimum rotation patterns, plant species mix, and grazing and harvesting management patterns to

optimize livestock production and the conservation of soil and water resources.

4. Determine the potential for hay and pasture production on land formerly in farmland or on unused cropland, especially in the northern part of the North Central Region.

Potential benefit from research:

Land susceptible to erosion or not now in crop production can be preserved for the future by using forages grazed by livestock or used for preserved feed. The result is a better economic utilization of the land with a minimum of water pollution from sediments resulting from erosion.

RPA 110 APPRAISAL OF FOREST AND RANGE RESOURCES

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.3	1.3	4.3

Problem situation in the industry and justification for research in this RPA:

Periodic appraisals of range and forage resources in the North Central Region are essential to determine the adequacy of public conservation policies and programs and to guide the decisions of producers relative to the development of pasture and range enterprises. Such appraisals are also important in assessing the extent of adoption and the impact of new technologies. Evaluation of this type will provide improved assessment of the total livestock and food resource base of the region. The major research objective in this area is to develop and use methodology for gathering and evaluating forage-feed resource data.

Objectives and (or) research approaches:

1. Use modern survey methods to accurately assess the location and acreage of range and related lands to provide improved planning and management of the range resource.

2. Develop practical methods for providing up-to-date information on the condition and trend of rangeland, based on quantity and quality factors related to productivity.

3. Develop models that will be useful in identifying areas of research needed for complete management of the resource, and that will, through an improved basis for decision making, integrate stocking rate, renovation, fertilization, and other management inputs to provide optimum production.

Potential benefit from research:

The forest and range resources of the North Central Region include millions of acres of commercial forest, farmstead forest, rangeland, and open wooded areas suitable for livestock grazing. In many instances, these resources are scattered in relatively small parcels, but sometimes they do occur as extensive acreages. Adequate survey to provide inventory and monitoring to follow changes in condition will allow integration with other forage-livestock resources to insure optimum management for production of forest and animal products.

RPA 112 IMPROVEMENT OF RANGE RESOURCES

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
12.7	16.7	30.7

Problem situation in the industry and justification for research in this RPA:

The Great Plains States within the North Central Region represent a major contribution to the total range resources of the United States. This area includes some of the most productive rangeland in the world. If, over time, the beef-cattle industry in the United States is to rely more heavily on forage feeds, it is essential that the basic characteristics of the vegetation be understood so that the level of production can be increased and the resource be protected through proper management. Research is needed to define the growth requirements and production factors of the many species involved and to relate these to the nutritive value of the forage and, in turn, to the nutritional requirements of the livestock. Improved techniques for revegetation of overgrazed and otherwise deteriorated areas are also needed. Research designed to improve range resources within the region would cover a wide range of objectives treating plant-variety development, crop cultural practices, and livestock-forage systems that individually or collectively might lead to improved productive capacity of this valuable resource.

Objectives and (or) research approaches:

1. Develop management systems to optimize forage production from rangelands through fertilization, renovation, mechanization, stocking rate, and other management factors.

2. Develop techniques for revegetation or renovation of deteriorated grasslands by seeding desirable species or by mechanical and (or) chemical methods, with or without seeding.

3. Develop technology to provide seed sources of important forage species and to develop methods of seeding and establishment for species with awns and appendages that cause problems in handling.

4. Develop improved cultivars of forage and range plants for use in establishing perennial vegetation on lands previously cultivated or otherwise disturbed by man, and for use in interseeding or renovation of existing grasslands.

5. Identify physiological and morphological characteristics related to production by individual forage species and relate these to management of the vegetation for optimum production.

6. Determine the effects of range and livestock management systems on the nutritional value of the forage as it relates to meeting animal requirements.

Potential benefit from research:

Application of technology developed through research will improve the range resource of the North Central Region and can double the region's potential for beef production. The economic impact of developing the full production potential of these rangelands will be important to the industry and to the consumer. Development of improved cultivars of important forage species, and development of improved management systems to provide adequate forage capable of meeting the nutrient requirements of the animal, will greatly increase the efficiency of beef production.

RPA 207 CONTROL OF INSECTS, MITES, SNAILS, AND SLUGS AFFECTING FIELD CROPS AND RANGE

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
15.3	16.3	23.3

Problem situation in the industry and justification for research in this RPA:

Insect damage in some crops grown for forage in the

North Central Region can reach disastrous proportions. This effect is particularly true on a continuing basis with respect to certain legume crops subject to attack by a complex of insects that includes the alfalfa weevil, the clover leaf weevil, the sweetclover weevil, the pea aphid, the spotted alfalfa aphid, the potato leafhopper, the meadow spittlebug, various grasshoppers, the variegated cutworm, the green clover worm, and a host of others. Control of these pests requires a continuous monitoring program, which will make possible early detection and identification of the specific insect or insects concerned in a particular area, followed by the prompt application of appropriate control practices. Destroying these pests *before* they become overwhelming in numbers and *before* they have caused extensive damage is the key to their control. Grasses also suffer major damage from white grubs, sawflies, and other insects. Thus it is important that research programs be maintained to deal with the control of insects in forage crops. It is also important that the search for more effective and less hazardous insecticides be continued.

Objectives and (or) research approaches:

1. Develop procedures for detecting, identifying, and monitoring insects in forage-crop areas.
2. Develop mathematical models that determine the economic threshold for insect damage and indicate when control measures should be initiated.
3. Evaluate promising insecticides as a means of developing safer and more effective materials.
4. Develop production and cultural practices that minimize insect damage.
5. Develop varieties of grasses and legumes with greater resistance or tolerance to insect damage, but with recognition of associated effects of acceptability and nutrient values.
6. Develop biological methods for controlling insects affecting forage crops.

Potential benefit from research:

Prevention of damage is the key to success in dealing with plant pests, and this goal can be achieved only when the pests are identified early and appropriate control measures begun before the damage has become extensive. Some entomologists recommend routine application of insecticides to second and third growth alfalfa, before the growth is 6 inches high, as a protective measure, particularly on the lighter soils during prolonged periods of dry weather. They point out that, under these conditions, insects commonly destroy ¼ to ½ ton per acre (\$12 to \$24/A), which could be prevented at a cost of \$6 to \$8/A. Approximately 16.7 million acres of alfalfa are grown for hay in the North Central Region. Another 15.1 million acres are planted to other forage species grown for hay. Achievement of objectives would substantially reduce the multimillion dollar losses annually caused by insects and related pests.

RPA 208 CONTROL OF DISEASES AND NEMATODES ON FIELD CROPS AND RANGE

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
7.6	8.6	19.6

Problem situation in the industry and justification for research in this RPA:

Plant pathogens such as fungi, bacteria, viruses, and nematodes are a constant threat to forage legumes and grasses. They adversely affect stand establishment, reduce

the longevity of perennial species, and significantly reduce forage yields and quality. A conservative estimate of losses from diseases to forage crops in the North Central Region is 400 million dollars annually. Control to date has been primarily by the growing of adapted, resistant varieties, cultural practices, and management. Nematicides have been used to a limited extent in nematode-infested areas, but few growers use any chemical for the control of plant pathogens. Substantial progress has been made in developing varieties resistant to some diseases, in adjusting soil fertility and pH, and in managing forage production to minimize effects of disease. No variety of any forage crop, however, is resistant to all diseases. A continuation and expansion of breeding programs is essential. Management of all aspects of forage production influences disease and deserves further study. Very little information is available on the effectiveness and economics of pesticides for the control of forage-crop diseases. The possible usefulness and safety of systemic pesticides to give more complete and enduring protection needs to be explored.

Objectives and (or) research approaches:

1. Develop superior varieties of grasses and legumes with more resistance to diseases.
2. Determine appropriate sequence of forages and other crops and a mechanism for controlling soil-borne diseases.
3. Develop appropriate production and cultural practices to minimize disease hazards.
4. Assess problem areas to determine the exact nature and geographic limits of the problem, then offer choice of crops and varieties for a locality. Distribution of the problem will influence priorities in a breeding program.
5. Evaluate promising disease-control materials as to effectiveness and safety.
6. Develop improved and safer methods of application of chemicals used for disease control.

Potential benefit from research:

Lower unit costs and reduced risks result from eradication or control of diseases. Serious fluctuations in farm supplies are reduced, and maximum production is realized. It is not realistic to assume that any increase in the amount of research could quickly eliminate all losses from diseases. It is realistic to assume, however, that a substantial increase in support could reduce losses by 10-25% (40 to 100 million dollars annually).

RPA 209 CONTROL OF WEEDS AND OTHER HAZARDS OF FIELD CROPS AND RANGE

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
4.0	6.0	12.0

Problem situation in the industry and justification for research in this RPA:

Information on weed control in forage crops, as well as control of brush and noxious plants in pastures, has not kept pace with progress attained in cultivated crop production. Lack of research effort on improved application techniques, biological control, and the ecology of specific weeds has created serious problems in the establishment and maintenance of forage plants. Weed infestation can cause serious damage in stand establishment and the ultimate productivity of land devoted to forage-crop production, as well as greatly reduce the acceptability of forage materials to livestock and the overall productivity of the forage-crop resource. Some weeds, notably grasses, have some value for forage, but most are considered inferior in quality to the cultivated forages they replace. Very little is known about

the protein content, digestibility, palatability, and other such factors of most of the weeds occurring in forage.

Objectives and (or) research approaches:

1. Evaluate effective and less hazardous herbicides for forage crops with particular emphasis on establishment of new seedlings.
2. Develop improved cultural practices in establishment of new seedlings.
3. Develop methods of eliminating weeds in established stands.
4. Develop more effective and safer methods for herbicide application.
5. Determine the effects of different species of weeds on forage quality, intake, and animal performance, including potential toxic effects.
6. Develop effective methods for the control of rodents damaging forage crops.

Potential benefit from research:

Achievement of objectives will not only increase the tonnage from our forage acres, but significantly increase forage quality and, consequently, animal gains per acre. The net result should be an increase in the amount of meat produced per acre and a reduced cost per pound of meat. Weed control will improve initial stands of forage crops and make possible their maximum productivity. It will increase the quality and feeding value of the forages produced. It will enable the grower to minimize the weed species that are inferior in forage quality and that often decrease forage consumption by animals. An important bonus of the proposed feeding trials is that they will provide much needed information on the effects of different kinds of weeds on forage quality.

RPA 212 CONTROL OF INTERNAL PARASITES OF LIVESTOCK, POULTRY, AND OTHER ANIMALS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
1.1	3.1	6.1

Problem situation in the industry and justification for research in this RPA:

The North Central Region is characterized by a mix of soil and climatic factors, which makes it possible to provide pastures of very high productivity. This results in intensive use of pasture areas with extremely dense livestock populations. There can be a close relationship between animal density and problems associated with parasite infestation of livestock. Thus, it is important to maintain research that will provide more effective parasite control under conditions typical of the region. Major research objectives in this area relate to the development of improved and safer chemical control for internal and external parasites of animals and the development of improved cultural and livestock management practices that minimize parasite infestation. Recent advances in the field of immunology have opened new avenues to explore in the control of parasitism. Immunology has many advantages because it does not require additional drugs or chemicals that may be injurious to animal health and may develop an increased nonspecific resistance against other parasites and microbial infections.

Objectives and (or) research approaches:

1. Develop management systems for livestock in pastures to minimize parasite infestation under intensive grazing systems.
2. Investigate the pathogenesis of intestinal parasites to gain a better understanding of the immune response and de-

velop methods of potentiating the host response to parasites.

3. Develop more effective low-cost anthelmintics with a broader spectrum and greater efficiency against immature forms and reduced toxic effects to the host.

4. Investigate potentially new methods of administering anthelmintics to minimize animal handling and allow treatment without confining the animals.

5. Develop potential chemicals or agents that may interrupt the life cycle of the parasite in the egg form and reduce contamination of grazing lands.

6. Determine the economic cost of various degrees of parasitism of beef cattle and the cost benefit to beef production of therapeutic and control regimes.

Potential benefit from research:

Improved methods of parasite control will allow for greater intensity of grazing and livestock production. This may be significant to the socioeconomic situation in the country as population and population density increase. Methods of control that minimize animal handling will contribute significantly to reduce production costs and thus benefit the consumer economically. These investigations may provide information that will offer a better understanding of the immunologic nature of some human parasitic diseases and lead to their control and prevention. The newer anthelmintic may be less toxic and safer for animals, consequently reducing any adverse effects of therapy. These products also may be useful in treating parasitism in other animals and man.

RPA 213 PROTECT LIVESTOCK, POULTRY, AND OTHER ANIMALS FROM TOXIC CHEMICALS, POISONOUS PLANTS, AND OTHER HAZARDS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
1.2	3.2	6.2

Problem situation in the industry and justification for research in this RPA:

Livestock may suffer losses in productivity from toxic chemicals, pesticides, poisonous plants, predators, and ingestion of metal and other foreign bodies that may be encountered in pasture crops and harvested forages. In certain parts of the North Central Region, poisonous plants on occasion can cause heavy losses, particularly when pasture or range feed supplies are limited or at seasons of the year when these plants are not discriminated against by the grazing animal. The major research objectives in this area relate to a broad range of management practices that might reduce such hazards to livestock.

Objectives and (or) research approaches:

1. Develop range-management practices that may minimize the frequency of acute bloat.
2. Develop methods for the low-cost alleviation of bloat.
3. Develop methods for alleviation of poisoning by toxic plants.
4. Identify toxic principles in poisonous plants.
5. Study the toxicologic effects of the poisonous principles in plants on the critical organ systems in the target species.
6. Develop suitable antedotal measures for the various toxic plants.

Potential benefit from research:

These investigations will provide for a better understanding of the poisonous plant problem in the North Central Region. There is a continuing need for sophisticated re-

search to develop new information on the toxic principle of plants. A large amount of the information on toxic principles of plants was developed at least 50 years ago and needs to be evaluated under current technology and management practices.

RPA 214 PROTECTION OF PLANTS, ANIMALS, AND MAN FROM HARMFUL EFFECTS OF POLLUTION

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.3	1.3	5.3

Problem situation in the industry and justification for re-search in this RPA:

Forages and the livestock consuming them may be subjected to harmful effects from a variety of pollution sources. In the interest of animal health and the ultimate protection of the consumer from possible harmful residues that may exist in meat products from animals consuming affected feedstuffs, it is important to maintain a major research effort in this area. Major research objectives should consider the development of improved methodology and instrumentation for detection of pollutants in crops, the determination of the degree of tolerance that may exist in plants and animals for common pollutant materials, and the possible development of forage-crop varieties that may resist the effects of such materials. Additional considerations would include the possibility of developing procedures for decontaminating crop materials subjected to pollutant sources.

Objectives and (or) research approaches:

1. Develop animal and pasture management practices that minimize the need for pesticides and other chemicals.
2. Develop improved methodology and instrumentation for detection of pollutants in forages and pasture crops.
3. Determine the tolerance of plants and animals for those pollutants that may occur in forage and pasture crops.
4. Develop forage and pasture crop varieties that resist the effects of pollutants.
5. Develop inhibiting or neutralizing agents that in themselves are not pollutants.
6. Investigate methods for removal by dilution of pollutants in forages and resulting animal products.
7. Conduct studies on methods of feed preparation to remove or obviate potentially toxic substances.
8. Determine the decay time for spontaneous autolysis or destruction of pollutants.

Potential benefit from research:

Investigations in this area will benefit the producer and the public because such research will allow for the economical production of meat without injurious effects to the environment. A significant factor in the cost of livestock production is feed. To have an economically sound feed supply, a variety of chemicals is needed. These include fertilizers, herbicides, and pesticides, but these products are potential animal and human health hazards, and the proposed research studies would tend to minimize the concentration of livestock pollutants in one area.

RPA 307 IMPROVEMENT OF BIOLOGICAL EFFICIENCY OF FIELD CROPS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
45.2	46.2	60.2

Problem situation in the industry and justification for re-search in this RPA:

Research to maintain or improve the biological efficiency of pasture and forage crops is important in determining the ability of agriculture to meet the feed and food needs of this nation and others around the world. The possibility of the beef industry relying to a greater extent on forage and pasture crops and to a lesser extent on the grain crops is extremely important in the overall concept of making more food and food grains available for human consumption. Thus a broad range of research effort needs to be undertaken to improve the overall productivity of all resources engaged in the production of such crops. The major objective in this research area relates to efforts dealing with genetic improvement of forage and pasture crops and cultural and management practices designed to improve the production efficiency of feed units on land in forage-crop production.

Objectives and (or) research approaches:

1. Identify germ plasm (including the C4 metabolism group) that is most efficient in converting nutrients into highly digestible plant materials.
2. Identify forage varieties with superior capabilities for deep rooting and increased yield in the North Central Region, particularly under stress conditions of heat and drouth.
3. Determine the interrelationships and cultural practices that maximize efficiency of yield of forage crops in the North Central Region.
4. Develop more precise instrumentation and techniques for monitoring and alternating growth patterns of forage plants as affected by environmental variables.
5. Determine reliable and economical systems of establishing perennial legumes in sods without plowing as a means of substituting for nitrogen applied to grass, particularly under drouth conditions.
6. Improve the reliability and economy of seeding grass pastures by a minimum of tillage and herbicide application to reduce energy requirements.
7. Investigate the possibility of using individual plant culture and haploids of forages to incorporate germ plasm, such as effective creeping-rooted habit, into alfalfa.
8. Screen populations of perennial legumes and grasses to identify germ plasm resistant to stresses of drouth, cold temperature, heat, alkalinity, salinity, pH, and wind, which could be incorporated into new cultivars by interspecific and intergeneric crosses.
9. Increase the seed size of legumes and grasses as an aid in more reliable emergence under drouth conditions.

Potential benefit from research:

Increasing forage production and utilization by a modest 5% on the forage acreage required to provide pasture and hay for the 15 million beef cows 2 years or older, excluding steers being finished, would have an annual value of about \$160 million. The increase could be a result of improved species or varieties or of improved methods of grazing, harvesting, or utilizing these species.

RPA 308 MECHANIZATION OF PRODUCTION OF FIELD CROPS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
2.8	5.8	7.8

Problem situation in the industry and justification for re-search in this RPA:

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 timeliness in accomplishing certain operations from seeding through harvesting and handling of the harvested crop. Research objectives in this area relate to improved mechanization for seedbed preparation, seeding, the development of equipment that minimizes cost as well as possible hazards to germination and emergence, development of equipment for more efficient harvesting and processing of forages, and development of forage varieties that have high adaptation to mechanized harvesting.

Objectives and (or) research approaches:

1. Develop more efficient mechanization for seedbed preparation and seeding, harvesting, and handling of forage crops and crop residues.
2. Develop labor-time saving instrumentation and machinery for automated monitoring of seeding.
3. Identify optimum relationships of machine power to the requirements of planting, cultivating, and harvesting equipment to maximize efficiency.
4. Develop cropping machinery that minimizes land preparation time, energy use, and cost.
5. Determine physical properties of forage seed and harvested forage products as these affect equipment specifications.
6. Develop forage varieties and cropping systems with greater adaptation to mechanization.
7. Identify optimum seedbed conditions for specific forages and development of machinery that will better create this environment.
8. Develop equipment that will more efficiently harvest forages, use less fuel (power) and labor, and maintain forage quality.

Potential benefit from research:

Increased mechanization in the production of field crops will lower costs for the establishment and maintenance of grazing lands. Production of desirable grasses and legumes in a given area can be increased through establishment and maintenance of a suitable seedbed and soil condition by tillage and by more efficient means of prior elimination of undesirable species. The development of efficient, high-speed seeders for surface operation will lower costs and improve the emergence of planted forages. The development of equipment to "ball" grass and legume seeds with soil and nutrients and the means of accurately distributing them will permit the rapid seeding of large areas when soil and water conditions permit.

RPA 309 PRODUCTION MANAGEMENT SYSTEMS FOR FIELD CROPS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
2.7	4.7	12.7

Problem situation in the industry and justification for research in this RPA:

Producers must often choose among a number of crops and crop sequences, as well as methods or systems to be used in the production of crops. Thus, it is important to provide research activities for the development of appropriate input data, which when used in the systems analysis approach, can improve the decision-making process relative to the most effective use of resources on the farm and in the region. Many variables must be considered in such analyses, and in many instances, appropriate inputs are not well supported

by research data. Thus, it becomes important not only to develop methodology for the decision-making process, but also to identify those areas where additional research is needed to improve the quality of inputs used in such a process. The major research objectives in this area relate to the development of appropriate methodology for arriving at complex decisions regarding the use of land and other resources, and to the development of improved quality of inputs used in this process.

Objectives and (or) research approaches:

1. Determine specific forage crops, crop varieties, and crop sequences or combinations that will optimize yield of nutrients per acre for specific areas within the North Central Region.
2. Determine optimum levels, types, and time of application of fertilizer and pesticides necessary to maximize forage yield for various areas within the North Central Region.
3. Determine the most effective scheme of fertilizer and pesticide application as it relates to method of seedbed preparation, type of soil, and use of irrigation.
4. Determine soil and forage management systems that most efficiently use time, labor resources, energy, and machinery available for production of forage crops in three subregions; Hay, Pasture, and Lake region; southern Corn Belt; and western Corn Belt and Great Plains.
5. Identify least-cost methods of production management, which tend to maximize crop production as well as energy efficiency in regions in objective 4.
6. Identify species or combinations of legumes and grass that will provide for maximum early and late pasturing in each of the three subregions listed in objective 4.
7. Identify factors for more uniform and reliable establishment of forages, particularly under stress conditions of drought.
8. Develop hay harvesting system(s) that will reduce forage loss from field to feeding, particularly for herds of fewer than 50 cows.
9. Develop methods of using animal wastes on forages.
10. Develop technology for using municipal sewage effluent on forages, and determine which forages will tolerate various rates of effluent application with optimum production.

Potential benefit from research:

Improved management systems for the use of forages in beef-cattle production will result in greater efficiency of land use with an increase in total beef production. As beef consumption per capita increases from 119 pounds in 1975 to a predicted 138 pounds in the year 2000 and as population increases from 215 million to 250 million, total beef consumption will increase from 25 billion pounds in 1975 to 35 billion pounds in 2000. Improved management systems will help in the increase in beef production predicted to meet the anticipated demand.

RPA 310 REPRODUCTIVE PERFORMANCE OF LIVESTOCK, POULTRY, AND OTHER ANIMALS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
5.8	6.8	14.8

Problem situation in the industry and justification for research in this RPA:

Presently, forages account for approximately 75% of the feed nutrients used for meat production by ruminants (cattle and sheep). Production of offspring to weaning requires

approximately 65% of the total digestible feed nutrients in ruminant animal production. Animals involved in the reproduction component of the total production cycle primarily utilize harvested and unharvested forages. The major research objective in this area relates to developing the necessary biological understanding required to synchronize mature size, growth rate, carcass composition, milk production level, market requirements, and other production parameters with the feed resource base to optimize reproduction rate. The information required to synchronize these animal production parameters with the feed-production resources (primarily forages) is necessary because of the diverse feed-production capabilities existing in the North Central Region and in the entire United States. The optimum milk-production level, mature size, growth rate, and reproduction rate likely varies with the feed-resource base, but adequate biological data are not available to synchronize the animal germ plasm resources to the feed resources on a production-system basis. Production efficiency is greatly affected by reproduction efficiency, and reproductive efficiency can be substantially increased by improving forage quality, palatability, and nutritive value to provide for a higher reproductive performance capability.

Objectives and (or) research approaches:

1. Determine relationships between reproductive performance of ruminants and forage nutrient availability as affected by stage of plant maturity and methods of harvesting and preservation.
2. Determine effect of biological type of animal, as reflected by mature size, growth rate, composition, and milk production, on intake of forages varying in palatability and nutritive value.
3. Determine relationship of nutrient requirements supplied by forages to growth, maintenance, gestation, lactation, and reproductive performance.
4. Develop life-cycle, beef-forage feeding systems to optimize reproductive performance for animals that vary in mature size, milk production level, and other production traits.
5. Improve palatability, nutritive values, and productivity of forages and methods of harvesting and utilizing these forages to provide for higher reproductive performance.
6. Identify any constituents of forage and waste products that may influence reproductive efficiency, and determine the physical or chemical pathways creating such effects.
7. Identify crop residues and other organic waste products that are acceptable sources of energy and other nutrients for maintaining efficient reproductive performance in cattle.

Potential benefit from research:

Increasing quality and productivity of forages for reproducing animals will effectively increase reproduction efficiency up to 10 percent. The ultimate effect would result in improved use of all resources engaged in beef production.

RPA 311 IMPROVEMENT OF BIOLOGICAL EFFICIENCY IN PRODUCTION OF LIVESTOCK, POULTRY, AND OTHER ANIMALS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
44.9	46.9	74.9

Problem situation in the industry and justification for research in this RPA:

The high fiber content of pasture and forage crops requires that such materials be utilized by ruminant animals to convert such crops to forms suitable for human consumption. The chemical and physical character of such crops results in relatively inefficient digestion and metabolism of the nutrients contained therein. This, coupled with the fact that cattle have relatively low reproductive rates, requires that major research efforts be directed toward improving the nutritional value of roughage materials with the goal that usable nutrient yield per unit of resource used in the production of such feeds be improved and that techniques be developed to enable the animal consuming such materials to be more efficient in the use of the nutrients provided. Major accomplishments in increasing the efficiency of forage utilization would result in more efficient livestock production with a reduction in the cost of meat to consumers. Research objectives in this area relate to a wide range of endeavors that would treat the problem of improving the efficiency of digestion and metabolism of forage and pasture crops by developing genetic materials that have higher nutritive value and by developing processing or other treatments that might render such crops more digestible. Major research objectives in this are the development of ration additives that could improve utilization of nutrients contained in forages, evaluation of genetic-feed environment interactions that could result in an improved fit between the type of animal and type of forage available, development of improved livestock management techniques for greater productivity, the search for improved methods for utilizing roughage materials currently not used for livestock feeds, and the development of more effective supplemental programs to insure efficient utilization of roughage materials and optimum performance of the livestock consuming such materials.

Objectives and (or) research approaches:

1. Develop chemical and microbial treatments as approaches to improved utilization of forages.
2. Develop procedures for increasing available energy and rate of intake of forages.
3. Determine fundamental relationships between physical form and chemical character of forages and rations containing forages as these influence intake, digestibility, and animal performance.
4. Develop more effective land use through recovery of nutrients produced in field crops, pastures, and range.
5. Determine the most effective supplemental programs for maximum utilization of the various forage types, including crop residues and weathered range grasses.
6. Develop techniques to minimize adverse effects of nutrient interactions on utilization of nutrients in forage materials.
7. Develop and evaluate feed additives and growth promotants that increase efficiency of forage utilization.
8. Develop methods for improved use of nonprotein nitrogen in roughage-containing rations.
9. Develop effective means of using crop and industrial waste products, especially those high in protein, as well as animal wastes in cattle rations.
10. Develop improved laboratory techniques for evaluating nutritional value of forages.
11. Determine interactions existing between genotype of animals and feed environment as an approach to an identification of improved germ plasm that offers more effective use of all forage resources.

Potential benefit from research:

Tremendous quantities of forages, both high and low quality, are available in the United States annually. Includ-

ing the crop residues, sufficient quantities of forage are available to maintain current levels of beef production without any grain feeding. At present, many of these forages are not high enough in quality to support reasonable performance of growing-finishing cattle. Research that produces improved digestibility, intake, or metabolism of forages can move the beef industry toward independence from grain use. In that way, beef cattle would not compete with humans or monogastric animals for grain. Potentially, this could reduce the cost of beef for consumers if the efficiency of forage use can be increased sufficiently.

RPA 313 PRODUCTION MANAGEMENT SYSTEMS FOR LIVESTOCK, POULTRY, AND OTHER ANIMALS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
3.8	5.8	9.8

Problem situation in the industry and justification for research in this RPA:

Resources available for the production of meat animals include soil, water, plant and animal germ plasm, capital, labor, and physical facilities and equipment. The available combinations and costs of these resources plus market requirements determine the relative efficiencies of different production strategies. The development of technology necessary to evaluate total systems efficiency of proposed management alternatives is a neglected area of research in the animal production field. Common assumptions imply that a given practice or livestock type will improve efficiency or profitability of an enterprise without fully considering interacting factors. Recent limited applications of systems analysis to the development and subsequent economic evaluation of biological models have opened the way to more comprehensive analysis of production alternatives. Continued joint efforts of biologists, engineers, and economists will enable the organization of production resources to maximize their "conversion" rate through the optimum integration and coordination of economics and technology. Inherent in this organizational process is the identification and evaluation of additional technological requirements. The major research objectives in this area would relate to further development of methodology for effective decision making in enterprises based on forages and livestock production. A second major objective would be to provide better definition of those inputs not presently well supported with research data as a means of identifying future research needs.

Objectives and (or) research approaches:

1. Develop quantitative models to identify and evaluate resources and technology of potential use in the production of meat animals and make general recommendations for their development, use, and (or) allocation.
2. Develop specific production "equations" to optimize meat production per unit of resource use for each of the many resource-market-technology situations representative of all segments of meat-animal agriculture in the North Central Region.
3. Identify and establish relative priorities of research needs in all areas of meat-animal production.
4. Identify animal germ plasm that will maximize effective use of forage resources.
5. Determine economic feasibility of grazing or harvesting of forages.
6. Identify proper grazing strategies to maximize yields of annual and perennial forages, including such factors as

types of animals and number of animal units per area of land resource used.

7. Evaluate alternative breeding strategies, such as rotational crossbreeding, multibreed crosses, or synthetic breeds, in various environments and production situations.

8. Develop optimal life-cycle feeding systems for different environments and resource types.

9. Evaluate the biological effects of variations in management decisions on things such as weaning age, length and time of breeding season, culling procedures, etc.

Potential benefit from research:

Synthesis of existing and newly developed technology from all research areas into production systems will identify more efficient ways to use this technology and will hasten its acceptance by the livestock industry. The simulation of meat-animal production systems offers the opportunity to try numerous bold and imaginative production alternatives and will lead to the discovery of new management alternatives. Meat-animal research priorities will be more clearly identified and research resources directed toward the most productive problem areas and to the critical experiments of these areas.

RPA 314 BEES AND OTHER POLLINATING INSECTS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
6.5	6.5	7.5

Problem situation in the industry and justification for research in this RPA:

The value of bees and other pollinating insects in certain types of forage production is very great. All major forage legumes (alfalfa, the various clovers, trefoil, the vetches, and lespedeza) are dependent on insects for the pollination necessary for seed production. Bees (the honey bee, the alkali bee, the alfalfa leaf-cutter bee, and the bumble bee) perform most of the pollination of forage legumes. In the United States, about 4.2 million colonies of honey bees annually produce more than 100 million dollars worth of honey and beeswax while also pollinating more than \$1 billion worth of agricultural crops. Their value as pollinators is more than 20 times the value of the honey and wax they produce. The north-central states produce very little alfalfa seed, but require about 65 million pounds per year (value = nearly \$100 million/year) to establish crop stands. Cost of seed is important to growers. Price is related to seed yields in states where seed is produced, and yields are related to the level of success of pollinators. It has been established that plants of alfalfa and other legumes differ in their attractiveness to bees and that bees differ in their efficiency as pollinators.

Objectives and (or) research approaches:

1. Identify strains of honey bees attracted to specific forage crops to increase efficiency of forage pollination and honey production.
2. Assess the value and feasibility of developing new strains of insects to be used in pollination of forage crops.
3. Identify strains of forage crops that are more attractive to pollinating insects.
4. Establish number of pollinators required per unit of area to be pollinated and the means of obtaining these numbers.
5. Obtain additional information on the effect of distribution of bee colonies in seed fields, time required for pollination, amount of isolation from competing crops, and

ways to further mechanize the handling and transport of colonies within and between fields.

Potential benefit from research:

The potential benefits from the proposed research are an adequate and dependable supply of forage legume seed at minimum cost. Legumes are the most important hay crops grown in the North Central Region and are completely dependent on seed for propagation. Seed production requires insect pollination. Any research that produces more efficient pollinators and more effective methods of handling these pollinators will produce seed more efficiently.

RPA 316 FARM BUSINESS MANAGEMENT

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
15.9	15.9	19.9

Problem situation in the industry and justification for research in this RPA:

Farm business management research is needed to help farm operators adjust to technological, economic, institutional, and social changes that occur continuously. Purchased inputs are increasingly being substituted for scarcer and more costly labor and land in production. New technology changes the competitive position of alternative production methods. New ways of doing business with suppliers and marketing firms require new types of decisions by the farm operator and open up new sources of financing. Changing market demands and USDA grading standards may require adjustment in the type of product produced. The major objectives of research in this area relate to the chain of decisions surrounding the production and marketing of forage crops and livestock as well as the most efficient and lowest cost alternatives for providing the inputs required in animal production.

Objectives and (or) research approaches:

1. Determine alternative agricultural enterprises and combinations of enterprises that would result in increased forage production.
2. Evaluate forage-livestock systems for the most efficient combination of available labor, capital, and equipment as determined by the makeup and size of the total enterprise.
3. Identify accurately for producers the effects of world and national policies on the future of feed grains and livestock production and the subsequent effect on the value of forage production.
4. Determine optimal time on feed for livestock of various biological types and crosses, taking into account alternative ration energy levels, growth rates, grain-forage price levels, feed-livestock price levels, new USDA grading standards, and selling strategies.

Potential benefit from research:

Past and ongoing research has indicated that adoption of new technologies, such as crossbreeding, can result in higher growth rates, conception, and feed efficiency. Further, crosses with heavier breeds change the composition of the carcass (i.e., higher percentages of retail product) but may result in higher calving difficulty and, therefore, a higher labor requirement at calving time. Research in farm management can benefit producers in helping them optimize net returns with the new technology and the associated changes in feeding, labor, and capital requirements. Research on the price and income effects of changes in USDA grading standards and marketing practices will

assist producers in altering their enterprise combination and feeding practices to adjust to the changed conditions. Increased accuracy in projections of world demand for U. S. livestock and feed helps forage and grain producers improve their long-range production decisions.

RPA 317 MECHANIZATION AND STRUCTURES USED IN PRODUCTION OF LIVESTOCK, POULTRY, AND OTHER ANIMALS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
1.2	3.2	6.2

Problem situation in the industry and justification for research in this RPA:

Many new mechanization problems and opportunities have arisen as a result of increasing numbers of animals in a single enterprise coupled with decreasing availability of labor. There's need and justification to devise ways to reduce drudgery and manual effort in animal production. Such problems include the handling of feed, forages, animal products, waste products, and other materials used in the production enterprise. The major objectives of research in this area would relate to the development of efficient and low-cost livestock facilities required in conjunction with a forage-based livestock program as well as the facilities required for efficient harvesting, handling, and storage of forage crops. Relationships using such methods and the attainment of maximum nutrient yield per unit of resource utilized will be a major consideration.

Objectives and (or) research approaches:

1. Identify interactions existing between methods of processing and storing of forages and nutrient retention and availability.
2. Develop structures and methods for efficient collection, separation, and storage of livestock and industrial wastes to preserve maximum nutrient value for recycling.
3. Determine structural requirements for most economical housing of animals and storage of forage.
4. Develop equipment and methods for the efficient collection, distribution, and blending of forage and other ration components.

Potential benefit from research:

Efficient, lower cost production of livestock through mechanization will provide meat at lesser cost in a situation where cereal grains are increasingly needed for human food and for monogastric livestock feeds. The increased efficiency of harvesting, preserving, and feeding the forage materials will lower the production cost of red meat and make it possible to produce more human food (meat) from the same land resource with all other constraints remaining constant. Through more timely harvesting and efficient preservation techniques, a higher percentage of essential and valuable nutrients will be preserved. This will increase the nutritional quality of the harvested forage and make it a more complete feed. Mechanical treatments in harvesting and preservation of forages will increase the digestibility of the forage by rolling or mashing and extraction of materials suitable for consumption by monogastric animals without significantly reducing the feed value for ruminants. The extraction of leaf protein through squeezing is such a process and could be a major source of animal feed protein.

RPA 318 NONCOMMODITY-ORIENTED BIOLOGICAL TECHNOLOGY AND BIOMETRY

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
		5.0

Problem situation in the industry and justification for research in this RPA:

The better understanding of cell systems, experimental design, and other improvements in general science technology make a significant contribution to other more specific research of individual plants and animals. In the forage and pasture research area, major research objectives would deal with the development of fundamental knowledge relative to the growth of plants and the biological nature of resistance to insects and diseases, methods for altering plant and animal growth that might ultimately render the production process more efficient, and the development of lower cost and more efficient experimental methodology that might ultimately render research programs more effective.

Objectives and (or) research approaches:

1. Determine metabolic pathways by which certain feed additives and growth promotants increase digestive and metabolic efficiency in converting forage to animal product.
2. Develop ruminal microbial populations that increase efficiency of conversion of forage and waste materials to animal product.
3. Determine control mechanisms of voluntary intake/rate of passage and metabolic pathways of utilization of microbial end products in ruminants.
4. Develop possible approaches to reduce the characteristic decrease in nutrient availability of plants with increasing maturity.
5. Identify new forage germ plasm that optimizes availability of nutrients produced at a given stage of physiological maturity and is also readily adaptable to the climatic conditions existing in the North Central Region.
6. Identify parasitic relationships that promote the use of biological methods of control of insects that damage forages or infest cattle.
7. Identify forage growth stimulants or inhibitors and determine the metabolic mechanisms that create such responses.
8. Identify antimetabolites in plants that will cause a reduction in insect damage without adversely affecting forage acceptability to animals.
9. Determine factors influencing abscising of older leaves on legumes in an attempt to prolong retention of leaves for stockpiling of forages for summer and fall grazing.
10. Study internal control of hormones in plant development including auxins, gibberellins, cytokinins, and abscisic acid as a means of increasing yield of forages.

Potential benefit from research:

A major benefit would be the increasing productivity of forages for livestock by basic research, resulting in increased animal production in the North Central Region. Equally important would be the increased efficiency of use of water, fertilizer, and energy as a result of the improved plant and animal performance.

RPA 405 PRODUCTION OF FIELD CROPS WITH IMPROVED ACCEPTABILITY

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
4.2	5.2	9.2

Problem situation in the industry and justification for research in this RPA:

To obtain maximum utilization of the resources used in the production of forage crops and pastures, it is essential that such crops be highly nutritious as well as palatable to the consuming animal so that sufficient quantities of nutrients are consumed to support efficient animal production. Therefore, research efforts must be directed toward the development of fundamental information that more clearly defines those plant attributes associated with not only nutrient quality, but also palatability or other factors that render such crops acceptable to livestock. In addition, the low concentration of certain important nutrients in roughages makes it impossible for animals to consume sufficient quantities to support acceptable levels of production. Therefore, it is desirable to seek methods whereby nutrient content of forages might be more highly concentrated so that animals might consume larger quantities of needed nutrients. The major research objectives in this area would relate to the development of basic knowledge relative to chemical and physical characteristics of forages as these are associated with palatability, the development of improved varieties that both are highly palatable and contain important nutrients in a more concentrated form, and the careful evaluation of possible improved cultural and management practices as well as processing techniques that tend to render roughage materials more nutritious and more highly palatable.

Objectives and (or) research approaches:

1. Develop fundamental knowledge relative to chemical, physical, and genetic bases that determine acceptability of forages and the resulting performance of consuming animals.
2. Develop varieties of grasses, legumes, and other forages that will provide a more concentrated source of important nutrients and greater nutrient yield per unit of resource used.
3. Develop cultural and other management practices that enhance forage quality and acceptability.
4. Develop economical processing techniques that render forages and crop residue more nutritious and more acceptable.
5. Improve the acceptability of reed canary grass, tall fescue, and other species, particularly in later stages of plant development, after identifying the causes of low acceptability of these grasses.
6. Develop long-lived varieties of alfalfa and other legumes with low bloat potential, especially in the western part of the North Central Region.

Potential benefit from research:

About three-fourths of the feed units consumed by beef cattle in the North Central area are forages, valued at about 5 billion dollars. Increasing the value of forages used for hay and pasture by 10% would mean an annual increase of \$500 million.

RPA 407 NEW AND IMPROVED FEED, TEXTILE, AND INDUSTRIAL PRODUCTS FROM FIELD CROPS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.8	0.8	3.8

Problem situation in the industry and justification for research in this RPA:

Numerous crops normally grown to provide forage for ruminants contain nutrients that, if made available through innovative processing techniques, would provide important sources of nutrients for monogastric animals and possibly for humans. Therefore, it would seem desirable to examine possible approaches to extracting and processing such nutrient-containing materials as sources of important nutrients for species other than ruminants. This is particularly true in terms of the protein-containing fraction of such crops usable as substitute sources of natural protein. This would free certain quantities of natural protein sources for human consumption. Thus a major objective in this research area would be devoted to the development of such innovative processing techniques for the accomplishment of this goal. In addition, efforts should be directed toward a variety of possible chemical, microbiological, and physical treatments of forage crops, which could possibly improve nutritional value and palatability for livestock.

Objectives and (or) research approaches:

1. Develop techniques for producing nutrient concentrates from forage crops.
2. Develop processing methods that will increase palatability and digestibility of roughages and forages to improve animal performance and productivity and to increase their efficiency of use.

Potential benefit from research:

The diversified agriculture of the North Central Region provides an abundance of a wide variety of crop by-products suitable for ruminant feed. Development of technology and equipment for altering the chemical and physical characteristics of these materials to improve intake and utilization by livestock would add tremendously to the feed resource. Extraction processes for removal of protein or other nutrients suitable for human or monogastric animal use, and design of systems to use the residue from these processes for ruminant feed, would add to the versatility and productiveness of land best suited to forage production.

RPA 408 QUALITY MAINTENANCE IN STORING AND MARKETING OF FIELD CROPS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.2	1.2	3.2

Problem situation in the industry and justification for research in this RPA:

Major losses can occur during storing and handling of crops grown as sources of harvested forage. Maintenance of quality against the inroads of insects, molds, moisture, chemical changes, and other deterioration is an important factor in minimizing cost per unit of feed produced. Major research effort in this area is directed to the prevention of these losses. Research objectives include innovative management concepts for crop materials during harvest, transport, storage, handling, and feeding. Objectives include machinery development, improved design of storage

facilities, improved equipment for removal from storage, mixing and other processing techniques, as well as protection of quality while such materials are maintained in feeding facilities.

Objectives and (or) research approaches:

1. Determine chemical and physical changes that occur in the forage after harvest and during the storage period.
2. Develop processing and storage methods that minimize deterioration of nutrient content and palatability during short-term and extended storage.
3. Develop economical methods of providing a desirable storage environment for forage crops.

Potential benefit from research:

The long winter feeding period in the northern areas of the North Central Region, and the need for supplemental stored feed in other areas, requires harvest preservation and storage of about one-fourth of the total forage produced. A small increase in retention of quality during this process would be of tremendous benefit to the beef industry. The advantages gained in using improved cultivars and intensive management practices in producing this forage are soon lost if quality is allowed to deteriorate during harvest and storage.

RPA 409 PRODUCTION OF ANIMAL PRODUCTS WITH IMPROVED ACCEPTABILITY

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
6.7	6.7	9.7

Problem situation in the industry and justification for research in this RPA:

With increasing interest in producing more of our total tonnage of beef from roughage and feeding lesser amounts of grain, there are fundamental questions raised as to feeding-management programs that result in products of high consumer acceptability. Alterations in ration components can be associated with changes in the length of time required to produce a given quantity of beef as well as alterations in the final product produced. Such effects may involve ratio of fat to lean, intramuscular fat deposition, and actual flavor components of the meat itself. Therefore, the major research objectives in this area relate to the development of fundamental information relative to ration effects on product desirability as well as the possible interaction between biological type of animal and the feed environment used in the production process.

Objectives and (or) research approaches:

1. Develop fundamental information relative to the effect of variable ratios and amounts of nutrients from alternative feed resources on quality and nutritional value of beef.
2. Determine the interaction of feeding regimen and maturity at slaughter on quality of beef.
3. Determine the interaction between genetics (biological type) of cattle and the feed environment as relates to product quality and production efficiency of beef.
4. Determine the relationship of beef quality to the feeding regimen and methods of meat processing.

Potential benefit from research:

Highly acceptable and highly nutritious beef can be produced with less grain feeding than is presently practiced. Greater and more efficient utilization of forages and the as-

sociated replacement for grains in beef production will offer improved efficiency in the use of resources in beef production.

RPA 501 IMPROVEMENT OF GRADES AND STANDARDS—CROP AND ANIMAL PRODUCTS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.1	1.1	2.1

Problem situation in the industry and justification for research in this RPA:

Grades and standards are designed to describe characteristics of a product that affect its value to users. Such grades and standards are necessary because the buyer and seller must appraise such characteristics to communicate as to the product value as well as to evaluate such value. Consideration of grades and standards of beef becomes extremely important as a research area allied to pasture and forage research in general because shifting of ration components normally used in cattle finishing to include greater quantities of roughages may have certain associated effects relative to meat characteristics resulting from such production systems. Therefore, it is extremely important to be able to relate such effects that may exist in terms of possible effects on consumer acceptance of the products produced. In addition, if the beef-cattle industry is to rely more heavily on forage materials in the future, there will be an increasing demand for objective measures of forage materials that may be traded in the market place. Such measures must be communicated verbally between buyer and seller to have an orderly marketing structure. Major research objectives relating to product quality and consumer desirability include objective measures of forage quality and acceptability to consuming animals, as well as effects that may be characteristically associated with ration component changes on the meat produced.

Objectives and (or) research approaches:

1. Develop objective measures that relate to product quality and consumer acceptability of beef.
2. Determine production systems, including the influence of ration, environment, and genetic factors, that produce beef of acceptable quality at the lowest cost and (or) most efficient level of resource use.
3. Determine objective measures that relate the nutritive value of forage materials that move into trade channels.
4. Develop objective measures for determining the nutritive value and associated economic value of different forage materials and grades.

Potential benefit from research:

Adjusting grading standards to more accurately reflect carcass quality can reduce the amounts of feed (especially grain) used to produce beef. If a lower fat-to-lean ratio is acceptable, forage could be used to a greater extent in beef production. Because lean is more efficiently produced than fat, the overall efficiency of beef production would be increased. The net result is potentially less feed to produce beef and a greater ratio of forage to grain in the feed used. By providing economic incentive for higher grades of forage, forage quality should increase. Higher quality forages potentially increase overall economic efficiency of beef production.

RPA 503 EFFICIENCY IN MARKETING AGRICULTURAL PRODUCTS AND PRODUCTION INPUTS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
3.1	4.1	7.1

Problem situation in the industry and justification for research in this RPA:

The farm supply, processing, and marketing sectors account for a large percentage of the retail value of food and fiber products. Thus, there are large potential returns from research to improve the efficiency of these sectors associated with the pasture and forage-livestock component. Major research objectives in this area relate to the determination of more effective livestock marketing systems. Major considerations would include techniques to improve the decision-making process relative to the purchase of supplies as well as marketing livestock produced. New technologies are available in marketing livestock, such as the teletype auction system used in Canada for marketing hogs, which have the potential to greatly improve the pricing accuracy and marketing efficiency in the livestock sector. The current grading system allows inequities to occur in livestock pricing and subdues incentives for producing lean beef currently sought by consumers.

Objectives and (or) research approaches:

1. Determine the most efficient and effective methods of acquiring inputs used in the production of forage crops.
2. Develop efficient marketing strategies for livestock raised primarily on forage crops.
3. Develop improved techniques for adjusting to changes in market conditions relative to the purchase of inputs and the marketing of livestock.
4. Analyze the benefits and costs involved in marketing livestock with a nationwide teletype auction system.
5. Investigate inequities and fallacies in the way livestock prices are established under the current grading system and recommend improved practices in livestock price determination.

Potential benefit from research:

Whenever pricing accuracy and marketing efficiency can be improved, benefits accrue to the production, distribution, retail, and consumption sectors. Research can generate answers to whether technologies now available can be implemented in the livestock marketing and grading system. Improved market information under new systems (such as the teletype auction) could provide feedback to producers concerning the precise type of animal desired by consumers, thereby resulting in possible savings in resources at the producer level and lower prices to consumers.

RPA 506 SUPPLY, DEMAND, AND PRICE ANALYSIS—CROP AND ANIMAL PRODUCTS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.4	0.4	2.4

Problem situation in the industry and justification for research in this RPA:

Reliable forecasts of supply, demand, and prices of products are essential to efficient and orderly production and marketing. Livestock producers, as well as those in-

dividuals servicing them, rely heavily on market information. It is important that such information be as accurate as possible. Therefore, major research objectives in this area should include the development of appropriate data and mathematical models for accurate forecasting of product supply and demand, the longer range demand for forage crops, pastures, and feedstuffs, the assessment of adjustments in production technology and other factors on the supply of feedstuffs, and the impact of altered feeding programs on the demand for feedstuffs.

Objectives and (or) research approaches:

1. Develop mathematical models that will permit accurate forecasting of changes in demand for livestock and the resulting demand for forage crops, pastures, and grains.
2. Develop mathematical models that will assess the economic impact on beef supply of changes in resource use.
3. Determine the effects of new production and processing technology and of technological developments in production of synthetics on the demand for livestock products and the resulting demand for forages.
4. Determine the impact of greater reliance on pastures and forages in beef production on the seasonal supply relationships of beef and on the characteristics of the product.
5. Determine data needs to improve the accuracy of these models.

Potential benefit from research:

Large swings in livestock prices result from either inaccurate demand and supply projections or failure of the system to adjust to projected changes in demand and supply levels. Improved projection models and greater adjustments to projected changes can result in less fluctuation in prices and better planning at all levels in the production and marketing sectors. As more stable livestock prices and production occur, demand for feed and other inputs will also stabilize, all else being equal.

RPA 507 COMPETITIVE INTERRELATIONSHIPS IN AGRICULTURE

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.7	0.7	4.7

Problem situation in the industry and justification for research in this RPA:

Adjustments in cropping patterns to meet the demands of a changing market (i.e., animals vs. humans, foreign vs. domestic markets) for food and feed grains are causing major changes in the relative competitive position of different regions within the United States. Thus, it is important to direct research objectives in this area toward an early evaluation of such changes in interregional competition so that regions might have early awareness of the impact of such adjustments on the agricultural enterprises within different regions. As the use of meat substitutes captures an increasing percentage of human protein requirements, it is important to project this trend and assess its impact on the demand for red meat.

Objectives and (or) research approaches:

1. Evaluate the competitive position of different regions and the adjustments that might occur in the production of beef, given greater reliance on forage crops and pastures and reduced levels of grain feeding.
2. Determine the competitive position of meat substitutes from plant sources and the prospects of protein synthesis from petroleum. Project the percentage of the U. S.

beef market that could be captured by these meat substitutes and determine the resulting impact on the demand for forages.

3. Evaluate the competitive position of resources for forage production versus the use of these resources in the production of food for domestic and foreign use or feed for export.

Potential benefit from research:

In recent years, large shifts have occurred in the location of production of various grains, oilseeds, and fibers. At the same time, changes have occurred in the demand for meat and in the relative prices of forages and feed grains. Research to determine the effect of these factors on beef production and recommendations for the shift of beef production among regions will help the industry foresee and prepare for adjustments and regional shifts, if necessary. Research as to the extent of the red meat market to be captured by meat substitutes will alert the beef industry as to potential demand requirements and allow time to shift supply to keep the market in balance.

RPA 510 GROUP ACTION AND MARKET POWER

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
		2.0

Problem situation in the industry and justification for research in this RPA:

Most cattle producers in the United States have herd sizes of less than 50 cows. Producers with small and medium-sized herds are finding it more and more difficult to compete with large units in the prices they receive for their products and the prices they pay for inputs. Research on group action, such as grazing associations, and other methods of managing range resources and livestock could improve their competitive position and reduce the continuing exit of producers from farming and ranching. Alternative marketing institutions, such as movement to a teletype auction system, could improve the competitive position of producers, as well as improve pricing and marketing efficiency.

Objectives and (or) research approaches:

1. Evaluate alternative forms of producer group action as related to beef production and marketing.
2. Assess alternative institutional devices for more effective marketing.

Potential benefit from research:

The major benefit from research in this area is the improved competitive position of producers with small and medium-sized units that could result from improved bargaining ability and increased efficiency in the marketing institutions.

RPA 603 TECHNICAL ASSISTANCE TO DEVELOPING COUNTRIES

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
		4.0

Problem situation in the industry and justification for research in this RPA:

In recognition of our vital stake in a peaceful and prosperous world and the needs of other countries to support their own requirements for livestock products, the United States has undertaken programs of technical assistance to

developing countries. Research objectives in this area relate to the development and adaptation of technology relating to efficient livestock and forage production for other regions of the world that may have soil and climatic conditions similar to those existing in the North Central Region.

Objectives and (or) research approaches:

1. Adapt technology developed for production of forage crops in the North Central Region for application in other parts of the world where similar climate and other crop conditions may exist.
2. Determine breeds and enterprise combinations that could be adapted to existing and improved forage conditions in other parts of the world where climate and other growing conditions are similar to the North Central Region.

Potential benefit from research:

Increased worldwide per-capita consumption of livestock products necessitates the transfer of knowledge of efficient livestock and crop production systems to other countries of the world, especially the less developed nations. By helping to increase their productive capacity, the United States can benefit through increased trade and goodwill.

RPA 701 INSURE FOOD PRODUCTS FREE OF TOXIC CONTAMINANTS INCLUDING RESIDUES FROM AGRICULTURAL AND OTHER SOURCES

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.2	0.2	5.2

Problem situation in the industry and justification for research in this RPA:

Research on toxic residues of agricultural origin is needed to determine the levels and circumstances under which chemicals may be safely used in crop and livestock production. There is widespread public concern as to the nature and seriousness of the hazards caused by the use of chemicals in production of farm products. Farmers have a vital stake in detection and elimination of these hazards because of their possible effects on human health, resulting hesitancy on the part of the consumers to buy certain farm products, and the income loss that may occur if products are not acceptable. Major research objectives in this area would include a variety of topics relating to the development of safer chemicals, the development of production methods that minimize the need for chemical application, a better understanding of metabolic pathways and possible residue hazards, the development of more accurate methods for determining residues that may exist in forages and animal products, and the development of effective techniques for decontamination of forages and animal products that may contain harmful residues.

Objectives and (or) research approaches:

1. Identify toxic and safe levels of chemicals used in forage production as they relate to use in the ultimate production of food for human consumption.
2. Develop rapid and low-cost methods for evaluation of chemicals used in forage production; evaluate the toxicity of these chemicals and their metabolites in feedstuffs and foodstuffs.
3. Identify metabolic pathways and eventual fates of chemicals used in forage production in both plant and animal materials.
4. Develop procedures and equipment to reduce or eliminate the possibility of toxic residues in forage crops.

5. Develop methods for decontamination or detoxification of animals that have consumed or contacted harmful chemicals.

Potential benefit from research:

The producer will benefit from the proposed research studies because the continued use of agricultural chemicals helps to insure that production per acre will be optimal. The consumer also benefits because of the assurance of a low-cost and healthful food supply. The proper use of agricultural chemicals should allow for a healthy agroecosystem in which commodities may be produced to the best advantage for all people in society.

RPA 702 PROTECT FOOD AND FEED SUPPLIES FROM HARMFUL MICROORGANISMS AND NATURALLY OCCURRING TOXINS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.2	2.2	5.2

Problem situation in the industry and justification for research in this RPA:

Agriculture has a responsibility for insuring the production of safe foods and feeds. The United States enjoys a reputation for food supplies that are microbiologically among the safest in the world. To maintain this high-quality food supply and the associated safety that we enjoy, it is essential that research efforts in this area be directed toward a variety of approaches that insure continued safety. Major research objectives would include techniques that eliminate the possibility of harmful microbiological contamination of forages in the interest of animal health, as well as any associated effects that might influence the safety of meat produced from such feeds.

Objectives and (or) research approaches:

1. Develop economically feasible procedures to reduce or eliminate harmful microorganisms in waste products being recycled as feedstuffs.
2. Develop methods to effectively detect and treat animal carriers of harmful microorganisms as well as methods of protection for noninfected animals.
3. Develop effective methods to prevent contamination of livestock forage with harmful microorganisms of human origin.
4. Develop procedures for processing and handling waste products applied to forages to prevent contamination and promote microbiological safety.
5. Develop methods to more accurately detect mycotoxins in forages and to prevent contamination of forages or eliminate them from such materials.
6. Develop cropping procedures, including cultivation, chemical treatment, harvesting and storing, that minimize the possibility of forage contamination by molds, fungi, and toxin.
7. Identify harmful microorganism pathways between humans and animals and develop chemical or physical inhibitors to block those pathways.
8. Identify and develop varieties of forages resistant to microbiological spoilage or naturally low in toxins and allergens.
9. Identify microbiologic methods of inhibiting or modifying the growth of molds, fungi, and other toxin-producing microbial agents in forages.

Potential benefit from research:

The research information provided will allow the

American consumer to have a continued abundant supply of meat that is relatively free of microbiological contamination. Information on the role of mycotoxins in diseases of man and animals is needed because the complete nature of this problem has never been fully explained. There are numerous economic and agro-ecosystem benefits if ways can be found to remove harmful microbial contaminants from animal wastes recycled as feeds. As livestock-raising practices move toward increased confinement of animals, the possible contamination of meat will increase, and methods must be found to reduce this possibility. If newer methods are found to effectively detect and treat animals with potential pathogenic microorganisms, this will reduce losses from disease and consequently lower production costs and cost of meat to the consumer.

RPA 901 ALLEVIATION OF SOIL, WATER, AND AIR POLLUTION AND DISPOSAL OF WASTES

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
0.2	1.2	7.2

Problem situation in the industry and justification for research in this RPA:

Soil, water, and air can be polluted with a variety of substances, both inorganic and organic. Some of the contaminants, in addition to those of industrial origin, are organic pesticides, growth-regulating chemicals, animal and crop wastes, pathogenic microorganisms, heavy metals, salts used for de-icing, lead from fuel combustion, and allergens and other materials. Agricultural research must be primarily concerned with alleviating pollution initiated by agricultural practices and methods for alleviating the effect of pollution-containing forages on the consuming animal as well as the ultimate effect on products produced from such forages. Major research efforts in this area should include identification of pollution sources that might commonly contaminate forages, the development of a better understanding of the metabolic pathways and fates of such materials, the establishment of acceptable levels of hazardous materials in the forages, and the development of appropriate waste-management systems that permit livestock producers to meet regulations relative to livestock waste handling.

Objectives and (or) research approaches:

1. Identify and characterize pollutants from agricultural sources and determine the frequency of their discharge.
2. Determine processing methods that will reduce pollutants in soil, air, and forages by removal of these pollutants from waste products.
3. Establish pollution-control standards for maximum contamination levels.
4. Identify pathways and time course for destruction of harmful pollutants that have already entered the general environment.
5. Establish acceptable waste-management systems that will meet regulations for present and future environmental protection.

Potential benefit from research:

The increasing need for meat will require an increased population density of animals on a given area of land. The research proposed will help provide the methods so these goals can be reached without increased pollution of the soil, air, and water. With increased animal production, there will

also be increased need for forages, so ways must be found to satisfactorily control pollutants from chemicals used in forage production. The proposed research should allow for a closer interaction of animals and man in the environment and improve the conditions in which this relationship occurs.

RPA 903 MULTIPLE-USE POTENTIAL OF FOREST LAND AND EVALUATION OF FORESTRY PROGRAMS

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
		2.0

Problem situation in the industry and justification for research in this RPA:

Most forest areas and related resources can be devoted to a wide variety of uses, depending on the owner's objectives and the allocation of investments for resource development. Much of the forest area of the North Central Region is associated with forage species that can be used for livestock production. Research information is needed to determine the best combination of uses for the forest areas on the basis of costs and long-term returns. Areas of research needed are related to management for forage production while maintaining the resource for wildlife, recreation, water, timber, and related purposes.

Objectives and (or) research approaches:

1. Determine workable combinations of forest land resource and grazing enterprises that optimize efficiency of use of these resources.
2. Develop feasibility studies for evaluating the relative cost and return of alternative forest land uses.
3. Determine the impact of expanded recreational facilities on the total productivity on forest and range lands.
4. Develop a system of computer data storage on a regional basis that will be capable of aiding in the decision-making process relative to resource use.

Potential benefit from research:

Forested areas, either natural or seeded, provide the unique habitat necessary for many wildlife species. These areas also provide unique recreational areas and often are capable of providing grazing for livestock. Evaluation of systems for integration of these multiple uses will provide guidelines for obtaining optimum levels of use from each component of the multiple-use system, while providing adequate protection to the resources involved and maintaining their aesthetic values.

RPA 904 FISH AND OTHER MARINE LIFE, FUR-BEARING ANIMALS, AND OTHER WILDLIFE

Present and Recommended Science Years of Effort:

FY 1974	FY 1980	FY 1985
20.1	21.1	25.1

Problem situation in the industry and justification for research in this RPA:

Research on wildlife, fur-bearing animals, fish, and other marine life is needed to meet the ever-growing demands of hunters, trappers, and fishermen. Specific areas of research include ecological and physiological requirements of these species, the selection and genetic improvement of plant species to provide feed and cover for them, and the study of management practices such as fertilizing, burning,

species manipulation, and season of use by domestic livestock to determine their effect on both land and water habitats.

Objectives and (or) research approaches:

1. Select and develop plant materials that adapt well to the North Central Region and provide food and cover for aquatic and terrestrial wildlife.
2. Develop methods of timber and forage management that optimize environment for wildlife development, including procedures for establishing, chemically treating, con-

trolling, and harvesting of trees and forages.

Potential benefit from research:

Increased knowledge of ecological and physiological requirements of wildlife, fur-bearing animals, fish and other marine life, and knowledge of livestock management practices conducive to maintaining and improving habitat, will insure maintaining all species in a productive condition, which, in turn, will insure the maintenance of recreational and aesthetic values, while making optimum use of forage, timber, and other resources associated with them.

Present and Recommended Science Years of Effort

TABLE 1. RESEARCH AND RECOMMENDED SCIENCE YEARS OF EFFORT

Project	Present	Recommended
1. Select and develop plant materials that adapt well to the North Central Region and provide food and cover for aquatic and terrestrial wildlife.	1.0	1.0
2. Develop methods of timber and forage management that optimize environment for wildlife development, including procedures for establishing, chemically treating, con-	1.0	1.0

Objectives and (or) research approaches:

1. Determine workable combinations of forest land use, timber, and forage enterprises that optimize efficiency of land use.
2. Develop feasibility studies for evaluating the impact of forest land use on wildlife habitat.

Potential benefit from research:

Increased knowledge of ecological and physiological requirements of wildlife, fur-bearing animals, fish and other marine life, and knowledge of livestock management practices conducive to maintaining and improving habitat, will insure maintaining all species in a productive condition, which, in turn, will insure the maintenance of recreational and aesthetic values, while making optimum use of forage, timber, and other resources associated with them.

Present and Recommended Science Years of Effort

TABLE 2. RESEARCH AND RECOMMENDED SCIENCE YEARS OF EFFORT

Project	Present	Recommended
1. Determine workable combinations of forest land use, timber, and forage enterprises that optimize efficiency of land use.	1.0	1.0
2. Develop feasibility studies for evaluating the impact of forest land use on wildlife habitat.	1.0	1.0

water infiltration, and some use by livestock to determine their effect on soil and water balance.

Objectives and (or) research approaches:

1. Select and develop plant materials that adapt well to the North Central Region and provide food and cover for aquatic and terrestrial wildlife.
2. Develop methods of timber and brush management that create an environment for wildlife development, including procedures for establishing, chemically treating, and

pruning and harvesting of species and forage.
Potential benefit from research:

Increased knowledge of ecological and silvicultural requirements of wildlife, fur-bearing animals, and other mammals and knowledge of livestock management practices will be useful in maintaining and improving land use systems supporting all species in a productive and sustainable manner. This research will ensure the maintenance of recreational and aesthetic values while making optimum use of large timber production areas associated with them.



The Experiment Station conducts its programs without discrimination as to race, color, sex, or national origin.