WILL MORE FORAGE PAY?

Economic Aspects of Using More Pasture and Forage on Farms

A Progress Report

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More than 60 farmers who have made progress in emphasizing forage production and utilization contributed their experiences toward development of the study.

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Prepared in the Bureau of Agricultural Economics

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INTRODUCTION[1]

Much is being done to explore the possibilities of increasing industrial utilization of both the basic and the waste products of agriculture. Less spectacular yet of as great, if not greater, significance are the possibilities in increased utilization of farm products on the farm. Wherever it is feasible to substitute forage crops on acres now producing corn, cotton, or wheat and to utilize them profitably through livestock, opportunities exist for combating the threat of surplus production of these crops. Adjustments of this type also work toward improving the national diet, conserving soil resources, and lending greater stability to farm incomes.

Those interested in either on-farm or off-farm utilization of farm products are faced with essentially these questions: (1) Is the proposed means of utilization technically feasible? (2) Will it pay the individual producer? and (3) Will it be to the advantage of the United States as a whole?

New industrial products derived from an agricultural source must compete both in performance and in price with those derived from

[1] This report was prepared as part of a study which has been supported by funds appropriated under authorization of the Research and Marketing Act.

other sources of raw materials. So too, on farms forages frequently compete directly with cash crops that are important sources of income. Their adoption or expansion hinges directly on the question of their profitable utilization. For an individual farm, the shift may involve a whole series of adjustments that call for time, money, and management. It may mean application of lime and fertilizer, purchase of seeds, fencing of fields, erection of farm service buildings, and buying new farm machinery. Additional livestock enterprises or greater emphasis on existing enterprises may be needed as well as a recasting of the whole program of farm labor and its distribution. The relative importance of these factors varies from farm to farm and from area to area, making the question of profitable utilization of farm forages one on which farmers everywhere need assistance.

Important segments of the information currently needed to make clear-cut appraisals are lacking. Research has not yet been developed, nor has farmer or rancher experience been sufficient to permit wide generalizations. The immediate problem then becomes one of fitting together what is available, supplemented when necessary with the best judgment of competent workers, so that a first approximation may be made toward the answers that are needed, and the way pointed toward more detailed studies that will provide more definite answers.

The hypothesis upon which this study rests is that it is desirable to shift more of our land resources to production of forage if producers can find ways to utilize the forage efficiently and profitably. Three major assumptions are made: (1) That surpluses of cash crops such as cotton, wheat, and corn may again prevail and that profitable alternative uses for some of the land now producing such crops will be needed; (2) that increased production of livestock and livestock products would be desirable from the standpoint of dietary deficiencies and consumers' food preferences; and (3) that a shift to forage crops from the cash crops which may be in surplus will tend to retard erosion and help to maintain soil fertility.

The analysis logically falls into three parts: (1) A review and appraisal of pertinent experimental data and inquiry into the experience of limited numbers of farmers and ranchers who have pioneered in forage production and utilization; (2) a more intensive appraisal of opportunities for profitable forage expansion and use in important farming systems in representative areas of the country; and (3) the aggregate effects of additional forage production and use on farms. This report deals with the first or reconnaissance phase and work is now going forward on the second.

In addition to consideration of effects on individual farms the aggregate effects that might result from more widespread production and utilization of forages also need study. As acreage in grasses and legumes expands, what crops will be displaced? Will significant changes occur in volume of crops that periodically are in surplus, such as corn, cotton, and wheat? What changes may we expect in volume of milk and meat produced and from what areas will much of the increase come? Will there be shifts in relative importance of different classes of livestock and in quantity and quality of livestock production? Will we be able to provide the meat and milk now needed to improve the national diet? Will the market for oilseed meals and other supplemental feeds increase or decrease as forages increase and are more fully used? What will be the effect on conservation of land resources and on stability of our systems of farming? Seeking answers to these and other related questions is the problem of the study upon which this report is based.

Part of the information needed for the analysis comes from the natural scientists who work to improve our grasses and legumes, and from those who study the feeding of livestock. But an equally important part is contributed by farmers and ranchers who have made progress in extending forages either by utilizing results of research or by their own experimentation. Using the best available data from these sources as to items that must be invested and the resulting outputs of grass and livestock products, prices and costs are applied to appraise the result in terms of income for typical farming situations. And incomes are examined both under conditions of favorable and less favorable price and cost relationships.

This comprehensive approach will involve studies over a period of several years. Funds and personnel are available for intensive work only in a limited number of areas representative of the more important situations in which increased utilization of forage seems possible. Appraisal of the aggregate effects on the national economy must necessarily wait upon results from the intensive area studies.

Although many considerations raised in various phases of this study are incapable of exact solution the work should provide a growing fund of information that will offer considerable guidance to farmers interested in expanding the use of forages. It should also provide some basis for forming judgments regarding the aggregate effects of more grass in farming systems—in possible changes in the Nation's pattern of crop and livestock production, in recognizing which areas have the greatest advantage in making such shifts, in gaining appreciation of factors that may promote or hinder such adjustments, and in general providing the understanding necessary to competent guidance of important segments of our agricultural programs.

FEED SUPPLIES AND THEIR UTILIZATION

Before turning to the story of the first year's work on this project, a few points regarding the present importance of forages in agriculture are presented. For the most part, production and use of forages are identified with the Nation's livestock industry which makes a very important contribution to agricultural production. In 1946 about 27 percent of the Nation's gross farm production was made up of livestock and its products when measured in terms of 1935–39—average dollars. This relationship remains fairly stable; it varied during the last quarter century from a low of 25 percent in 1937 to a high of 33 percent in 1934. The severe droughts of 1934 and 1936 are largely responsible for these variations, first by sending unusually large numbers of stock to market when supplies of feed were drastically cut and in the same process curtailing numbers that normally would have been marketed a few years later.

But such comparisons stand out in even bolder relief when made against the Nation's food supply alone. In 1946 about 45 percent by weight of all food consumed in the United States, nearly 49 percent of its nutrient content, and about 60 percent of all food expenditures were for livestock and livestock products. Consumption of citrus fruits, leafy green and yellow vegetables, and livestock and its products has advanced more rapidly than has that of other foodstuffs since 1935–39. Dietary habits formed during a period of high purchasing power are not easily cast aside under less prosperous conditions; and should consumers' purchasing power be maintained, dietary habits may well make additional gains which will involve an even greater proportion of our national food supply in the form of livestock and livestock products.

It has been estimated that if per capita consumption were to be increased 8 percent above 1946 rates and if the national food supply were in a form which would satisfy dietary needs, and desires, our 1955 population would require 10 percent more dairy products, 18 percent more meat, poultry and fish, 9 percent more fats and oils, including butter, bacon and fat cuts, and 29 percent less grain products than the record quantities produced for food (*4*, *tables 14*, *18*).[2]

Meat and milk, however, are end products of the farm assembly line. They depend in turn upon production of forages, commercial byproducts, and feed grains which are utilized through livestock. And, as shown in table 1, this feed base for livestock employs a surprisingly large proportion of the land that is devoted to agricultural uses in the United States.

Of our nearly 2 billion acres (1.9 billion) of land area, about two-thirds contribute in greater or lesser degree to livestock production. Roughly a third of this land is outside of farm boundaries; it furnishes grazing on public or private forested areas and on our public domain. The remaining two-thirds within farms is again largely made up of grazing lands of varying degrees of productivity. In 1944, for instance, of 845 million acres of farm land that contributed directly to livestock production, 576 million were woodland pasture, nonplowable pasture, or plowable pasture in addition to rotation pasture. The remaining 269 million acres represented a part of the cropland base, about 60 percent of all cropland in 1944. The cropland acreage is more productive. It includes 161 million acres of feed-grain crops, corn, sorghums, oats, and barley; 60 million acres of all kinds of hay crops; and 48 million acres of cropland used only for pasture.

In addition to these direct sources of livestock feed we must not forget the important direct contributions that result from production of a number of our cash crops. Cottonseed, flaxseed and soybean meals, beet tops and pulp, and even the gleanings from crop aftermath are examples.

But what of the relative importance of these sources of livestock feed and in particular of the roughages with which the study was especially concerned? Table 2 indicates that during the period 1942–46 roughage supplied almost 55 percent of all livestock feed, whereas concentrates, in one form or another, supplied the remaining 45 percent.

The feed grains—corn, oats. barley, and sorghum grains—and wheat and rye fed contributed 36 percent of the total feed units fed to livestock during the period 1942–46. Corn, by far the most important of the feed grains, furnished about two-thirds of these feed units and this excludes the corn fed in silage. Oats supplied about half of the

[2] Italic numbers in parentheses refer to literature cited, pp. 88–90.

remaining third, with wheat, sorghum grains, and rye making up the balance in the order named.

TABLE 1.—*Lands contributing directly to livestock feeds and total land area, United States, 1944* [1]

Item	Acreage	Percentage of United States land area
	Million acres	*Percent*
Cropland:		
Feed grains	161	
All hay	60	
Used only for pasture (rotation pasture)	48	
Total	269	14. 1
Grazing land:		
On farms and ranches:		
Woodland	95	
Nonplowable	420	
Plowable (in addition to rotation pasture)	61	
Total	576	30. 2
Not on farms and ranches:		
Nonforested	178	
Forested	250	
Total	428	22. 5
Grand total	1, 273	66. 8
Land area of the United States:		
Not in farms	763	40. 1
In farms:		
Cropland	451	23. 7
Other	691	36. 2
Total	1, 142	59. 9
Grand total	1, 905	100. 0

[1] United States Census of Agriculture, 1945 (*34*) and Graphic Summary of Land Utilization in the United States. (*35*)

Commercial byproduct feeds include oilseed cakes and meals, millfeeds, animal proteins, and such miscellaneous items as corn byproducts, alfalfa meal, and brewers' and distillers' dried grains. About half of the 7.3 percent of the total feed units contributed by commercial byproducts comes from oilseed cakes and meals, about 30 percent from millfeeds, 10 percent from animal proteins, and 10 percent from miscellaneous sources.

Of the other concentrates, shown in table 2 to contribute less than 2 percent to the total supply of feed units, about 60 percent comes from seeds such as peanuts, velvet beans, cowpeas, and cottonseed fed or grazed, with skim milk, buttermilk, and whey fed as liquids making up the remaining 40 percent.

TABLE 2.—*Relative importance of different sources of livestock feed, United States, average 1942–46* [1]

Item	Percentage of total feed units
	Percent
Concentrates:	
All feed grains [2]	36. 1
Commercial byproducts	7. 3
Other	1. 8
Total	45. 2
Roughage:	
Hay	15. 6
Pasture and grazing	34. 1
Other	5. 1
Total	54. 8
Total feed	100. 0

[1] All feeds converted to a feed-unit basis in terms of equivalent of pounds of corn.
[2] Excluding corn in silage.

Unpublished data, Bureau of Agricultural Economics, R. D. Jennings.

Table 2 indicates that nearly 16 percent of the 1942–46 feed units were derived from hay crops. Alfalfa furnished about a third of these feed units from hay, clover and timothy about 30 percent, wild hay from 10 to 13 percent, with the remainder from soybeans, grains, peanut vines, cowpeas, and sweetclovers.

Pasture and grazing was second only to feed grains as a supplier of livestock feed during 1942–46; it contributed well over a third of the total feed units. Although it is difficult to estimate the relative importance of the different types of pasture and grazing lands, they may be ranked roughly in the following order: Rotation and plowable pasture on farms and ranches; nonplowable and woodland pasture on farms and ranches, grazing land not on farms and ranches; and crop residues pastured (table 1).

Other types of roughage such as corn and sorghum silage, wet beet pulp, sorghum forage, and corn stover supply about 5 percent of the Nation's livestock feed. Corn stover contributes about a half and the silages nearly another half of the feed units supplied by this group.

Both concentrates and roughages are included in the rations for each class of farm livestock but their relative importance varies widely. On an average, less of the feed for hogs and poultry is composed of roughages but dairy and beef cattle, horses, mules, and sheep derive well over two-thirds of their feed from this source (table 3). This characteristic is so pronounced that different classes of livestock are commonly thought of as roughage-consuming or grain-consuming types. But this is only a rough distinction. Dairy cattle generally obtain some grain as well as hay and pasture, whereas the fattening of feeder stock on concentrates is an important farm enterprise in many areas. Draft animals are usually grained, at least while doing hard work. Study of table 3 will reveal important differences in the way each class of livestock utilizes feed.

Table 3.—*Sources of feed units for principal classes of farm livestock, United States, average 1942–46*

Item	Hogs	Poultry	Dairy cattle	Beef cattle	Sheep	Horses and mules
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Concentrates:						
All grain fed [1]	86. 6	70. 7	15. 8	15. 5	5. 0	31. 6
Commercial byproducts	6. 2	22. 7	8. 4	2. 3	1. 0	. 4
Other	4. 6	1. 9	2. 0	. 6		
Total [1]	97. 4	95. 3	26. 2	18. 4	6. 0	32. 0
Roughage:						
Hay			26. 5	14. 1	12. 5	33. 1
Pasture	2. 6	4. 7	37. 4	60. 0	78. 4	32. 6
Other			9. 9	7. 5	3. 1	2. 3
Total	2. 6	4. 7	73. 8	81. 6	94. 0	68. 0
Total feed	100. 0	100. 0	100. 0	100. 0	100. 0	100. 0

[1] Excluding corn in silage.

Unpublished data, Bureau of Agricultural Economics, R. D. Jennings.

Another facet of the feed-utilization story is presented in table 4. During the period 1942–46 hogs consumed nearly 43 percent of all grain fed to livestock in the United States and the three kinds of livestock—hogs, poultry, and dairy cattle—took nearly 80 percent of all the grain fed.

Poultry and dairy cattle were the largest consumers of commercial byproduct feeds such as oilseed meals, each utilizing well over a third of the total quantity fed. Dairy cattle took well over half the hay, and beef cattle and farm-produced power (horses and mules) each accounted for about a fifth of the total hay fed. Beef and dairy cattle were the principal consumers of pasture, as sheep numbers were at abnormally low levels. More than 60 percent of the other roughage such as corn and sorghum silage, corn stover, wet beet pulp, and sorghum forage were utilized by dairy cattle in 1942–46.

Tables 2, 3, and 4 present a picture of the relative importance of different sources of livestock feed for the country as a whole. Specific relationships for any local area are likely to vary significantly from the national averages, however. During the war tentative information was assembled on common rates of feeding in the different States. These showed that milk cows in Western States are fed around 1,500 pounds of concentrates and about 5,500 pounds of hay per year as compared with 2,500 pounds of concentrates and 4,000 pounds of hay in

Northeastern States. Horses and mules got only around 400 pounds of concentrates in the West as compared with nearly six times this quantity in Southern States. In general, Western States tended to make as full use as possible of their high-quality legume hays that are largely produced under irrigation, reducing concentrate feeding in the process. In areas in which concentrate feeds are produced in quantity, they tended to assume greater importance in the livestock ration.

TABLE 4.—*Percentage of the total units of each kind of feed that was utilized by different classes of livestock, United States, average 1942–46*

Item	Hogs	Poultry	Dairy cattle	Beef cattle	Sheep	Horses and mules	Other livestock [1]	Total
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Concentrates:								
All grain fed [2]	42.7	22.3	13.6	9.1	1.0	8.6	2.7	100
Commercial byproducts [3]	14.9	35.2	36.5	6.7	.9	.4	5.4	100
Other [4]	46.7	12.1	34.6	6.6				100
Total	38.3	24.1	18.2	8.6	1.0	6.8	3.0	100
Roughage:								
Hay [5]			53.2	19.0	5.7	20.5	1.6	100
Pasture [6]	1.4	1.6	34.3	37.0	16.5	9.2		100
Other [7]			60.6	30.8	4.3	4.3		100
Total	.8	1.0	42.1	31.3	12.3	12.0	.5	100
Total feed	17.8	11.4	31.3	21.0	7.2	9.7	1.6	100

[1] Livestock in cities and farm livestock for which there are no statistics such as ducks, geese, guineas, pigeons, etc.

[2] Corn, excluding that in silage, barley, oats, sorghum grains, wheat, and rye.

[3] Oilseed meals, animal proteins, corn byproducts, grain millfeeds, alfalfa meal, brewers' and distillers' dried grains, etc.

[4] Velvet beans, cowpeas, soybeans, peanuts, cottonseed, etc., fed or grazed; skim milk, buttermilk and whey fed on farms (dry equivalent).

[5] All tame and wild hay.

[6] Based largely on estimates of numbers of livestock on hand Jan. 1 and estimates of pasture condition.

[7] Corn and sorghum silage, wet beet pulp, sorghum forage, and an estimate for corn stover.

Unpublished data, Bureau of Agricultural Economics, R. D. Jennings.

Although there is latitude for substitution between feeds, much remains to be done to establish levels of production to be obtained from rations carrying different proportions of feeds. Further work is needed, both to determine the technical possibilities and to appraise their effects on farm profits.

A REPORT OF PROGRESS

Work on the reconnaissance phase of this project got under way in October of 1947. Three full-time professional men—one each for the Northern, the Southern, and the Western States did the research. The results of their preliminary examinations of experimental work and of farmer and rancher experience are contained in this progress report.

In the Northern States many research workers and farmers were interviewed during the first year. A limited number of production plans representative of some important farming situations in the Corn Belt have been developed to illustrate opportunities for increasing forage utilization on farms and some of the problems involved.

As part of the more intensive work in the second phase of the study as it relates to the Northern States, an appraisal of farming adjustments with special reference to the economic utilization of more grass and legumes is now being made for the Ida-Monona soil area of western Iowa. This study, a cooperative undertaking with the Iowa Agricultural Experiment Station, seeks to find the relative profitableness to individual farmers of alternative systems of farming based upon different levels of grass and legume production and utilization. Major changes in sytems of farming and in soil-management practices are needed in this steeply rolling area to maintain and improve soil resources. The effects that utilization of more forages would have on individual farm costs and returns and on the pattern of farming in the area are not clear. Factors that accelerate and impede the rate of progress in forage extension in the area will be studied, as well as interfarm and inter-area movement of feed crops, possible changes in number and size of farms, in the market supply and price situation, and related factors.

Other intensive work in the Northern States is planned for selected areas of the Lake States. Here potential economic benefits and farm-management problems associated with the utilization of grass silage are to be studied for typical systems of farming. Cooperative work is expected to begin during the last half of 1949. Many agronomists, animal husbandmen, and agricultural engineers in this area are convinced that making the first cutting of legumes and grass into silage, using improved machinery and techniques already developed, produces more and better quality feed at lower cost per unit than does making it into hay. Yet few farmers on small and medium-sized farms have adopted grass silage. Reasons for this situation are to be sought in this investigation.

The Southern States present a wide variety of physical and economic problems in extending forage production and utilization. Only in recent years have advances in plant breeding and in methods of livestock production made it feasible to consider livestock systems of farming as serious competitors of cotton, and even yet such systems are not practicable in all portions of the area because of conditions of soil, climate, and topography.

During the reconnaissance year, major emphasis in these States was on gaining an understanding of the varied problems and possibilities in forage utilization over wide areas of the South. In this report experiences of a number of farmers who have made progress in using the forages illustrate problems that need further consideration in intensive studies.

The first of these is being made in cooperation with the Alabama Experiment Station where alternative systems of farming in the

Piedmont area of the State are being studied with special attention given to those systems that emphasize utilization of pasture, hay, and other forage. A considerable number of farmers are being interviewed and out of this group a smaller number is being selected for special study. A number of visits are being made to the latter group throughout the year to obtain current and detailed records of feed production, feed purchases, grazing and feeding practices, grazing record by fields, and production of meat and milk. Equal attention is being given to costs of pasture establishment and maintenance and returns from sales of seed and hay, or from use as a soiling crop. These data, together with those obtained from experimental results, should provide a basis for economic evaluation of alternatives available to farmers in much of the Piedmont area.

In the Western States ranching, dry farming, and irrigation are found singly and in combination. In all these situations opportunities exist for increasing the quality and quantity of forage production and for greater efficiency in its use. During the reconnaissance year attention centered largely on the economic feasibility of substituting range grasses on some of the lower yielding wheat lands found on representative ranches and wheat-livestock combinations in the northern Great Plains. Attention was given to methods of revegetation that are technically feasible and economically profitable and to problems facing farmers and ranchers during the years needed to bring about the adjustments. Preliminary findings from these studies are presented in this progress report.

More intensive work is now under way in cooperation with the Kansas Agricultural Experiment Station. In Kansas, in anticipation of possible surpluses of and lower prices for wheat an economic appraisal is under way of the possibilities of utilizing wheat for feed and its relationship to forage production and utilization in representative wheat-producing areas. Under such conditions, alternatives open to farmers could include growing wheat and selling it at a feed price or establishing livestock enterprises and utilizing wheat as a feed, together with forages obtained by reseeding the less productive wheat lands to grass, and by winter grazing some of the small grain crops. Analysis will be confined to possibilities and problems on representative farms and ranches in western Kansas. Similar work in the wheat-producing areas of the northern Great Plains and the Pacific Northwest is planned for the year ahead to obtain a well-rounded picture of alternatives open to farmers in the main wheat-producing areas of the country.

Other intensive work is needed in the western irrigated valleys where forages may serve to introduce greater stability into farming systems and at the same time to alleviate surplus production of cash crops such as potatoes.

SUMMARY OF PRELIMINARY FINDINGS

The reconnaissance work of the first year was the basis for development of some preliminary conclusions and it has laid the necessary foundation for more intensive work to follow. Subsequent phases will provide a better basis for drawing conclusions as to the economic feasibility of greater emphasis on forage production and utilization on

American farms. Statements at the end of each of the regional sections summarize what can be said about the work done to date. (See pp. 36, 54, and 79.) Following are some tentative observations of a more general nature arising out of the study.

1. In all sections of the country are farmers who have made progress in developing systems of farming that make more use of the forage crops. Many of these farmers are above average in managerial ability, skilled in handling of livestock, or have adequate capital reserves for making changes in their farming systems. The present farming systems of some of these farmers have been achieved through a process of evaluation and experimentation covering extended periods of time. Although they have made use of results of research and of the experience of other farmers, considerable effort and ingenuity have been necessary to adapt them to their individual situations.

2. There is an extremely wide range in farmer investment for handling and harvesting forage. In some instances forage is harvested by livestock grazing it off; in others heavy investments are incurred for field choppers or balers, elevators, barn driers, silos, etc. This is an important consideration in obtaining the greatest economic advantage from farming systems organized to give greater emphasis to forage production and utilization.

3. Where shifts are made from cash-crop systems of farming to those that emphasize forage production and its utilization through livestock, additional skills and a higher type of management are required of the farm operator.

4. Factors that tend to encourage production and utilization of more forage in farming systems are:

(*a*) Reserves of capital accumulated during the war years which farmers are willing to invest in developing more stable farming systems. A temporary reduction in current income can now be experienced with but little inconvenience for the sake of more stable future incomes.

(*b*) Realization is growing that soil resources are exhaustible and that increased emphasis on forage production and utilization affords an effective means of maintaining and even of increasing fertility reserves.

(*c*) State and Federal educational and action programs, with their emphasis on soil and water conservation and stability in farming, together with the various incentives offered to induce change, continue to be important in stimulating farmer interest.

(*d*) Development of new and improved forage crops and the increasing body of knowledge regarding possibilities for profitable utilization are having a cumulative effect.

(*e*) Wartime experience with high prices for feed grains, particularly in feed-deficit areas, stimulate farmer interest in home-grown leguminous forages of high quality.

5. Factors that tend to retard production and utilization of more forage in farming systems are:

(*a*) Greater *current* returns from competing enterprises.

(*b*) Difficulty in some areas and on some farms in financing the investments necessary to initiate and develop systems that produce and utilize more forage. Principal outlays that may be involved in additional forage production are for fertilizers, grass seeds, fencing, and equipment for producing, harvesting, and storing the crop. Those involved in forage utilization may include investments in livestock and in the buildings and equipment needed to service a livestock enterprise. Not all of these items constitute problems for every farmer who adjusts toward greater emphasis on forages but some of them are sure to have their impact. The relative scarcity of grass and legume seeds is perhaps one of the most commonly experienced retarding factors and the current high price of these seeds is a real impediment in some areas.

(*c*) Concentration on short-run profits at the expense of long-time farm stability and reluctance to experience an adjustment period of several years during which annual income may be below that currently realized.

(*d*) Failure to give as much attention to improved practices in production of high-quality hays and pastures as to the cash-crop enterprises on the farm.

(*e*) Systems of leasing land that discourage the tenant from making other than short-time investments.

(*f*) Farms that are too small to engage in other than intensive systems of farming.

(*g*) Unwillingness of operators of cash-crop farms to acquire skills needed in livestock production.

(*h*) Need in some instances for additional labor which the farmer is not interested in providing because it means working more hours.

(*i*) Farmer reluctance to assume risks. In many instances new techniques and unfamiliar practices must be applied and investments made with some degree of uncertainty regarding results.

In the northern Great Plains, for instance, many of the good stands of crested wheat grass during the last decade occurred in years of exceptionally favorable growing conditions as judged by past records. Although experimental seedings in 1933 and 1935 came through the droughts of 1934 and 1936, farmers are likely to wonder whether they can count on obtaining a good stand of grass in the 3 years assumed in this report. Longer periods of waiting would involve additional income deferments and make the adjustment both more difficult and more costly.

6. A growing body of research at the land-grant colleges and in the United States Department of Agriculture is designed to throw more light on production and utilization of forage. Much of the existing research data, although of value for other purposes, has only limited usefulness in this study. Many of the agronomic studies have been conducted on a plot basis and feeding experiments frequently have been confined to a single lot of high-quality animals and to a single feeding rate. Needed are experiments designed to approximate as closely as possible conditions found on representative farm units and the practical range of feeding rates and substitutions of one type of feed for another. Close cooperation between agricultural economists and natural scientists is desirable to insure that results of physical research will lend themselves to economic evaluation.

7. Among the additional physical data needed as a basis for economic evaluation are the following:

(*a*) Quantity of concentrates needed by milking cows when on good pasture of different kinds of grasses and legumes.

(*b*) Milk production that may be expected from individual cows when they are fed different proportions of roughages and concentrates.

(*c*) Effect on death loss, calf crop, etc., of feeding more good-quality forage and less concentrates.

(*d*) Amounts of concentrates and roughages required to carry different grades of feeder cattle to different well-defined slaughter grades when the proportion of concentrates and roughages is varied.

(*e*) Feed required and rate of gain when growing and fattening pigs are fed rations that contain varying proportions of concentrates and forages.

(*f*) Effect of stage of maturity of hay at time of harvest upon the quantity and quality of the resulting forage.

(*g*) Loss of feed nutrients from field-cured hay compared with barn-dried or ensiled hay in different farming areas.

(*h*) Relative soil losses, both in quantity of total soil and in mineral elements, that result from different cropping plans.

(*i*) Effects on crop and pasture yields and on the level of soil fertility of various cropping systems and combinations of cropping practices, including both the current systems and practices and those that give greater emphasis to forage production.

8. During the reconnaissance phase of this study it has not been possible to consider certain aspects that will need attention in more intensive phases of the work. Some of these may be mentioned:

(*a*) Grassland systems of farming that call for less intensive cultivation of the land are usually thought of as extensive systems that require larger acreages to provide an adequate farm income than do systems that apply more labor and capital to each acre. The whole problem of size of enterprise needs evaluation in its effect on the economic feasibility of extending use of the forage. The work to date indicates that many opportunities exist to give greater emphasis to forage production and utilization on present types and sizes of farms through small to medium increases in acreages of forage crops and by giving more attention to yield and quality of these crops.

(*b*) In this preliminary analysis, attention has been largely focused on the out-of-pocket costs involved in extending forage uses and in the net cash incomes that might result. Although recognition has been given to the influence of forages in maintaining and improving soil productivity, no money value has been placed on this contribution in the economic analysis. Variations in sales value of farms afford a poor basis for these evaluations as they are influenced largely by farmers' expectations of continuation of present levels of income and do not reflect actual changes in productivity of the land. This problem is not an easy one but it deserves study in any careful analysis of the net effect of adjustments in farming.

(*c*) Capabilities of the soils of individual farms need to be considered not only from the point of view of crops alone, but in relation to crops that are supported with such mechanical practices as terraces, contour planting, strip cropping, and the like. The use of such practices makes it feasible to keep some land in cultivation that otherwise would need to be kept in permanent grasses and legumes. The economic effects of using these practices in combination with different cropping systems on different soils needs further investigation.

(*d*) To date the analysis has been almost entirely in terms of effects on individual farms. Equally significant are aggregate effects on an area, a region, and the Nation as a whole. More grass and legumes mean fewer acres of other crops formerly using the cropland. More beef and milk may mean fewer hogs and less soybeans. What shifts in cropping and livestock patterns are foreseeable? What rates of progress are likely to be made in obtaining desirable adjustments? What effect will changes in systems of farming have on price relationships?

These are questions that cannot be accurately measured with the data now available, yet no adequate analysis can ignore them. In intensive phases of this study aggregate effects are to be studied, at least on the basis of representative farming areas. There it should be possible to appraise the extent to which forage crops might be expected to displace cash crops, to study interfarm movements of feed and livestock, inshipments of concentrates, feeds and forages, market outlets for more of the products of roughage-consuming livestock, and other factors that will have a cumulative effect as more and more farmers give greater emphasis to forage.

PROCEDURE AND METHOD

As previously indicated, work during the first year of this project has included survey and appraisal of past and present research in the fields of forage production and utilization to determine the more promising technical possibilities. The literature in these fields has been studied and many researchers at the land-grant colleges and in various branches of the Federal Government have given valuable assistance. Research results have been supplemented wherever possible with farmer experience to determine what happens under actual farming conditions when these adjustments are made.

Out of this combination of research results and their application on farms, economic appraisals have been made for a limited number of farming systems of the probable results of more forage on farm organization, operation, and cash income. In appraising the income possibilities of these farming systems it is necessary to use some level of prices and costs. Current levels are most convenient to use but current conditions are always subject to change. Prices received by farmers in 1947 were 278 percent of those for the base period 1910–14, whereas prices they paid for living and production, including interest and taxes, were 231 percent. Thus, 1947 was a year not only of high prices but also of very favorable relationship between prices received and paid by farmers. It is doubly necessary therefore that appraisals also be made for levels of prices and costs that represent less favorable conditions.

Farming systems, to be stable, must be able to weather the lean years as well as to take advantage of the more prosperous ones. Two levels of prices and costs have been selected, therefore, as bases for the economic appraisals that have been made. The nature of these is described in the following paragraphs.

In the report "Long-Range Agricultural Policy" prepared by the Bureau of Agricultural Economics for the Committee on Agriculture of the United States House of Representatives in March 1948 (*33*), careful study was made of situations that might exist during 1955–65 in the United States under different assumptions regarding employment, income, prices, and related factors. These, partially summarized in table 5, have been related to actual periods in the past.

The period 1942–46 nearly approaches the full-employment situation, whereas prices and costs of 1925–29 approximate the situation of intermediate employment-average level. The period 1935–39 is most closely identified with the situation of intermediate employment, depression level.

Price-cost data for the 1942–46 and 1925–29 periods have been used as general guides to test the farming systems discussed subsequently in this study. The relationships shown in table 5 for the country as a whole have been generally adapted to those actually prevailing in areas in which case farms are located. In the interest of simplification, reference is made to the "high level" and the "medium level" of prices and costs. The historical periods as such have little significance other than to aid in establishing general levels of farm prices and costs and internal price and cost relationships that conform with situations that have prevailed for agriculture. Indeed, *general* adoption of the forage-using systems of farming that are described would in all probability generate an entirely new set of farm price and cost relationships. These could have a considerably different effect upon farm returns from those used in this study, which assumes moderate rates of progress in the extension of forages in the near future.

TABLE 5.—*Indexes of prices received and paid by farmers, and parity ratio, assumed situations and selected historical periods, 1910–14=100*

Situation	Prices received by farmers	Prices paid by farmers [1]	Parity ratio [2]
High employment [3]	200	200	100
1942–46 (high price level)	196	170	115
Intermediate employment [3]	150	175	86
1925–29 (medium price level)	149	168	89
Intermediate employment [3]	100	150	67
1935–39 (low price level)	107	128	84

[1] Including interest and taxes.
[2] Ratio of prices received to prices paid, for commodities, interest, and taxes.
[3] For a more complete description of the conditions assumed to accompany these levels of employment see Long-Range Agricultural Policy (*33, table 4*).

NORTHERN STATES—PRELIMINARY FINDINGS

TECHNICAL POSSIBILITIES FOR THE PRODUCTION OF FORAGES

New and extended uses of forages in the Northern States—Corn Belt, Lake, and Northeastern States—are based upon species of grasses and legumes long known to be adapted to the soil and climatic conditions of this part of the United States. As these conditions vary

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within the area, no one species is universally adapted. Of the grasses, Kentucky blue grass, Canada blue grass, timothy, smooth brome grass, orchard grass, red top, Reed canary grass, meadow fescue, and sudan grass are most important. Outstanding among the legumes are alfalfa, medium red clover, mammoth red clover, biennial sweetclovers, white clover, Ladino clover, Korean lespedeza, and common lespedeza. Other grasses and legumes are often valuable as forage crops, particularly when some of the more important ones fail temporarily or when special pasturage is wanted (*36, pp. 391–454*).

Although high-producing species of grasses and legumes have been introduced into the Northern States in late years this has not prevented progress in development of better adapted and higher-yielding forages. Plant breeders have perfected new strains of both grasses and legumes. Much has been accomplished in obtaining inherently heavier producing strains and strains that are resistant to disease, heat, and drought.

Progress in obtaining increased production from forage crops has not been limited to plant breeding. A great deal has been learned in recent years about mixing grasses and legumes in seedings. Both experimental and farm results indicate that mixtures usually produce more heavily than do grasses and legumes when seeded alone. A complex mixture of sweetclover, red clover, alsike, and timothy, for example, produced more pounds of beef an acre than any single grass or legume checked in a study at the Illinois Experiment Station (*29, p. 38*). Some Illinois farmers find this mixture superior to more simple combinations of seeds. A mixture of alfalfa, red clover, Ladino clover, and either timothy or smooth bromegrass, for example, is used to advantage on some dairy farms in northeastern Ohio. But many other Corn Belt farmers believe that they get better results from simpler mixtures, such as smooth bromegrass and alfalfa. Orchard grass and alfalfa are used on some dairy farms in the southern part of the Northeastern States.

The wide variety of mixtures in use is an indication of the lack of uniformity in soils and climate, the need for different kinds of forage, and the diversity of farmer interest in production of high-producing, high-quality forage. Hand in hand with fuller understanding of the advantages of seeding mixtures of grasses and legumes instead of single plantings of either has come a better knowledge of the importance of lime, phosphate and potash, and of good seedbed preparation in establishing and maintaining high-yielding stands of forages. Methods for renovating permanent pastures without plowing also have been worked out.

Production of large quantities of forage an acre seldom is an end in itself. Rather, it is a means to greater production of livestock and of livestock products. This being true, need arises for preservation of forage for utilization in winter feeding operations. In recent years agricultural engineers have done much to develop machines that make the harvest of forage crops easier. These machines may aid, too, in production of better-quality hays and silages. But these achievements have not benefited all farms alike. Because of the high cost of the new machines, field choppers and pick-up balers for example, farmers and dairymen who harvest large tonnages of forages have gained most.

A great need remains for improved forage-harvesting machines adapted to farms on which small to medium tonnages of forage are stored.

Technical Possibilities for Utilization of Forages

Utilization of forages in the Northern States has not changed in any real way for a long time. Some grasses and legumes are now used in preparation of vitamin products. Somewhat more alfalfa is made into meal than earlier. At times forages are used solely for green manure. But all of these uses combined account for only a small fraction of the forages produced. Today, as 25 years ago, the bulk of grasses and legumes grown in the Northern States are used by livestock. Looking ahead, no new uses for the forage crops of this region appear in the offing.[3] Analysis of the economic utilization of forage crops becomes, then, a problem of examining possibilities for profitable changes in ways in which grasses and legumes are presently used on farms.

Every class of farm livestock possesses the physical capacity to utilize forage in some amount. Information in tables 3 and 4 shows the extent to which each class used forages during 1942–46. It was observed that the ruminants—cattle and sheep—depended heaviest upon this kind of feed.

Mature cattle, sheep, and idle horses may be *maintained* in good health on good-quality forages alone. Hogs and chickens, though, need some concentrates. Otherwise, their body weights and normal body functions are not maintained. In practice, however, all farm livestock usually get some concentrates at some time during the course of each year. A notable exception are beef cows carried solely on pasturage and good-quality legume hay. Feeding of many of the concentrates is an economic matter. Grains and byproduct feeds are fed in amounts in excess of those needed to meet the maintenance requirements of the animals because it pays to do so. They increase the volume and quality of product per animal. The value of the additional product obtained from feeding concentrates is greater than the added cost of the feeds.

Because the feeding of concentrates to farm livestock is based heavily upon economic elements, it follows that there is considerable flexibility in the nature of the rations fed. At times of high prices for livestock and livestock products and low prices for feeds, farmers find it profitable to increase rations. When the situation is reversed, with low livestock prices and high feed prices, it pays to reduce them. Adjustments made in rations because of changes in the relationship between feed and livestock prices often involve substitution of forage for concentrates and vice versa. This is especially true for farm animals that have the capacity to utilize large quantities of roughage. Production costs are not considered in this section.

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[3] Attention is directed to the distinction between the use of forage crops on individual farms and in agriculture generally. Production and utilization of a forage crop on a farm on which it had not been used earlier would represent a new use of the crop on *that* farm. But when already in use on other farms this would not represent a new use in agriculture. Rather it would be an extension of its use in agriculture. On this basis opportunities remain for new uses of forage crops on individual farms.

But production obtained from feeds is likely to be changed in the process of modifying rations. An understanding of the extent of change in output of livestock products, as the ratio between forage and concentrates in the ration varies, is essential to a full exploration of utilization of forage by livestock.

DAIRY CATTLE

Numerous dairy-cattle feeding investigations have been carried out at Federal and State experiment stations to study the problem of including more and better roughage in rations fed dairy cows. Generally, these investigations have involved high-producing cows and excellent roughage. The hay fed has usually been alfalfa. The cows have been handled apart from other phases of farming by skilled technicians. The findings are good guide-posts, but because of these features of the experiments, results obtained are difficult to interpret for farm conditions. Farmers use many low-producing cows and much low-quality roughage. The dairy enterprise generally is part of a farming system rather than the whole farm business.

In one feeding experiment 12 cows were fed through 4 lactation periods (*11*). Their milk and butterfat productions on four planes of feeding were studied. It was found that when cows received alfalfa hay alone or good pasture alone they produced only 70 percent as much milk as when fed a ration of alfalfa hay, corn silage, pasture in season, and concentrates at an average rate of 1 pound of grain for each 4.3 pounds of milk produced. With corn silage added to alfalfa or pasture, the cows produced 73 percent as much milk as when full fed. The addition of ground barley to alfalfa hay or pasture alone, when fed at the rate of 1 pound to 6 pounds of milk, resulted in the cows producing 86 percent as much milk as when full fed. Other experiments (*10; 25; 21, pp. 33–35*), indicated findings generally in the same direction as these, but the exact relationships observed between production of milk from a full feed compared with that from a ration of roughage alone, or some other ration representing less than a full feed, have varied. Woodward (*40, pp. 47–55*) reckoning with the numerous results made the observation that:

> The guess from these data is that a ration composed solely of good alfalfa when fed to good cows milked twice a day will support a production of as much as 0.8 pound of butterfat a day as an average for the lactation period or approximately 250 pounds a year, if the cows calve every 12 months. Substituting corn silage for a part of the alfalfa will increase the production to approximately 275 pounds; and if cows have first-class pasturage along with the alfalfa hay and corn silage, it is possible to further increase the production to 300 pounds of fat in a year.

His summary data indicated also that the feeding of a small to moderate quantity of grain along with good forage increased the output of butterfat about 17 percent (from 300 to 350 pounds) compared with that obtained from the feeding of a good all-roughage ration made up of alfalfa hay, corn silage, and pasturage. Considering all facts from these materials, one perhaps could do no better than generalize that *good* cows fed a limited grain ration (1 pound of grain to 6 pounds of milk) along with all the good alfalfa hay, corn silage, and pasturage they want will produce approximately 90 percent of their output of milk under a full-grain ration (1 pound of grain to 3 pounds of milk). Removing the grain from the previous ration their production of milk will be approximately 70 percent of that when full fed. Should the ration consist of alfalfa hay alone, output of milk would be about 60 percent of that when the cows were full fed.

The amount of roughage cows will eat when given as much hay, silage, and other roughages as they want generally changes as the grain ration is increased or decreased.[4] An experiment at the Virginia station (*25*) indicated that when 2,100 pounds of grain a year were eaten by cows getting all of the good roughage they wanted, the intake of roughage was reduced by about 1,100 pounds of hay equivalent compared with the amount eaten when no grain was eaten. At the same time production of milk increased 1,200 to 1,400 pounds. In this test the grain-fed cows got grain at the rate of 1 pound of grain to about every 4.4 pounds of milk produced. A summary of several experiments (*21, pp. 33–35*) in which a small to moderate amount of grain (the average being approximately 1,500 pounds) was fed along with good forage indicated that the feeding of 100 pounds of grain resulted in consumption of the equivalent of 47 pounds less hay compared with a ration of roughage alone, and the production of 91 pounds more milk. It is expected that the displacement of roughage by concentrates will differ from these results as the rate of grain feeding increases. An average for all rates of grain feeding would be expected to approximate 75 pounds of hay equivalent saved for each additional 100 pounds of grain consumed when roughage is fed in unlimited amounts. Changes in output of milk would accompany substitution of concentrates for roughage.

BEEF CATTLE

Systems of beef-cattle fattening found in the Northern States range from the raising of grass-fattened slaughter cattle to the fattening of prime steers in dry lot on rations that contain 75 or more bushels of corn for each steer. These extremes represent, on the one hand, beef production from roughage alone, on the other, beef production from little roughage and much concentrate feed.

Under usual market conditions for beef cattle, older grass-fed animals are more acceptable for slaughter than young stuff. This arises because 2- and 3-year olds are able to use a higher proportion of their feed for "finish" than are calves and yearlings. A demonstration of this was observed in an experiment at the Missouri station (*32*). Starting with choice beef calves, investigators there studied the growth and development of the cattle, wintered on good roughages and grazed on good pasturage in summer, from weaning time until they were 3 years old. It was noted that not until the animals were long 2-year olds did *most* of them carry enough flesh to grade as "killing" cattle on the market. Before reaching that age only a *few* carried sufficient finish to sell as "killing" cattle.

Feed requirements of beef cattle are well known. Knowledge concerning them has been accumulated from the findings of numerous controlled feeding experiments and from wide experience of cattlemen. Greatest emphasis has been placed upon requirements of animals managed under dry-lot conditions. Information as to the kind of

[4] Cows getting good-quality roughage in limited quantities eat about the same amount of hay and other roughage regardless of the amount of grain fed.

beef that may be produced from rations that contain varying proportions of grain and forages, when pasturage is involved, is limited. The problem is complicated by the fact that there are several classes, ages, and grades of feeder cattle. No two groups would give the same results when fed like rations.

The importance of this problem is well recognized by animal husbandrymen and agronomists. Small starts have been made to assemble the necessary data. At the Illinois station (*19, pp. 19–22*) "Good" 2-year old steers were grain-fed on blue grass pasture in the spring and summer of 1946. Of the three lots of steers used, one was finished for "Choice" slaughter cattle, one for "Good" and the third "Commercial." To finish the steers for Choice slaughter grade required 44 bushels of shelled corn for each steer and an average of 183 days feeding. To finish for the grade Good fat cattle, each steer took 20 bushels of shelled corn and an average of 93 days of feeding. Finishing the steers as Commercial fat cattle took 5 bushels of shelled corn a head and a feeding period that averaged 32 days. The Choice fat cattle dressed out highest with a dressing percentage of 61.6. This compared with 60.5 for the Good and 57.6 for the Commercial grades.

A continuing experiment at the Page County, Iowa, Experimental Farm (*27*) is designed to provide some information regarding the problem of using liberal amounts of forage in beef-cattle feeding programs. Beginning in May of 1946, yearling feeder steers of Good to Choice quality were handled in three different ways. One group of feeders was full-fed in dry lot, a second group was self-fed on brome-alfalfa pasture and finished in dry lot. A third bunch of steers was grazed on brome-alfalfa pasture alone and finished in dry lot. All lots of steers were finished to low Choice fat cattle. To achieve this required 159 days of feeding and 43 bushels of ground ear corn a head for the dry-lot animals, 193 days feeding and 39 bushels of corn for the steers self-fed on pasture and finished in dry lot, and 229 days and 25 bushels of corn for the animals grazed on pasture alone and then fed in dry lot.

Brome-alfalfa pasture is used in cattle-feeding operations on some farms in the western Corn Belt. In some instances in which this kind of pasture is used, farmers feed 40 to 45 bushels of corn (excluding any that may be in silage) a head to good-quality yearling steers in finishing out fat cattle of 1,050 or 1,100 pounds grading high Good or low Choice.

SHEEP AND LAMBS

High-quality native market lambs may be raised in the Northern States on forage alone. The secret of success with a ewe flock and lamb system of market lamb production is the control of internal parasites and provision of an abundance of green succulent feed for the lambs and ewes. Results of one experiment (*15*) showed that over a 3-year period suckling lambs, when both lambs and ewes were on pasture only, gained weight at almost the same daily rate as lambs handled similarly, but given access to shelled corn in creeps. Lambs that got no corn had as good finish at the end of the test as the ones that did. Other comparisons made in the same experiment showed that lambs suckling their dams on pasture gained weight considerably faster than lambs fed in dry lot while their dams grazed.

A specific indication of the quality of native market lambs that may be produced on pasture alone is provided by another feeding test (*14*). Out of 128 lambs finished for market on pasture only, when the lambs suckled ewes grazing the same pasture, 121 graded Choice on the rail, 6 were Good and only 1 was Commercial.

Even though high-quality native market lambs may be raised without the use of grain for the lambs, the ewe flock and lamb system of sheep management does require some concentrate feeds. Grain is fed to the ewes over a period of about 8 weeks centering around the date of lambing. The ratio of roughage feeds to grains is nevertheless high for this system (*20*). Only one system of sheep feeding and management followed in the Northern States may be handled solely on forages. This involves the finishing of Texas yearling and California spring lambs on pasture alone over an approximate 4-month period beginning in May or June. Occasionally if pasture fails to continue green and succulent in late summer before the lambs carry the desired finish for market, some grain may need to be fed lambs finished by this system.

HOGS

Forage crops, although not satisfactory as the sole ration of hogs for extended periods of time, make valuable contributions to hog feeding and management systems. Brood sows make good use of high-quality pasture and legume hay, as they do not require fattening rations. Their need is for feeds that maintain thrift, normal foetal development before farrowing, good milk flow following farrowing, and limited gains in weight. Very satisfactory rations for brood sows in dry lot contain 15 percent alfalfa hay. When on good legume pasture, bred sows require very little protein supplement and only 50 to 60 percent of the concentrate feeds necessary under dry-lot conditions (*41, pp. 99–103*).

A farmer in the western Corn Belt reports that he carried gilts bred for fall farrowing in 1947 on high-quality red clover and timothy pasture and a small amount of mineral as the only ration during 7 weeks early in the gestation period. Following this period oats and protein were fed. Pigs farrowed were vigorous and healthy, but carried little "baby" fat. Litters were average in size for the farm. This incident, although an isolated one, illustrates heavy use of forages by bred gilts. The experienced hog grower was satisfied with the results.

Growing pigs fed in dry lot for fattening need legume hay meal in their rations. Alfalfa meal, soybean hay meal, and other ground high-quality legume hays provide some of the essential food elements likely to be inadequately supplied by the principal concentrate feeds eaten. A series of experiments at the Agricultural Research Center of the United States Department of Agriculture indicated that gains were somewhat more rapid when dry-lot fattening pigs were fed rations containing 5 and 10 percent hay meals than when they were fed rations containing no hay meal or rations carrying as much as 15 and 20 percent hay meal (*41*).

Feeding trials at the Wisconsin Agricultural Experiment Station indicated that 15 percent alfalfa meal of good quality in the rations of growing pigs fattening in dry lot produced slightly more rapid gains than 5 percent (*39*). These results do not mean that growing-fattening pigs fed in dry lot are not capable of using forages in larger amounts than 10 or 15 percent of the ration. The maximum amount of forage that they may use depends upon their tolerance for fiber in the feeds eaten. It has been indicated that as much as 8 percent of fiber in the ration is well tolerated. This level permits use of as much as 20 percent of forage of 30-percent fiber content in a mixture of corn, tankage, and linseed meal (*7*).

Growing-fattening pigs full-fed corn and tankage on good pasture not only use fewer pounds of concentrates for each 100 pounds gain in weight, but gain at a more rapid rate than pigs full-fed a well-balanced ration of corn and tankage in dry lot (*24, pp. 894–896*). Full-feeding pigs on good pasture, however, is not an absolute requirement. There is considerable flexibility in the rate at which concentrates may be fed without encountering unsatisfactory development of the animals. Rate of gain and feed required to produce a given total gain in weight of the pigs are likely to differ, though, for several rates of concentrate feeding. An early feeding test at the Iowa Experiment Station (*80*) showed that pigs receiving half a corn ration on good alfalfa pasture required 53 days more than pigs self-fed a corn ration on the same kind of pasture to reach the weight of 225 pounds. Moreover, the limited-fed pigs ate a total of 29 pounds more corn and tankage for each 100 pounds of gain. Results very similar to these were observed at the same station when blue grass pasture supplied the forage for the pigs (*9*).

Economic Possibilities for Producing and Utilizing Forages in Selected Farming Systems

The foregoing summary is sufficient to indicate that in spite of gaps much technical knowledge is now available regarding production and use of forage crops on farms of the Northern States. But this does not mean that forages are utilized in abundance in farming systems. Economic considerations enter in. Farmers examine the technical possibilities of producing and using larger quantities of forages in terms of what these mean to costs and returns. When they know the effects upon their pocketbooks, it becomes easy to act. The new idea is rejected or it is accepted and incorporated into the farming systems. In practice, new ideas, even though profitable, may not always be accepted by farmers because of some institutional barrier such as tenure arrangements or because present income must be reduced so future income may be increased.

As a part of this study, production plans were developed for some farms in the Corn Belt. By restricting analysis to this one area within the Northern States, certain problems are brought into focus within a short space better than if single farms from several areas had been studied. Farms selected for consideration illustrate well-defined kinds of production situations common in the Corn Belt: (1) Intensive cash-grain production in which corn and soybeans are the major crops and sources of income; (2) cash-grain production, resting heavily upon corn with small grain as a less important source of income; (3) general farming on more rolling land—a farming system in which no single product receives major emphasis.

Development of production plans was managed so that information would be provided regarding the way in which greater production and use of forages affected certain parts of the farm business. Particular attention was given to changes in kinds and numbers of livestock handled; to the need for new outlays of capital; to the effects upon the level of cash expenditures, receipts, and net cash farm income; and to requirements for power and labor. More forages were introduced into the farming systems through crop rotations that contain higher proportions of grass and legume forage crops than are provided by the present cropping systems. These rotations are identical with some of those in use today. They were selected without reference to their specific effects upon conservation of soil resources. It was assumed that any crop rotation that increases the proportion of land in mixtures of grasses and legumes is desirable from a conservation point of view, even though it falls short of providing a given degree of conservation of soil resources. Capabilities of soils on the three farms were not developed in detail. This aspect was considered broadly, however, in selecting the rotations.

Alternative production plans for the three farms are offered without claim that they represent combinations of enterprises that would give the maximum level of net farm income. Undoubtedly, other farming systems making heavy use of forages that would be more profitable than these may be developed. The proposed plans illustrate rather far-reaching changes in organization of the three farms. In contrast to these, many farms of the Northern States already are developed around heavy production and use of forages. On some of these, however, forages might be made more profitable by producing higher-quality grasses and legumes and by using them more effectively.

Throughout the development of production plans for the farms, use was made of both experimental findings and experiences of some 20 farmers of the Northern States who produce and use large quantities of forages. Calculations as to income and expense were based upon the two sets of prices paid and received by farmers outlined on pages 14 and 15.

A 240-ACRE CASH-GRAIN FARM OF THE CENTRAL CORN BELT

As much as 75 or 80 percent of the crop acreage of some level, all-tillable cash-grain farms in the heavy soybean-growing area of the central Corn Belt is in corn and soybeans. Production of forages is low. Little livestock is kept. Income is obtained largely from the sale of grain and soybeans. Crop acreages now common on a typical 240-acre farm in this area are shown in table 6. Slightly more soybeans than corn are grown under the present plan. Under the medium level of prices, a net cash farm income of about $4,300 would be expected. This would be stepped up one-half under the high level of prices.

Utilization of a large quantity of forage on farms of the Corn Belt is possible by finishing beef cattle on pasture (fig. 1). This kind of cattle feeding appeals to many farmers. Feeder cattle are laid in on the farms in September or October, roughed through the winter, turned onto high-quality pasture in the spring, and either finished off late in the summer by feeding grain on pasture or in dry lot for a brief period. The fat-slaughter cattle are marketed after about

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a year on the farm. Before this kind of beef-feeding program could be handled on the 240-acre cash-grain farm described, changes in the cropping system would be needed. Alternative production plans developed for this farm are on the basis of a 3-year crop rotation of corn, oats, and hay or rotation pasture. With this rotation of crops a third of the cropland would be in grasses and legumes. This proportion is indicated as generally necessary in this area if maximum crop yields are to be maintained (*36, p. 428*). Plans 2 and 3 of table 6 show the more important details of the alternative plans.

TABLE 6.—*Comparative data of alternative production plans for a 240-acre cash-grain farm of the central Corn Belt*

Item	No. 1 present plan cash-grain	No. 2 plan with feeder cattle wintered on hay and finished on pasture	No. 3 plan with feeder cattle wintered on corn silage and finished on pasture
Crop acreages:	*Acres*	*Acres*	*Acres*
Corn	70	75	75
Soybeans	100	----------	----------
Oats	25	75	75
Hay	20	25	14
Rotation pasture	5	50	61
Permanent pasture	15	10	10
Important kinds of livestock:	*Head*	*Head*	*Head*
Hogs	38	38	38
Milk cows	3	2	2
Feeder steers bought	----------	60	70
Fat cattle sold	----------	59	69
Laying flock	100	100	100
Receipts and expenditures:			
Medium price level:	*Dollars*	*Dollars*	*Dollars*
Cash receipts	7, 108	11, 426	12, 724
Cash expenditures	2, 782	[1] 6, 372	[1] 7, 077
Net cash farm income	4, 326	[2] 5, 054	[2] 5, 647
High price level:			
Cash receipts	9, 903	15, 714	17, 402
Cash expenditures	3, 405	[3] 8, 137	[3] 9, 018
Net cash farm income	6, 498	[2] 7, 577	[2] 8, 384
New investments needed compared with present plan:			
Medium price level:			
Limestone	----------	1, 250	1, 250
Machinery	----------	1, 300	1, 700

[1] Includes cost of feeder cattle bought, $3,100 under plan 2 and $3,600 under plan 3.

[2] Excluding any interest paid on necessary investments in feeder cattle, limestone, or additional machinery required to carry out the production plan.

[3] Includes cost of feeder cattle bought, $4,300 under plan 2 and $5,000 under plan 3.

FIGURE 1.—This excellent bromegrass pasture and a light daily feed of corn put good gains on these Corn Belt steers.

Before attempting to establish a cropping system containing one-third grasses and legumes, the fields would be limed. Although the rate of application would vary by fields, depending upon the results of soil tests, the average rate for the farm would be approximately 2 tons of limestone an acre, representing an investment of $1,250 under medium prices. Supplemental applications of limestone would be made at the rate of 1 ton an acre every 6 years. Superphosphate would be used at the rate of 250 pounds an acre on fields when seeded to oats and to the grass-legume mixture of alfalfa, red clover, and timothy.

Cattle handled on the farm to use the large quantities of forages produced would be western feeder steers of Good quality. They would weigh an average of about 600 pounds when bought. A total gain averaging 550 pounds a steer would be put on. When marketed, the steers would grade Medium. To buy the 60 head of steers handled in plan 2 (59 steers sold) in which hay was the main winter feed, would take $3,100 under medium prices. In plan 3, when corn silage was used as the major winter feed, more steers could be handled on the farm. The investment in 70 head of cattle (69 head sold) bought for this plan would be $3,600 under medium prices. Under the high level of prices the cattle under both plans would cost nearly 40 percent more. Such expenditures, even the lowest at $3,100, represent outlays of working capital that some farmers would not be interested in making.

Analysis of the receipts and expenditures involved in the alternative production plans shows that receipts, expenditures, and net cash farm income are larger under the beef-cattle feeding plans than under the cash-grain farming system. Net cash farm income would be greater when cattle are wintered on corn silage rather than on hay. Plans 2 and 3 would be more profitable under the high than under the medium level of prices. These data reflect possible greater yields of crops which probably would result from the 3-year rotation. No allowance is made, however, for the possible decline in crop yields arising from continued use of the existing cash-grain system. Data shown for the beef-cattle feeding plans also represent results that would be expected after the production systems were established. During the change-over there would be some loss of net cash farm income compared with that realized from the existing cash-grain plan.

Production plans 2 and 3 may appear more profitable than the existing cash-grain system, when compared on the basis of net cash-farm income than they really are. It depends upon whether the farmer will need to borrow money to make the change, or whether he will use capital reserves that are drawing interest. If the farmer had to borrow 5-percent money to make the new investments in limestone, grass-seeding, hay-making, and silage-making equipment and to buy the cattle, he would have interest costs of $282 for plan 2 and $328 for plan 3 under medium prices. These additional costs would reduce the advantage of the beef-cattle feeding systems, particularly that of plan 2.

Farming systems like these set up under the production plan that involve the feeding of beef cattle are often considered to be extensive in nature compared with the cash-grain system. So far as the work of an individual farmer is concerned this is not true. He would work 60 to 75 percent more hours a year in handling the beef-cattle systems than in carrying the cash-grain system along, but for the most part this would represent fuller use of available time. Much of the additional work would be on livestock during the winter, a slack season on most cash-grain farms. Fewer acres of cash grains and more acres of forage crops would reduce power requirements of the farm. They would mean a 10- to 15-percent decrease in tractor hours—not enough to warrant reductions in number of tractors or in the amount or size of associated equipment.

Sales of cash crops would differ under plans 2 and 3 from those under the present plan. Elimination of soybeans from the cropping system would mean that no soybeans would be sold under either plan 2 or plan 3. At present, 2,300 bushels are marketed. In contrast, more corn and oats would be sold. The 2,265 bushels of corn now sold would be increased by 275 to 360 bushels. Sales of oats would jump from 550 bushels a year to 2,400 bushels.

A 160-ACRE CASH-GRAIN FARM OF THE WESTERN CORN BELT

Half the acreage of some quarter-section farms in the cash-grain area of the western Corn Belt is in corn. The rest of the farm is used for small grains, hay, and pasture. Acreages of crops on a nearly all-tillable, 160-acre cash-grain farm of this part of the Corn Belt are shown under plan 1 of table 7. The livestock system on this farm is meager; it consists of 5 brood sows from which 26 spring pigs are marketed, 3 cows, and a laying flock of 100 hens.

The soils of the 160-acre farm present no problems in production of forage crops once the lime and phosphorus deficiencies are corrected. Bromegrass and alfalfa in a mixture should do well. Market outlets for the farm suggest that greater use of forages might be achieved through handling feeder calves or through the keeping of a few dual-purpose cows and the handling of a smaller number of feeder calves.

TABLE 7.—*Comparative data of alternative production plans for a 160-acre cash-grain farm of the western Corn Belt*

Item	No. 1 present plan cash-grain	No. 2 plan with feeder calves wintered on hay and finished on pasture	No. 3 plan with milk cows, feeder calves, and 16 brood sows	No. 4 plan with green-manure crop
Crop acreages:	*Acres*	*Acres*	*Acres*	*Acres*
Corn	85	35	54	62½
Oats	40	35	27	62½
Hay	20	23	24	20
Sweetclover in oats as green manure	--------	--------	--------	(42½)
Rotation pasture	--------	52	40	--------
Permanent pasture	10	10	10	10
Important kinds of livestock:	*Head*	*Head*	*Head*	*Head*
Hogs sold	31	31	99	31
Milk cows	3	3	8	3
Feeder calves bought	--------	75	19	--------
Fat cattle sold	--------	75	25	--------
Laying flock	100	100	100	100
Receipts and expenditures:				
Medium price level:	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Cash receipts	4, 934	10, 797	8, 798	5, 223
Cash expenditures	1, 764	[1] 5, 846	[1] 3, 175	1, 936
Net cash farm income	3, 170	[2] 4, 951	[2] 5, 623	[2] 3, 287
High price level:				
Cash receipts	7. 357	15, 021	12, 040	7, 917
Cash expenditures	2, 664	[3] 8, 056	[3] 3, 989	2, 360
Net cash farm income	5, 183	[2] 6, 965	[2] 8, 051	[2] 5, 557
New investments needed compared with present plan:				
Medium price level:				
Limestone	--------	950	950	900
Machinery	--------	700	700	60
Livestock, excluding feeder calves	--------	--------	1, 000	--------

[1] Includes cost of feeder calves bought, $2,900 for plan 2, $750 for plan 3.
[2] Excludes interest on any money borrowed to make new investments necessary for production plan.
[3] Includes cost of feeder calves bought, $4,400 for plan 2, $1,100 for plan 3.

A production plan for the farm in which feeder calves would be finished for market—plan 2 of table 7—would be based upon an approximate 4-year rotation of crops involving 1 year of corn, 1 year of small grain, and 2 years of a bromegrass-alfalfa mixture. The 10 acres of permanent pasture would be seeded to a bromegrass-alfalfa mixture. An initial application of 310 tons of limestone, an average of 2 tons an acre on the 155 acres, would involve an investment of $950 under medium prices. Following the first complete liming, fields would receive supplemental applications of limestone at the rate of 1 ton an acre every 4 years. Every year superphosphate would be applied to the acreage seeded to oats and to the grass and legume mixture. Approximately 250 pounds an acre would be applied. This cropping system would rapidly build up the level of soil fertility. Because of this, an allowance has been made in plan 2 for an increase in yield of corn from 55 to 70 bushels an acre and in yield of oats from 35 to 50 bushels an acre.

Cattle-feeding operations for the farm under plan 2 would consist of feeding 77 head of calves a year. Two of these would be raised on the farm, and 75 bought. Allowing for the loss of 2 calves during the year, 75 head would be finished out. Western steer calves averaging 450 pounds and grading Good would be laid in during September or October. They would be carried during the winter period on brome-alfalfa hay and a small daily allowance (one-fourth pound) of a high-protein oil meal. When turned on brome-alfalfa pasture in the spring, feeding of ground ear corn would start and continue until the calves were ready for market about the last part of September. By feeding approximately 35 bushels of corn a calf, the animals should weigh around 1,100 pounds when marketed and they should grade Low Good.

Compared with the present production plan of the farm, cash expenditures under plan 2, including $2,900 for feeder calves, would be increased about 3½ times. Receipts would be more than enough greater to cover the additional expenses. Even if interest had to be paid on money borrowed to buy the cattle and to make the other necessary capital outlays needed to handle the cattle-feeding operations, net cash farm income of plan 2 would be larger than that for the present plan.

To get the higher net cash farm income by feeding calves, the farmer would put in many more hours of work than in growing cash crops. His work would be doubled. Half of the increase, however, would come in the 4 months December through March, a slack work period on cash-grain farms. Hours of tractor use would be similar under the two production plans.

More corn would be needed on the farm under plan 2 than would be produced on the 35 acres planted to this crop. Approximately 900 bushels of corn would be bought. On the other hand, increased production of oats under plan 2 would result in sales of about 1,330 bushels, 400 bushels more than under the present plan.

A production plan that is suggested by some people as highly efficient for 160-acre farms in the western Corn Belt combines a number of livestock enterprises with a well-balanced cropping program. In detail, the plan calls for raising about 100 market hogs, finishing out some 25 beef calves, a part of which are raised on the farm, and milking 8 or so cows. Butterfat is sold. Liberal amounts of forages would be provided in the cropping system. A plan of this kind has been worked out for the 160-acre cash-grain farm. Some of the details are shown under plan 3 of table 7.

The specific cropping program for plan 3 would consist of an approximate 5-year rotation on 145 acres and permanent bluegrass pasture on 10 acres. The sequence of crops in the established rotation would be corn, corn, oats, followed by bromegrass-alfalfa mixtures for 2 years. Following an initial application of limestone, as outlined under plan 2, supplemental applications would be made at the rate of

1 ton an acre every 5 years. Superphosphate at the rate of 250 pounds an acre would be applied each year on the acreage seeded to oats and the grass and legume mixture. Crop yields would be increased after a few years by this crop-and soil-management program. Perhaps the improvement would not be so rapid as under plan 2, as that plan carried a slightly higher proportion of legume mixtures. An allowance was made under plan 3 for an increase of from 55 to 68 bushels of corn an acre and from 35 to 48 bushels of oats.

By raising 100 spring pigs a year—production from 16 sows—approximately 99 hogs would be available for market (fig. 2). Eight

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FIGURE 2.—Good legume pasture, when used to a limited extent, saves concentrate feeds and at the same time makes for faster gains on hogs.

dual-purpose cows would be kept for milking. Calves from these cows would provide for replacements and for 6 calves a year that would go into a beef-feeding program built around the buying of 19 head of feeder calves. Feeder calves would be handled in the same way as outlined for plan 2.

To carry out plan 3, new investments would not only be required for limestone and machinery, compared with the existing cash-grain plan, but also for livestock. An additional investment of about $1,000 in livestock, excluding feeder calves bought, would be necessary under medium prices. But, compared with the present plan, there would be an improvement in net cash farm income. With a medium level of prices the increase would be approximately 75 percent, not allowing for possible interest that might have to be paid on new investments needed to get plan 3 established. Even though prices received for butterfat were somewhat less favorable than assumed when based upon historical data, the increase in net cash farm income would be substantial. This greater net cash farm income is enough to justify the cash-grain farmer in borrowing all the money necessary to establish plan 3, if need be, providing he is free to change his system of farming and has the ability to handle livestock. Annual interest charges could be handled and the loans paid off within a few years. To accomplish this, however, the farmer would work more hours than under the cash-grain plan. His work hours would be more than doubled. As most of the greater requirements for labor would come from the livestock enterprises, a large part of which would be winter work, the farmer could carry the additional work load. Power requirements, measured in hours of tractor use, would be about the same under plan 3 as under the cash-grain plan.

About 950 bushels of corn would be sold from the farm under plan 3. This would be 3,000 bushels less than marketed under the present plan. Approximately 850 bushels of oats would be moved to market under plan 3, slightly less than is sold from the farm under the present system.

Under plan 3 net cash farm income would be somewhat higher than under plan 2. The feeding of a much smaller number of calves under plan 3 than under plan 2 would reduce the cash outlay needed for feeders by $2,150 under medium prices. This point deserves attention. Because of this lower cash outlay plan 3 would be more stable at times of serious breaks in farm prices than would plan 2. But the farmer's work load would be greater under plan 3; it would be increased the equivalent of thirty-five 10-hour days.

Use of forage crops in farm production plans is not limited to situations in which livestock, particularly roughage-consuming livestock, is handled. Legumes may be used as green-manure crops. Plan 4 of table 7 gives details of a production plan in which sweetclover is sown in oats as a green-manure crop ahead of corn that follows the next year.

A 2-year rotation of corn and oats would be established on 125 acres of the farm. In addition, 20 acres of clover-timothy meadow and 10 acres of permanent pasture would be available. Each year, 20 acres of the land sown to oats would be seeded to a clover-timothy mixture to be used for hay the following year. The remainder of the acreage in oats would be seeded to biennial sweetclover. The sweetclover would be plowed down the following spring and the land planted to corn. Corn would be planted also on the 20 acres broken out of clover-timothy sod every year.

New investments necessary to establish the green-manure cropping system would not be great. An initial application of limestone on the 145 acres of cropland would involve an investment of about $900 at medium prices. A grass-seeding attachment for the grain drill would be acquired.

For present purposes allowances are made for 20 percent higher yields of corn and between 25 and 30 percent larger yields of oats under the green-manure system. On this basis, net cash farm income under plan 4 would be a little higher than under the present plan; both are based upon cash grain. Approximately 3,400 bushels of corn and 2,400 bushels of oats would be sold from the farm. Compared with the present plan this would represent a reduction of about 550 bushels in amount of corn sold and an increase of 1,450 bushels in quantity of oats marketed. By reducing acreage planted to corn, the farmer would work a few less hours under plan 4 than he is now working. Hours of tractor use, too, would be reduced slightly under the green-manure cropping program. The important advantage of the use of sweetclover would be the establishment of a more permanent system of farming.

A 225-ACRE GENERAL FARM OF THE CENTRAL CORN BELT

Many farms of the Corn Belt are not organized to specialize in production of a single, or a related group of products such as cash grains. Rather, they are built around a number of enterprises, each in itself only a small part of the over-all organization. Farms of this kind are found in parts of the Corn Belt that have more rolling topography and soils of lower inherent fertility. One farm of this kind is located a few miles from a medium-sized industrial city of the Midwest. It is a "rough" farm with timber soils that have been heavily used. Some gullies have formed and are growing. Buildings are old. Many service buildings have passed their usefulness and need to be rebuilt if livestock is to be kept. Good soil-management programs have been started from time to time in recent years, but they were not carried through on a continuing basis. However, limestone and phosphates applied at these times have solved the decline of soil fertility and they make it simpler to establish higher-yielding grasses and legumes today than would otherwise be the case.

The production plan now followed on the farm places about equal emphasis upon crop sales and sales of whole milk in the nearby city. Sales of livestock are of lesser importance. The cropping program stresses grains; only a fourth of the cropland is in grasses and legumes. This is shown by data listed for the present production plan in table 8.

Because of the physical characteristics of this farm and its location within the milkshed of a thriving city, it appears that a production plan built around the heavy use of forages through dairy cows would be highly efficient (fig. 3). At the same time, somewhat more hogs could be raised to utilize corn produced on the farm. To establish a production plan of this kind, a 4-year rotation of corn, oats, and 2 years of a bromegrass-alfalfa mixture would be set up on 128 acres of the 145 acres of cropland. The remaining 17 acres of cropland—land adjacent to "draws" and land of quite steep slope—would be seeded permanently to a bromegrass-alfalfa mixture and renovated about every 4 years. The 45 acres of permanent pasture would be used without renovation. Annually, 27 tons of limestone, 5½ tons of superphosphate, and 2 tons of commercial fertilizer of 0–14–6 analysis would be applied. Limestone and commercial fertilizer would go on corn ground; superphosphate on oats ground. The per acre yield of corn would be increased from 35 to 45 bushels, that of oats from 30 to 40 bushels, and that of grass-legume hay from 2 to 2½ tons.

Livestock for this production plan—plan 2 of table 8—would consist of 10 brood sows producing only spring pigs, 25 milk cows, with replacements raised on the farm, and a laying flock of 100 hens. The dairy herd would be grade animals of dairy breeding producing an

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average of about 7,000 pounds of milk a year. The cows would be fed home-produced grains supplemented by soybean meal. Rate of feeding would be approximately 1 pound of concentrates to every 3½ pounds of milk. Bromegrass-alfalfa hay would be fed as the only roughage during the winter at a rate of 3 tons for each cow.

TABLE 8.—*Comparative data of alternative production plans for a 225-acre general farm of the central Corn Belt*

Item	No. 1 present plan—general farming	No. 2 plan—dairying	No. 3 plan—beef calves wintered and finished on pasture	No. 4 plan—combination of dairying and beef cattle
Crop acreages:	*Acres*	*Acres*	*Acres*	*Acres*
Corn	51	32	32	32
Oats	37	32	32	32
Wheat	10	--------	--------	--------
Rye	10	--------	--------	--------
Timothy hay	10	--------	--------	--------
Grass-legume hay	25	64	19	34
Rotation grass-legume pasture	--------	--------	45	30
Permanent grass-legume pasture	--------	17	17	17
Permanent blue grass pasture	45	45	45	45
Idle	2	--------	--------	--------
Important kinds of livestock:	*Head*	*Head*	*Head*	*Head*
Hogs sold	24	59	59	59
Milk cows	10	25	2	12
Feeder calves bought	--------	--------	43	--------
Fat cattle sold	--------	--------	42	19
Beef cows	--------	--------	--------	10
Laying hens	100	100	100	100
Receipts and expenditures:	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Medium price level:				
Cash receipts	4, 212	7, 453	6, 946	6, 077
Cash expenditures	2, 376	4, 184	[2] 5, 278	3, 356
Net cash farm income	1, 836	[1] 3, 269	[1] 1, 668	[1] 2, 721
High price level:				
Cash receipts	5, 738	9, 722	9, 466	8, 096
Cash expenditures	2, 736	4, 937	[3] 6, 810	4, 041
Net cash farm income	3, 002	[1] 4, 785	[1] 2, 656	[1] 4, 055
New investments needed compared with present plan:				
Medium price level:				
Livestock, excluding feeder calves bought	--------	2, 250	--------	1, 400
Service buildings	--------	2, 350	1, 350	2, 350
Dairy equipment	--------	600	--------	600
Fencing	--------	1, 300	1, 300	1, 300

[1] Excluding the effects of any interest paid on money borrowed to make new investments needed to establish production plan.
[2] Including the cost of feeder calves, $1,860.
[3] Including the cost of feeder calves, $2,580.

Figure 3.—Dairy cows make heavy use of pasture like this mixture of alfalfa, Ladino clover, and bromegrass. Forage and concentrates may be interchanged over a wide range in the rations of dairy cows. The better the forage the more grain it may displace.

Production plan 2 could not be carried out without new investments in livestock, buildings, fencing, and equipment. A total outlay of $6,500 under medium prices would be necessary compared with the present plan. But net cash farm income would be greater under plan 2 than under the present production program. Under the medium level of prices the increase would approximate $1,400. This increase in net cash farm income would provide for the interest and for repaying the $6,500 needed for new investments, if all were borrowed, in 6 years.

Total labor requirements would be 2½ to 3 times greater under plan 2 than under the present plan. To handle the 25-cow dairy enterprise would necessitate employment of one hired man throughout the year. Cost of this labor was included in computing the above net cash farm income. With the help of one man, the farmer would have to work only about 40 percent more hours than at present. Half of the additional hours would represent work on livestock in December through February.

Under plan 2 a fairly good balance would exist between feed production and feed requirements of the livestock handled. But there would be a surplus of 67 tons of bromegrass-alfalfa hay which would be sold. It would be possible, however, for this forage to be utilized through feeding out a small number of beef calves without adding greatly to the labor load of the farm. About 15 head of calves could be handled. Because there would be no surplus of corn under plan 2, some 525 bushels would have to be bought in order to finish the calves out. When all elements were reflected in net cash farm income, the addition of 15 head of feeder calves to plan 2 would not be profitable. Net cash farm income would be larger when the surplus hay was sold than when put through feeder calves as pasture and hay and supplemented with purchased corn. A different relationship between prices of hay, corn, and calves could make the feeding of calves the more profitable. This might be the situation in years of large hay production in the community.

Some farmers do not like to have hired workers the year around as would be necessary under plan 2. Others do not wish to be tied to fairly rigid work schedules such as those required in dairy farming. Plan 3, table 8, represents an exploration into the problem of using large quantities of forage, and at the same time holding down the labor load. The same cropping system would be followed under plan 3 as under plan 2. However, less than a third of the 64 acres in the bromegrass-alfalfa mixture would be used for hay. Forty-five acres would be used for pasture. The dairy herd would be displaced by a beef-feeding operation in which 42 feeder calves would be finished each year. The calves would be handled in the same way as those involved under plan 2 for the 160-acre cash-grain farm already discussed, page 27.

Handling beef calves instead of dairying would require much less labor on this 225-acre farm. The farmer would need to work only a few more hours a year than he is now working and only a few days of hired labor would be necessary during the year. Plan 3, too, would be possible without so great an investment in buildings and without any investment in dairy equipment. On the other hand, net cash farm income would be far below that of plan 2 and even below that of the present plan. Compared with the present production plan, however, the program of feeding out beef calves would assure a continuing higher level of crop yields.

Because of the low level of net cash farm income indicated for plan 3 when feeder calves are bought and finished out, largely on purchased corn, a question arises regarding the kind of results that might be obtained if some dairying and beef feeding were combined. One combination of these two enterprises is provided for in plan 4 of table 8. Again, the cropping system is the same as under the 25-cow dairy setup, except that less hay is harvested. Acreage not needed for hay is used as pasture. Milk from 12 cows would be sold as whole milk. These cows, of a heavy dairy breed, would be bred to a beef bull and the calves added to those raised by a herd of 10 beef cows for feeding out. The same number of market hogs would be raised as under plan 2.

Investments required to establish plan 4 would be $850 less than under plan 2. This difference would arise because fewer dairy cows would have to be acquired. The beef cows needed could be bought for less per head than dairy cows.

Although net cash farm income under plan 4 would be greater than that of the present plan, it would not equal that from plan 2. At the same time the farmer would be working about 30 percent more hours than when handling the 25-cow dairy enterprise with the help of 1 hired man.

Some of the forage on this farm might be handled as silage rather than as hay. Intensive experiments have been conducted at the Agricultural Research Center of the United States Department of Agriculture on the comparative efficiency of ensiling, barn-curing, and field-curing forage crops. Published data covering the first year's results (*18*) show that for the first two cuttings of alfalfa made in 1945 an average of 92.5 percent of the original crop used for silage was taken off the field and 82 percent was fed. Compared with this, 81 percent of the field-cured forage was taken off the field and 76.5 percent was fed.[5] These results were obtained under generally favorable weather conditions. Further investigations under very poor haying conditions have shown the spread between the silage and field-cured hay to be much wider than the above.[6]

It is not presumed that the above findings would be applicable to the central Corn Belt. But in the absence of specific data of the same kind for the Corn Belt, they may be used to explore the possibility of making silage from some of the forage harvested on the 225-acre general farm under study.

Although silage made from forage crops may make up the entire roughage ration of dairy cows, beef cows, and fattening cattle, it is generally suggested that these animals be fed at least small amounts of hay along with such silage (*38*).

This feeding practice is followed when grass silage is made and used in connection with plan 4 for the farm.

Production of hay under plan 4 is based upon three cuttings of field-cured forage from 34 acres of a bromegrass-alfalfa mixture. Analysis indicates that if the first and third cuttings from this acreage were made into silage rather than into hay, approximately three additional tons of dry matter in the form of roughage would be available for feed.[7] Storage of silage would be no serious problem as two concrete-stave silos are now on the farm, although they would have to be reinforced and equipped with new doors.

Because the farmer would be carrying a heavy work load under plan 4, it would not be feasible to utilize the three additional tons of dry matter in forage gained by making silage to increase the dairy enterprise. The most practicable use of this feed would be through 2 feeder calves bought locally and added to the 19 head handled under plan 4. If this were done and the silage were made by the wilt method with a stationary chopper, the net farm cash income would be increased $250 above that of plan 4 under medium prices. Additional investments required would approximate $550. The farmer's work load would be slightly increased. Were silos not already on the farm, it appears that this increase in net farm cash income would not justify investment in a new tower silo that might cost $1,200. A trench silo, however, constructed at low cost, would be practicable. Should the saving in dry matter in forage by use of silage be greater than that assumed here for discussion, even construction of a new tower silo might be economical. Specific information of actual year-to-year losses of feed nutrients in field-cured forage on the individual farm is needed for determination of this.

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[5] This investigation also showed that the silage, at time of feeding, contained more protein than did the field-cured hay.

[6] Continuation of work reported in (*18*) data not yet published.

[7] There would also be a gain in protein. For purposes of analysis, the increase in protein is not considered. In practice, the use of grass silage would mean rations of higher protein content, if the rate of feeding concentrates were not changed and the same amount of dry matter in roughage were fed as when field-cured hay was used.

Tentative Conclusions

The foregoing analysis of the economic possibilities of producing and using forages on three Corn Belt farms leads to the following tentative conclusions:

(1) New investments in the farm business are essential in establishing and operating farm production plans which involve production and use of large quantities of forage on cash-grain and some general farms of the Corn Belt.

(2) "High-forage" systems of farming in the Corn Belt involve larger cash expenditures than cash-grain systems and some general farming systems. When feeder cattle are bought to utilize large quantities of forage, the farmer increases his risk of financial loss.

(3) Although many high-forage systems of farming in the Corn Belt increase net cash farm income compared with present cash-grain and general systems, not all of them do and each farmer will do well to analyze his own situation carefully before making the shift. In some instances, although net cash farm income is increased, the difference is not enough to encourage adoption of the system.

(4) Net cash farm income from the high-forage systems in the Corn Belt would be larger, in nearly every instance, under the high level of prices than under the medium level. Compared with the net cash farm income to be obtained from present systems of farming under both medium and high levels of prices, the percentage increase in income resulting from a shift to more forage would be greater under medium prices than under high prices. This feature grows out of the relationships between grain and livestock prices in the two levels of prices. The result would be different were these relationships changed.

(5) Less corn and soybeans would be sold from Corn Belt farms for a few years after they were changed over to the production and utilization of large quantities of forage. At the same time the quantity of oats sold would be reduced very little and often it would be increased. In time, however, because of the soil-building effects of the high-legume rotations and continued progress in other phases of good soil management and in crop production, more corn could be sold under some high-forage systems than is now marketed under the cash-grain system. Fewer soybeans would continue to be sold from the farm. However, the total amount of digestible nutrients in the corn and oats marketed could be about as much as is now represented in the combined sales of corn, oats, and soybeans.

(6) *Corn Belt farmers generally would put in more days of work in carrying out systems of farming which involve the production and use of large amounts of forage than in handling present cash-grain and some of the general farming systems.* Even though net cash farm income were increased, the return for each hour of labor would not be so large as under present farming systems.

(7) Much of the extra labor, however, would come during the winter months, making a more uniform distribution of work throughout the year.

(8) Power requirements of farms, measured in terms of hours of tractor use, are not lowered materially by high-forage systems compared with cash-grain and general systems.

(9) Achievement of the high-forage systems of farming outlined here for selected farms of the Corn Belt would involve changes of

major proportions in farm organization and operation. More moderate shifts to grasses and legumes than called for in these systems probably could be made more quickly and more easily on many farms.

SOUTHERN STATES—PRELIMINARY FINDINGS

Because of relatively high prices for livestock and livestock products, greatly increased local demand, and relative shortage of farm labor, many farmers in the South turned to more livestock during the war. Some of this increased production was based on concentrate feed purchased at high prices. These farmers are wondering how they can reduce the cost of producing milk and beef. In some areas of the South, particularly in the limestone areas of Kentucky, Tennessee, and Virginia, bluegrass grows naturally and makes excellent pasture for a part of the year. Recent experiments at the State experiment stations and experience of farmers indicate that the carrying capacity of these pastures can be materially increased. In many areas farther south, cropland left idle reverts to briars, bushes, or trees. Even if the bushes are kept down, the native pasture is rather low in carrying capacity and is not very nutritious. Furthermore, it becomes quite unpalatable and is often short in growth during the dry summer months.

Except in cases of free range, woodland and swamp grazing, farmers in the deep South have learned that building a fence around a field which is no longer fit for cropping does not return much grazing and income. But recent developments at southern experiment stations have demonstrated that in many areas in the South, permanent pastures with very high carrying capacities can be developed and that the quality of hay can be improved. Furthermore, temporary or rotation pasture can be developed to supplement the permanent pastures. However, the development of either type of pasture and of alfalfa requires rather heavy inputs of phosphates and, in many cases, other fertilizer and lime as well as seed, fencing, etc.

There is considerable interest in development of pasture and other forage because many farmers are of the opinion that the old stand-by crops of cotton, peanuts, and tobacco are likely to be in trouble before too many years have passed. Therefore, this investigation involves testing whether it is technically feasible and economically profitable for southern farmers to convert their present farming systems to systems that depend almost entirely upon pasture, hay, and other forage for utilization by livestock. It is the proposition to be proved or disproved, in whole or in part. It must stand or fall on the basis of results from physical and economic research and farmer experience. Examples of research and farm experience reported in the following pages give a clue as to how far southern farmers can profitably go in utilization of forage in a livestock program, but a more definitive answer will come only after completion of intensive study in representative type-of-farming areas.

New Systems of Forage Utilization at Southern Experiment Stations

FOR BEEF CATTLE

In the Black Belt of Alabama, the substation at Marion Junction has worked for nearly 20 years to develop a sound management system for production of beef cattle. Efforts have been devoted toward determining the most practicable system of producing market animals and toward developing a cropping system that will maintain cattle in satisfactory condition on *grazing* crops the greatest length of time during the year. (*1*)

From this work it has been found that a combination of black medic, white clover, and Dallis grass are the best permanent pasture plants for lime soils of the Black Belt (fig. 4). These pastures provide grazing about the middle of March and reach their peak in May From early spring to July 1, clovers are dominant. After the summer rains, Dallis grass causes another peak in grazing capacity. Between the clover and grass peaks it is sometimes necessary to use supplementary grazing areas.

To supplement the permanent pasture a combination of Caley peas

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FIGURE 4.—Beef cattle on permanent pasture of white clover, black medic, and Dallis grass at the Black Belt Experiment Station of Alabama.

and Johnson grass has proved best. Caley peas, interplanted with Johnson grass, come up in the fall, furnish some grazing throughout the winter, and make an excellent pasture in March and April. The peas which mature and produce seed in May are left on the ground to volunteer the following fall. Johnson grass volunteers following the pea crop. It is grazed in July, if needed, otherwise it is cut for hay as a reserve for winter roughage. The second crop of Johnson grass is allowed to mature in the field. After frost, the frosted Johnson grass with Caley peas coming up under it furnishes good winter grazing. When the grazing gets short, Johnson-grass hay is fed.

Following this system at this substation, it has been found technically feasible to carry a cow and her calf the year round on 3 acres. Two acres are in permanent pasture and 1 acre in supplementary pasture and hay.

A similar system for year-round production of feed and forage has been tried in the Piedmont and Upper Coastal Plains (*13*). This experiment utilized 2½ acres per cow as follows:

1 acre of sericea lespedeza
1 acre of kudzu
½ acre of manganese bur-clover followed by grain sorghum.

Other crops may be substituted in this system, including improved pasture, alfalfa, Johnson grass, crimson clover, Caley peas, and Sudan grass.

In a 3-year trial 1944–46 this system produced an average of 191 pounds of beef per acre per year. Only the grain sorghum requires reseeding. In addition to the seeding and cultivation of the grain sorghum, the principal yearly cash cost was about $6 per acre for fertilizer.

FOR DAIRY COWS

In the Black Belt of Alabama, (*2*) a farm-size experimental dairy on 80 acres of land of relatively low fertility was started in 1941. One purpose in establishing this unit was to determine how much of the feed required could be produced on the farm. Seventy-two acres were divided into three fields and fenced so the farm could be managed to obtain maximum grazing the year round. Field No. 1 contained 18 acres of oats and black medic followed by Johnson grass. Field No. 2 had 18 acres of Caley peas followed by Johnson grass. Field No. 3 had 36 acres of permanent pasture consisting of black medic, white clover, and Dallis grass.

In order to take full advantage of the grazing, the cows were bred to freshen in the spring. During the winter they were in field No. 1 on fall-seeded oats, supplemented by stacked Johnson hay. About March 1 they went to Caley peas in field No. 2, where they grazed until the plants began to bloom. Then they were removed to field No. 3, which is permanent pasture. The pasture was grazed in spring and summer as long as it supplied nutritious green feed. When grazing on this field was reduced by drought or frost, Johnson grass in fields Nos. 1 and 2 was grazed. After harvest of oats in field No. 1 and Caley pea seed had matured in field No. 2, the Johnson grass was cut and stacked for winter feeding. When rainfall was good the Johnson grass made a second crop, which was left standing for grazing after frost.

The 1941–45 summary of the data for this experimental dairy farm follows:

Acres in farm	80	Capital investment [1]	$3,913
Acres in pasture	36	Cash receipts	2,335
Acres in crops	36	Cash expenses	1,175
Acres in woods	8	Net cash income	1,160
Number of milk cows	25		

[1] Land $2,230, livestock $1,135, other $548.

All roughage required was produced on the farm. An average of about 8¾ tons of cottonseed meal or peanut meal was bought each year. The farm supported 25 cows or 1 for each 3 acres, again demonstrating for the Black Belt the technical feasibility of a year-round grazing system. For the 1941–45 period, this farm produced an average yearly net cash farm income of $1,160, not including milk-subsidy payments. When the receipts and expenses are adjusted to a medium price level (as defined on pp. 14 and 15), the net cash farm income would be about $685. With the high price level the net cash farm income would approximate $970, or nearly $200 below the actual results of wartime prices. Thus, with the actual situation and the two assumed price levels, this experimental dairy farm would yield a net cash income, but the amounts are small—too small for a satisfactory income to the farm operator.

Whether the profit would be more or less if concentrates were not fed is a question for further study. Purchased feed was the greatest single cash expense, and purchased feeds run up the cost of producing milk rapidly. The experiment station officials believe that fewer concentrates will be needed in the future, because more protein will be supplied by increased yields of legumes in the cropping system. There may be more profitable alternatives and other possibilities need study, but the point to be emphasized here is that a roughage system can be made to work satisfactorily in the Black Belt. Although the farm was operated under the direct supervision of the superintendent of the branch experiment station the practices are not complex and it is believed that the average farmer could carry them out with financial returns about as good as those shown here.

An experiment at Auburn, Ala., (*12*) to determine the best system for year-round feed and forage production and utilization in the Piedmont and upper Coastal Plain areas was conducted successfully in 1945 and 1946 with 3¼ acres per cow, as follows:

¾ acre sericea lespedeza
1 acre kudzu
1 acre oats
½ acre manganese bur-clover followed by grain sorghum.

No feed was bought, and the home-grown feed was utilized as follows:

Nov. 15–Feb. 15____Grazed oats and fed kudzu hay and grain-sorghum stover when needed.
Feb. 15–Apr. 15____Grazed manganese bur-clover and fed grain-sorghum stover and kudzu hay.
Apr. 15–June 7____Grazed sericea lespedeza.
June 8–June 18____Grazed kudzu, except in 1946 cows remained on sericea.
June 18–Oct. 2____Grazed sericea lespedeza.
Oct. 2–Nov. 15____Grazed sericea lespedeza and kudzu.

Four dairy cows received all their feed for a 2-year period from crops grown on 13 acres of land. Surplus feed, amounting to 4 tons of oat hay, 3 tons of kudzu hay, and more than 2 tons of grain-sorghum stover, was produced. Three acres of sericea lespedeza furnished all the feed eaten by four cows for approximately 6 months each year. The four cows averaged 5,242 pounds of milk per cow per year for the 2-year period.

Among the important advantages of the system are: (1) Cows do much of the harvesting, thus saving labor; (2) pasture or hay is available 12 months of the year; (3) land is protected by crops much of the year; (4) soil fertility is improved.

In the Tennessee Valley area of Alabama an 87-acre farm dairy experiment (*31*) indicates that (1) good grade cows on pasture and hay alone will produce an average of 2½ gallons of milk per day for more than 300 milking days, and (2) concentrates fed to such cows did not increase production of milk enough to pay for the concentrates.

The herd was divided into two groups of nine cows each. One group had pasture and hay, the other had concentrates in addition to the pasture and hay. For 2 years concentrates were fed at the rate of 1 pound for each 3 pounds of milk produced; during the next 2 years it was reduced to 1 pound for each 4 pounds of milk.

The 3½ acres of grazing crops per cow and the method of utilization is as follows:

(1) Permanent pasture—1 acre. The pasture is composed of white clover, hop clover, bluegrass, and Dallis grass. From about May 1 to October 1, it supplied all of the grazing, except in drought periods. In such periods the cows are grazed on alfalfa. The permanent pasture is also used at times in March, April, and November.

(2) Alfalfa—one-half acre. Alfalfa can be used wholly as a hay crop or as a combination hay and temporary grazing crop. The first two or three cuttings are usually baled for winter feeding. During dry periods, it has provided emergency grazing for an average of 60 days a year. Alfalfa hay is fed at the rate of about 30 pounds per cow per day or three-fourths ton per winter season when pasture is not available because weather conditions do not permit grazing the temporary crops. Kudzu or sericea lespedeza may be substituted for the alfalfa.

(3) Oats—1 acre. Winter oats are used for fall and winter grazing, October 15 to March 1, as weather and soil conditions permit. During four seasons oats were grazed an average of 56 days. Oats produce grain which is harvested about June 10. Then in late July or early August this land is planted to crimson clover and rye grass. Grazing begins again in early October and lasts until early May, as soil conditions permit. An average of 140 days grazing was obtained for four seasons. A crimson clover seed crop is harvested the latter part of May. The land is next planted to grain sorghum in June or early July.

(4) Crimson clover and ryegrass—1 acre. This acre alternates with the one above and follows the same rotation a year later.

Grade Jersey cows in this experiment that were also fed concentrates averaged 6,953 pounds of milk a year for the 4-year period; cows not getting concentrates produced 6,354 pounds. The concentrate-fed group averaged 309 milking days per cow, and the group that did not receive concentrates averaged 304 days. Concentrates fed averaged 2,167 pounds per cow per year, resulting in an additional 599 pounds of milk per cow.

After deducting expenses for land, rent, and all cash costs the net annual farm income of the experimental dairy for the 4-year period averaged $5,531 a year, or $64 an acre, including surplus seed and grains produced and sold. These amounted to an average of $2,821 per year, or more than half the average income. It was profitable to operate the dairy from 1942–46 with half of the cows receiving concentrates. Indications are that the system would pay with less favorable prices than prevailed in 1942–46, and that it would pay more without concentrates than if these feeds were purchased and fed. Except in unusual circumstances a ton of concentrates would cost more than 600 pounds of milk would bring to a farmer.

An experiment in Tennessee (*16*) with all-year pasture and hay ration produced 76 percent as much milk as pasture and hay plus grain. The permanent pastures were mixtures: Alfalfa and lespedeza; white, red and hop clovers; and orchard, redtop, and Bermuda grasses. Sudan grass was used for emergency summer pasture and crimson clover and rye grass for winter grazing. In this case 1,933 pounds of grain increased production of milk by 2,536 pounds. Furthermore, hay, pasture, and silage requirements for the grain-fed cows were reduced. An important difference in the two experiments was the productive capacity of the cows. The Tennessee cows were higher producers by about 2,000 pounds. Several farmers interviewed for this study stated that they would continue to feed grain to high-producing cows. These two experiments seem to support the economic wisdom of the practice. But just what is a high-producing cow? At what point does it pay to feed grain?

New Systems of Forage Utilization on Southern Farms

A few farmers in Southern States have gone all the way from farming systems that relied heavily on row crops, grain, and other concentrates to systems that depend almost wholly upon hay, pasture, and other forage. Examples of this type are scarce and special conditions about the farm or the operator set it apart from other farms. Far more numerous and far more important perhaps, though not so noticeable, are the thousands of farmers who have moderately stepped up acreages of hay, pasture, and other forage or have adopted practices to increase yields of forage. Several farms on which the forage and livestock feeding program is between the two extremes have been visited and information collected that will help to determine how far farmers generally may find it profitable to go toward more grassland. Some of these notes on specific farms and detailed data for selected farms are given in the pages that follow.

FARM A

Farm A, a dairy farm in Culpeper County, Va., has been converted completely to hay and pasture production within the last 10 years. The number of cows milked, about 56, has not changed. But the crop conversion has been from no alfalfa to 90 acres and from 20 acres of corn and 30–35 acres of small grains to none of these crops. Fertilization has been stepped up greatly. Feeding practices have been altered considerably.

Every acre of this farm is cleared and is in hay or pasture. Most of it is Bucks-Davidson silty clay loam. About two-thirds of the farm has a C slope, or 7 to 14 percent; a fourth of the acreage has a B slope, or 2 to 7 percent; and the remainder is a D slope, or 14 to 25 percent. When the soil map was made in 1941, about a fourth of the acreage had up to 25 percent of the topsoil gone, 25 to 75 percent was gone from half of the farm, and more than 75 percent from the other fourth of the acreage.

The 281 acres support an average of 56 milk cows, 2 bulls, 30 heifers, and 15 calves, with no other types of livestock on the farm. Cows graze from April 1 to October 1; heifers and calves from April 1 to November 1. The 85 acres of permanent pasture used by 56 cows are in 4 fields and the cows are rotated each 2 weeks. Other pastures, about 50 acres, are used by heifers and calves. About 45 acres are in lespedeza for hay. Pastures are primarily mixtures of blue grass and white or Ladino clovers. Supplementary summer pastures of sudan grass, about 10 acres, are considered necessary but no attempt is made to grow a winter pasture because the operator thought it would not be a paying proposition. In those years in which the sudan grass is not needed for grazing, it is used for silage. The aftermath may then be grazed.

As no corn is grown, silage is made from the first and part of the second cutting of alfalfa. All alfalfa plantings include some grasses and clovers. Yields run about 1 ton of hay and more than 3 tons of silage per acre.

In addition to the pasture of about 1½ acres per cow, fresh-cut and chopped alfalfa hay is delivered in boxes daily to the cows on pasture at the rate of about 50 pounds per head. This practice is costly and data are insufficient to determine its full economic implication. From October 15 to May 15 the milk cows are fed hay at the rate of 10 pounds per head a day and grass silage at the rate of 30 pounds per head. Heifers are fed 7 pounds of hay or 25 pounds of grass silage per head a day from November 1 to April 1. Small calves get 3 pounds of grain and all the hay they will consume, probably 3 or 4 pounds.

This is an all-roughage dairy farm at present only from the standpoint that no concentrates are home-grown. Commercial mixed dairy feed is bought and fed at the rate of 1 pound to 5 pounds of milk. But when milk prices drop, the operator plans to eliminate grain from his feeding system, except for very high-producing cows, and small calves. Purchased feed is his second largest cash expense.

Farm A has not changed in size. Nor has the major land use changed. It has about the same acreage of permanent pasture and cropland it had 10 years ago. The numbers and kinds of livestock are the same, too. What has happened and what is the significance of the changes? The 132 acres of cropland, a third of which was formerly in corn and small grains, is now all in hay. Most of it produces high-quality legumes and grasses that are utilized as silage, soiling, or chopped and barn-cured hay. The low-yielding, low-quality hays are almost a thing of the past on this farm.

The 137 acres of permanent pasture are in better mixtures of grasses and legumes. Pastures and hay lands are liberally fertilized. Pastures get an average of 750 pounds of 0–12–12 per acre annually and are limed once each 5 years at a rate of 1 ton per acre. Alfalfa is fertilized with 1,000 pounds per acre of 0–12–12 or 2–12–12 at seeding and is treated annually with about 750 pounds of similar analysis fertilizer. Mowing of pastures is now common practice on farm A. A field chopper and barn hay driers comprise the important changes in machinery. The field chopper reduces labor requirements for harvesting hay and this machine plus barn-curing of hay adds immeasurably to the quality of the feed. Production of milk has been increased to about 9,000 pounds per cow. Land use has been improved, but there is no satisfactory way to indicate the value of this gain in economic terms.

Farmer A has demonstrated the technical feasibility of a grassland farm. Has he gone too far? Should he grow his own grain? Is his plan the most profitable one? These are difficult questions. In 1946–48, the net cash farm income was between $4,000 and $6,000 per year. If prices were at the medium level, receipts would be less than expenses by more than $1,000, assuming continuation of the present level of inputs and outputs. But according to the operator he would not continue his present rate of grain feeding nor would he employ as much labor, if prices were to drop. Perhaps he would also reduce his fertilizer application. This would reduce expenditures for these three items. His production would drop too, though not enough to keep him from making a little profit. With prices received and prices paid at the high level as defined in this study, net cash farm income would be about $1,000, with no change in inputs or outputs.

FARM B

Farm B, also in Culpeper County, has soils and slopes similar to those of farm A. The 346 acres are used as follows: Corn and small grains, 69 acres; alfalfa, 74 acres; permanent pasture, 178 acres; and other land 25 acres. The present crop-rotation system calls for corn (about 25 acres) 1 year, small grain 2 years, and alfalfa 5 years. The core of the former system was 50 acres of corn. It did not include alfalfa.

Farm B supports an average of 50 milk cows, 15 dry and nurse cows, 30 bred heifers, 20 year-old heifers, 36 heifer calves, 4 bulls, 4 horses, 2 sows, and 1 boar. The tenants also keep some chickens. Two of the horses are kept for riding and 2 for a little light work. The hogs supply meat for owner and tenants.

Milk cows receive grain at the rate of 1 pound to 4 pounds of milk. The mixture is made from home-grown corn, oats, and barley and purchased bran and cottonseed meal, as follows:

	Pounds	
Corn	700	12 percent protein.
Oats	600	
Barley	300	
Bran [1]	200	
Cottonseed meal [1]	200	

[1] Bran and cottonseed meal are fed only in winter.

Thirty pounds of corn silage per cow a day are fed regularly from October 1 to April 15 and at other times during the year if pasture becomes short. Hay is fed throughout the year except in May and June, for a total of about 3 tons per cow. It is fed three times a day: 5 a. m., 10 a. m., and 4 p. m. Bred heifers get 10 pounds of silage each per day from November 1 to April 20. They are fed hay on pasture in November as well as for the remainder of the winter. They consume about 1¼ tons. Young heifers and small calves eat about one-half ton of hay each. Except for one bunch of yearling heifers all livestock were fed grain every day in 1947.

Cows graze from April 20 to November 1, 1 week per field in each of four fields. Heifers and bulls graze from April 20 to December 1.

The present owner started the changes on this farm when he acquired it late in 1937. He has reduced acreages of corn and small grains, added alfalfa, improved the permanent pastures, and built up the dairy herd. He has not made the complete conversion to pasture and hay that was done on farm A—at least not yet. He grows most of his own concentrates—in 1947 he bought only 4 tons of cottonseed meal and 5 tons of bran, compared with 100 tons of commercial mixed dairy feed purchased for farm A. Farmer B uses corn silage but he has ordered a field chopper and will try some grass silage. He believes he will stick to corn silage!

Beginning in 1938, the entire farm, cropland and pasture, received an annual application of 500 pounds per acre of 0–12–12. The 1947 rate was 600 pounds. It has been well limed regularly. The entire farm is covered with 10 tons of manure per acre about once in 3 years. Pastures are mowed about three times each summer.

On farm B as on farm A, better land use and conservation of the farm resources are direct and important aspects of more forage production. A subjective way to evaluate this contribution is to look at it the way the owner of the farm does. He says that if prices drop he can coast along for 2 or 3 years without applying more fertilizer.

FARM C

Farm C, in Fairfax County, Va., is operated similarly to Farm A. It has only 96 acres, 70 of which are in hay and pasture and the remainder in woods. The 70 acres furnish an abundance of pasture for 35 milk cows, 130 tons of grass silage, hay to winter the cows, and up to 40 tons of hay annually for sale (fig. 5). Until 18 years ago all the

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FIGURE 5.—Dairy cows reaching for grass silage on a Fairfax County, Va., farm.

cultivable land except small exercise lots for the cows was planted to corn. Three silos were filled and silage was fed the year round. A cloudburst swept a hillside cornfield away and this farmer did not plant corn again. Most of his land is in alfalfa, Ladino clover, orchard grass, and timothy. He sells hay, buys grain. He fertilizes heavily, 600 to 1,000 pounds per acre of 3–12–6 annually. Lime is spread every fifth year at the rate of 2 tons an acre. About half the farm is covered with manure each year. For several years milk sales have grossed $16,000 to $18,000 a year.

Farm C, like farm A, has demonstrated the technical feasibility of a grassland system. It is a show place known far and wide. Other farmers can grow more grass, but all farmers do not have the same talent for forage and livestock production as has the operator of farm C.

The changes made on farms A, B, and C are significant. Not many farmers have gone so far in changing from corn and other crops to high-quality pasture and hay crops. Many, however, have started in the same direction. Whether they should go as far as farmers A and C or stop short of complete conversion to grassland as farmer B has done is a question that is not answered in this progress report. It is to be studied further and reported upon in a subsequent report.

FARM D

In Washington County, Tenn., *Farm D* is an unusual example of forage utilization. This 70-acre farm with only 58 acres open has about 60 head of Aberdeen-Angus cattle. Only 3 or 4 acres could be called level. Most of it has considerable slope—up to 50 percent or more in a few places. The 56 acres of cropland are used as follows: Corn, 1 acre; alfalfa, 14 acres; pasture, 40 acres; and garden, 1 acre. In the middle twenties corn was grown on about 45 acres of the land, yielding 15 to 20 bushels per acre. This system was not changed materially until 1938 when the farm was selected for unit test demonstration under the Tennessee Valley Authority program. Since that time an average of 2½ tons of 16-percent or equivalent superphosphate has been applied per acre, along with a total of 5 tons of lime per acre. Some potash has also been applied. TVA has furnished about 21 percent of the phosphate used.

The acre of corn yields 100 bushels now, compared with 42 bushels in 1938. Yields of alfalfa hay are high. Good permanent pastures are disked and planted to rye grass, crimson clover, or other winter crops to increase production. This farmer is running his own experiment station, as so many of the leading grassland farmers are doing. Agronomists, soil chemists, economists, and others are watching and counseling. Are his practices practicable? Has he reached or passed the physical optimum with respect to phosphate and lime? How will this physical optimum, when found, relate to the economic optimum? The experts at the experiment station and the TVA say they don't know the answers. It all looks good on this farm.

In 1938, before it was converted to a grassland program, the farm system brought in a net cash income of about $600. This would amount to nearly $800 with the medium price level and $1,200 at the high price level used in this study (table 9). After converting the farm to grassland, actual net cash income for 1945–47 averaged more than $4,000 a year. With the same inputs and outputs as in 1945–47 and at the two assumed price levels the net cash income for the grassland program at the medium price level would be about $1,060. But at the high price level the net cash income would be about $2,600.

TABLE 9.—*Comparative data for 2 beef-cattle farms selected because they have changed to more hay, pasture, and other forage* [1]

Item	Farm D		Farm E	
	Former plan	Present plan	Former plan	Present plan
Land use:	*Acres*	*Acres*	*Acres*	*Acres*
Land in farm	68	70	317	317
Cropland	33	15	135	81
Open pasture	25	43	159	213
Woodland	5	5	20	20
Other land	5	7	3	3
Major crops:				
Corn	6	1	26	3
Wheat	4	0	9	0
Oats	7	0	5	0
Hay	14	13	110	88
Livestock:	*Number*	*Number*	*Number*	*Number*
Workstock	2	0	7	6
All cattle and calves	11	64	93	96
Beef cows	0	24	35	54
Dairy cows	6	2	2	0
Brood sows	2	2	2	0
Chickens	78	40	90	60
Cash receipts:	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Actual prices	1, 005	7, 981	3, 638	6, 254
Medium price level	1, 379	4, 468	4, 971	3, 467
High price level	1, 880	6, 362	6, 867	4, 953
Cash expenses:				
Actual prices	407	3, 868	1, 213	2, 152
Medium price level	584	3, 408	1, 982	1, 937
High price level	657	3, 783	2, 257	2, 105
Net cash income:				
Actual prices	598	4, 113	2, 425	4, 102
Medium price level	795	1, 060	2, 989	1, 530
High price level	1, 223	2, 579	4, 610	2, 848
Investment: [2]				
Real estate	13, 400	14, 493	6, 500	6, 500
Machinery and equipment	227	2, 693	481	559
Livestock	1, 157	13, 540	3, 552	4, 256
Feed and supplies	248	1, 550	1, 840	2, 330
Total	15, 032	32, 276	12, 373	13, 645

[1] Basic data for farms D and E are from farm record books and were made available through the cooperation of the Agricultural Extension Services of Tennessee and Virginia, respectively. Former plan for farm D is for 1938; for farm E it is 1940. Present plan for both farms is an average of 1945–47. Actual prices used above refer to these dates. See pp. 14 and 15 for explanation of medium- and high-price levels.

[2] Data are as of the beginning of the first year and ending of the last year for each farm.

FARM E

In Louisa County, Va., *farm E*, a beef-cattle farm, is operated quite differently. It has five times as much open land but it carries only 50 percent more animal units than the farm described above. Farm E has 3 acres of corn every other year. The remainder of the farm is in hay and pasture, which receives lime and fertilizer at moderate rates. There is no expensive machinery on the farm—all of it is valued at about $560. The operator says he works 2 months during the year—long enough to harvest 100 tons of hay. He has a hired man for these 2 months. It is the easy way to farm. He no longer grows 26 acres of corn, 9 acres of wheat, and 5 acres of oats, as he did in 1940 (table 9).

With the former plan, farm E had a net cash income of more than $2,400 in 1940. Had that system been continued this figure would have amounted to about $3,000 at the medium price level and $4,600 at the high price level. Upon changing to more grassland and operating on a fairly extensive basis, the actual net cash income was more than $4,000 a year for 1945–47. If it is assumed that inputs and outputs will remain constant at the assumed price levels, this actual figure would drop to about $1,500 at the medium price level and it would still be only $2,850 at the high price level. These dollar figures do not include values for conservation or better land as a result of the grassland program.

Detailed farm records show that both farm D and farm E have gone far in forage utilization with financial success. There are many alternatives. Farm E could be made to support two or three times as much livestock. But to do so, fertilization rates would have to be stepped up, more hay produced and harvested, and other changes made, including more labor. The operator of farm E has reared his family and wants to take life easy from now on. The operator of farm D is a young man. Age, family needs, interests, management aptitudes, etc., result in important differences in the extent to which farmers will produce and utilize forage in their livestock programs. Many of the outstanding examples of farmers who are maximizing forage are older men who want to minimize physical labor. Some do it as does farmer E, on an extensive grazing basis, but others go all out for the latest labor-saving machinery.

Cash expenses for fertilizer, lime, and seeds on highly developed grassland farms run high (fig. 6). For an 8-year period, farm D averaged $13.68 per year per acre of open land (cropland and open pasture). Yearly averages ranged from $4.09 per acre in 1940 to $28.12 in 1947. Farm E spent only $2.42 per year per acre, which is more nearly in line with similar expenditures on farms I and J. All of these farms are considered outstanding grassland farms in their respective communities. Table 10 shows the cash expenditure for fertilizer, lime, and seeds per acre of open land for the four farms for which other data are given in tables 9 and 11.

Table 10.—*Cash expenditure for fertilizers, lime, and seeds per acre for 4 farms, 1940–47*

Farm	1940	1941	1942	1943	1944	1945	1946	1947	Average
D	$4.09	$5.83	$8.45	$8.52	$18.26	$22.38	$13.79	$28.12	$13.68
E	1.43	1.53	1.19	1.80	1.36	2.71	2.60	6.78	2.42
I	1.95	1.28	2.51	1.45	3.49	1.88	3.58	4.46	2.57
J	------	2.07	2.28	4.49	4.37	3.92	4.93	7.35	4.20

FIGURE 6.—This North Carolina grass and legume pasture was improved materially by the application of lime, phosphate, and potash.

FARM F

Farm F, in the Piedmont, Lee County, Ala., was a cotton farm until 3 years ago. The records show 64 acres in cotton in 1941. None has been grown since 1945 and the operator says he will not grow cotton again. He has about 50 cows; milks 6 or 8 to keep his small grade A dairy in operation. The cattle enterprise is not a new one; he kept 25 to 30 cows while growing cotton. The major land use is about as follows: Alfalfa, 5 acres; sericea lespedeza, 60 acres; crimson clover, 12 acres; corn, 20 acres; kudzu, 20 acres; grain sorghum, 12 acres; truck, 2 acres; orchard, 2 acres; permanent pasture, 100 acres; woodland pasture, 349 acres.

The operator of farm F expected to add 10 acres of alfalfa in September 1948. He planted his first alfalfa in 1942. His 5 acres at that time made a total of 14 acres in the county. There are 775 acres in Lee County now. He planted his sericea during the war. Because he had no labor he had to sow the land to something. He likes sericea but considers alfalfa the best all-round dairy feed. It can be used as hay or pasture—both of which are good.

The operator cuts 15 to 20 acres of sericea for hay. Yields are about half a ton per acre the first cutting. The second cutting is combined for seed. Some of the seed is sold, some planted. The 5 acres of alfalfa yield 1 ton an acre per cutting, with from two to four cuttings.

Oats are planted for fall and winter grazing, crimson clover for spring grazing, kudzu for summer dry spells, and sericea for the principal grazing. The 100 acres of other pasture consist of hop clover, bur clover, Dallis grass, carpet grass, and white Dutch clover.

Although year-round grazing is provided, milk cows are fed ground corn and cottonseed meal throughout the year with alfalfa hay in winter. Dry cows and other cattle get hay in the bad winter months. Pasture is so abundant that there is no particular problem about enough feed even in dry weather, although it may not be of the best quality. Here extra land for a summer crop and surplus dry forage in the permanent pastures might be unnecessary if irrigation of a small acreage could be provided economically.

The cows average about 1½ gallons of milk per day. Some experiments and farmer experience indicate that this quantity of milk can be obtained from good pasture and hay without the use of concentrates.

FARM G

In the Coastal Plain of Alabama, in Macon County, the operator of *farm G* specializes in wintering beef cattle and producing blue lupine seed. He buys stocker cattle weighing about 400 pounds in the fall, feeds them until April when they weigh about 500 pounds and the Black Belt farmers are ready to buy them. In addition to the stockers he keeps about 15 cows throughout the year. The cattle are fed grain sorghum and graze manganese bur clover beginning about February 1, which is part of one of the systems recommended by the experiment station.

FARM H

Many farmers in the Black Belt follow the recommendations of the Alabama station as to their beef-cattle enterprises. Typical of these is the operator of *farm H* located in Macon County. He has a herd of about 135 cows. His 664 acres are used as follows: Caley peas and Johnson grass, 60 acres; oats, 20 acres; permanent pasture, 554 acres; woodland, 30 acres. The 60 acres of Caley peas furnish winter pasture for his herd. During this period of about 100 days, dry cows get 1½ to 2 pounds a day of a commercial concentrate. Cows nursing calves get about 4 pounds a day. All cows get an average of 10 to 12 pounds of hay a day. Hay feeding is increased on very cold days and decreased on warm sunny days. All feeding is on the ground in the pasture fields.

Johnson grass following the Caley peas is not grazed but it is cut twice for hay—in July and September or October. Some farmers recommend grazing the last cutting. Except for dry periods this farm would support more livestock, but the operator prefers too much grass to too many cattle. That is the philosophy expressed by many other livestock farmers. Many say that winter pastures are not always dependable and they keep a reserve of hay. Then they can sell the hay if their pastures are good or they can buy more cattle and feed the hay.

Could the concentrates be eliminated from the feeding plan of farm H? Or could they be grown on the farm, if needed? Could grain sorghum be grown and harvested by the cattle? This will be tried for the first time in the fall of 1948. How far can the operator of farm H and other Black Belt farmers profitably go in production and utilization of hay, pasture, and other forage on their beef-cattle farms? More data on inputs and outputs and a careful budgeting process will give a clearer answer than can be given with information now available.

FARM I

Farm I, Alleghany County, N. C., is a mountain farm of 206 acres, only 123 acres of which is cropland and open pasture. (See table 11 for break-down of land use.) The open land is about equally divided between Ashe and Porters soil types. As organized, the cropland has slopes ranging from 2 to 8 percent; the pasture goes from about 10 to 30 percent; and the 77 acres of woodland are generally steeper than 30 percent.

What has happened on farm I since the present operator took over in 1938? Nine acres of steep cropland were converted to pasture or other use. Acreage of corn was cut in half; acreage of hay almost tripled. The number of cattle and calves has increased nearly three times. The former plan had 71 acres of permanent pasture and 13 head of cattle and calves. The present system has 76 acres of open pasture and 35 head of cattle and calves.

Before 1938 no lime or phosphate had been used on farm I. Permanent pastures were in poor condition and rampant with briars and other undesirable growth. Hay was of low quality. All the open land has now been limed and phosphated—a total of 4 tons of lime and 400 pounds of phosphate per acre having been applied in the 10-year period. Lime, fertilizer, and seeds cost $2.57 per acre of open land a year. (See p. 48.)

From 11 acres of mixed grasses producing 8 tons of low-quality hay in 1940, farmer I went to 18 acres of better quality grass-legume hay producing 18 tons, plus 8 acres of alfalfa producing 24 tons, plus 5 acres of small grains cut for hay. The permanent pastures produce considerably more forage now and the soil is better protected.

In 1940, under the former plan, farm I produced a net cash income of $361, which is approximately the amount that would be realized under a medium-price level and half what a high-price level would bring in (table 11). With the present plan farm I had an average net cash income of $4,722 for 1945–47. Under a medium-price level this figure would drop to $2,640, but on a high-price level it would amount to about $3,500. These data suggest that the conversion paid well. In this case conversion was primarily one of liming, fertilizing, and reseeding permanent pastures; increasing acreage and kinds of hay and fertilizing the hay crop; and increasing the number of dairy cows. The total investment went up from $8,458 under the former plan to $20,435 under the present plan, table 11 indicating the relative importance of different changes in investment.

FARM J

Farm J, Nottoway County, Va., is a dairy farm with 307 acres of open land. (See table 11 for break-down of major land use.) With the former plan only 218 acres were cropland and open pasture in 1941. An additional 89 acres were cleared or included with a small tract bought in 1947.

Changes on farm J include increasing cropland from 58 to 77 acres; pasture from 122 to 230 acres; milk cows from 26 to 42; and total investment from $20,000 to $40,000. Acreage of corn, largely for silage, was decreased from 23 to 17 acres. Acreage of hay went up from 35 to 50 acres and production from 38 to 82 tons, with a large part of the

TABLE 11.—*Comparative data for two dairy farms selected because they have changed to more hay, pasture, and other forage* [1]

Item	Farm I		Farm J	
	Former plan	Present plan	Former plan	Present plan
Land use:	*Acres*	*Acres*	*Acres*	*Acres*
Land in farm	206	206	513	540
Cropland	56	47	58	77
Open pasture	71	76	122	230
Woodland	77	77	333	233
Other land	2	6		
Major crops:				
Corn	12	6	23	17
Oats	5	5	0	0
Hay	11	31	35	50
Livestock:	*Number*	*Number*	*Number*	*Number*
Work stock	4	2	3	2
All cattle and calves	13	35	44	69
Dairy cows	8	23	26	42
Brood sows	4	0	0	0
Chickens	30	51	33	40
Cash receipts:	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Actual prices	860	7, 804	5, 910	13, 889
Medium price level	1, 153	5, 211	6, 742	9, 284
High price level	1, 667	6, 532	8, 434	11, 604
Cash expenses:				
Actual prices	499	3, 082	4, 238	8, 068
Medium price level	786	2, 571	6, 382	6, 690
High price level	891	3, 036	7, 539	7, 696
Net cash income:				
Actual prices	361	4, 722	1, 672	5, 821
Medium price level	367	2, 640	360	2, 594
High price level	776	3, 496	895	3, 908
Investment: [2]				
Real estate	6, 785	10, 234	15, 525	21, 752
Machinery and equipment	472	3, 515	1, 010	4, 402
Livestock	1, 020	5, 157	2, 978	11, 000
Feed and supplies	181	1, 529	755	3, 053
Total	8, 458	20, 435	20, 268	40, 207

[1] Basic data for farms I and J are from farm record books and were made available through the cooperation of the Agricultural Extension Services of North Carolina and Virginia, respectively. Former plan for farm I is for 1940; for farm J it is 1941. Present plan for both farms is an average of 1945–47. Actual prices used above refer to these dates. See pp. 14 and 15 for explanation of medium- and high-price level.

[2] Data are as of the beginning of the first year and ending of the last year for each farm.

increase in acreage and production coming from alfalfa. The use of a mow hay drier lessens the hazards of hay harvesting, and the operator of farm J says his cows eat more of the barn-dried hay than they do of field-cured hay.

Farm I had a fair pasture base to start from, but pastures on farm J were started from scratch, that is, from unimproved open areas called pasture and from old fields. As a specific example of the use of lime, fertilizer, and seeds, farmer J seeded 8 acres, using per acre, 2 pounds Ladino clover, 10 pounds of orchard grass and 1 pound of redtop, 400 pounds of 65-percent superphosphate, 600 pounds of 4–12–4, and 2 tons of lime. Cash costs for these materials would be about $33 an acre at the medium-price level and $35 at the high-price level. For maintenance, 1,000 pounds of 0–12–12 per acre a year would be required. This would cost about $15 per acre at the medium-price level and $16 at the high-price level. For the farm as a whole, lime, fertilizer, and seeds cost an average of $4.20 per acre of open land per year from 1941–47; in 1947 these costs were $7.35 per acre.

Farm J is not so far advanced in the development of a forage program as is farm I, but both are showing up well on the income side. With the former plan the net cash income on farm J was $1,672 in 1941. With medium prices this would have been only $360 and with high prices, $895. With the present plan, however, the actual average net cash income was $5,821 in 1945–47. At the medium-price level, the present plan would bring in a net cash income of about $2,600 and $3,900 at the high-price level.

In Georgia, a farmer-writer (*5*) describes what he calls "weather-proof farming"—a 365-day pasture grazing, using four crops. With this system livestock graze Kentucky 31 fescue from November 1 to April 1. From the fescue they go to Ladino clover for about 5 weeks and then on to sericea lespedeza when it is about 6 inches tall in early May. Sericea is pastured until the middle of September. The fourth crop is kudzu, which is grazed until the cycle is started again with fescue. Thus, three legumes and a grass provide year-round grazing.

Production Practices in Relation to Forage Production

Fertilization, and some other practices, have so much to do with the economics of hay, pasture, and other forage utilization that it seems appropriate to give it some space in this publication. Fertilizers affect the quantity, quality, mineral, vitamin, and protein content, palatability, etc., of hay and pasture, which in turn, affect utilization.

At the Black Belt substation of Alabama, an annual application of 400 pounds of phosphate and 50 pounds of muriate of potash per acre to black medic, white clover, and Dallis grass pastures has about doubled the yield of beef over unfertilized pastures. Each dollar spent for fertilizers has produced an increase of 42 pounds of beef (*1*). The economic limit of fertilizer application has not been determined, however.

The Virginia station ran tests on the utilization of bluegrass pasture from fertilized and unfertilized plots. They found no difference in milk production per cow and no significant difference in nutritive value of fertilized and unfertilized pasture. However, the increased yield of the fertilized pasture justified the use of fertilizers (*6*).

In a series of tests at different locations in Alabama, yield and mineral content of pasture plants were greatly increased by applications of lime and fertilizer. Significantly, regardless of fertilization rates, the quality of plants on Norfolk sandy loam at the Gulf coast substation did not exceed that of plants from unfertilized plots on Bell and Houston clays at the Black Belt substation. Likewise, the quality of fertilized plants on Bell and Houston clays at the Black Belt substation did not exceed that of plants from unfertilized plots on Decatur clay loam at the Tennessee Valley substation (*23*). There are striking differences within a single State. What is the situation from State to State throughout the South?

The Bureau of Dairy Industry, at its dairy field experiment station near Lewisburg, Tenn., conducted an important pasture study from 1943–46. Investigations on undisturbed bluegrass sod showed that mowing about twice a year increased the annual production of total digestive nutrients by an average of 23 percent. Liming, manuring, mowing, and seeding, although the seeding was not too effective, resulted in an average of approximately 40 percent more total digestible nutrients produced yearly than were produced on the untreated bluegrass.

Experiments on pastures established on bluegrass sod by preparing seedbeds and sowing mixtures of orchard grass, bluegrass, white clover, and hop clover showed that the application of an average of about 16 pounds of nitrogen per acre a year increased the yield of total digestible nutrients by 20 percent. The same amount of nitrogen plus about 100 pounds of 20-percent superphosphate annually increased the yield by 15 percent; 4.8 tons of manure per acre increased it 29 percent.

Ladino clover and orchard grass gave a 26-percent greater yield than white clover and orchard grass—both treated alike on land that had been in field crops. Ladino clover and orchard grass produced 201 percent more grazing than the untreated blue grass (*37*).

Some farmers who want to be sure of year-round grazing are considering possibilities of irrigation. One in six of the leading grassland farmers interviewed in the South had some tentative plan for irrigating pasture. Several farmers have already requested assistance from their extension specialists on irrigation installations. Technical feasibility is almost certain; economic feasibility will require further study. The heavy rainfall and long growing season plus supplemental irrigation, together with numerous improved practices, could mean phenomenal increases in production and utilization of forage in the South.

Costs of clearing and irrigation of land are high. It would be folly to generalize on the potentialities of irrigation for livestock farming in the South. But thousands of farmers have the water and the physical setting for irrigation installations that would insure green pastures in the dry spells that come each year. Without irrigation, livestock farmers in the South must maintain extra investment in land for temporary crops to graze during dry spells, in silos to store extra silage, or in facilities to keep an extra supply of hay or other feeds. For success some provision must be made to tide livestock over the dry spells. Could irrigation of even a small pasture provide the necessary insurance? An irrigation installation might release 5, 10, 20, or more acres now devoted to a temporary crop for other use.

Tentative Conclusions

Experiment stations and some farmers have demonstrated the technical feasibility of farming systems that depend almost entirely upon hay, pasture, and other forage. To achieve satisfactory year-round systems of forage utilization, however, temporary or supplementary crops are necessary in most southern areas for which research data and farm experience are available. The necessity for the temporary crops for summer grazing in many areas can be overcome technically through irrigation. But data are too limited to generalize about whether it would be generally profitable to irrigate permanent pastures.

From the income side, this preliminary study suggests quite strongly that except for special situations, southern farmers will not find it profitable to go entirely to hay, pasture, and other forage. On the other hand, it strongly suggests that farmers will find it profitable to go much further into hay, pasture, and other forage for utilization by livestock than they have gone thus far. Farms completely covered with grasses and legumes can be found here and there and they make excellent case studies, but the majority of southern farms will not soon be so completely covered. It takes a long time to make the adjustment, especially on small farms and by farmers who do not have ready cash or who need the money for current living expenses.

It should be pointed out here that recent years have been good ones for farmers to make the adjustment to grass. If the economic incentive has not been good enough during this period one is justified in asking, when will it be good enough? Some farmers admit freely that certain practices, such as high applications of fertilizer, were adopted because their incomes were good and they considered it one way of putting money in the bank. They expect to withdraw this money if economic conditions put them under pressure. As some say, "We will coast along." In some instances expenditures for heavy applications of fertilizer have probably been made to reduce income taxes. That is to say, our tax system has promoted grassland agriculture.

There are economic obstacles, institutional obstacles, lack of knowledge, plain inertia, and other reasons for the seemingly slow change to production and utilization of forage. Nevertheless, the thousands of farmers who add a few acres of pasture, a few hundred pounds of fertilizer, some new grasses and legumes, and other practices, all put together, will make a lot more hay, pasture, and other forage and livestock in the South.

Nearly all examples of outstanding grassland farms are operated by outstanding men. One thing common to all the case farms studied in the South is the superior managerial ability of the operators, which seems to go hand in hand with a willingness to experiment on a farm basis with ideas that look promising.

Farm experience and experimental results indicate that it is technically feasible and economically profitable to produce milk in the South from a year-round grazing system. Both sources of information suggest, however, that it will pay to feed concentrates, even though purchased, to the higher producing cows.

Information available as to year-round grazing systems; specialized experiments on winter, rotational, and forest grazing, and supplemental feeding; and experiments on fertilization offer many possibilities for further economic appraisal. Except in a limited way, data have not been worked into possible farm organizations for this preliminary study. Possible combinations that might be made from experimental results are so numerous that all of them will never be tested as farm alternatives. Some of the more promising will have to be tried out to see how they will fit into the operations of representative farms.

Experiments show the potentialities but farmers quite often have some practical problems that prevent them from realizing the potential. This is especially true with the results from controlled-grazing experiments.

WESTERN STATES—PRELIMINARY FINDINGS

Because of variable climatic and physical conditions, and the many different types of farming practiced, a generalized treatment of this subject for the West is impossible. Therefore only a few of the many important aspects are discussed. Among these are economic appraisals of the effects of reseeding wheat land to crested wheat grass, of including this grass in long-time crop rotations with cash-grain crops in the drier areas of the northern Plains, of increasing acreages of grasses and legumes in crop rotations in the main corn-producing area of the Plains, and of artificial and natural reseeding of the range. In addition to the foregoing, other important range-management practices, together with some of the possibilities and problems involved in irrigated pastures and range, are discussed.

The same factors—high prices and generally favorable precipitation—during and following both World Wars I and II, resulted in the breaking and planting to wheat of vast areas of grassland in the West. Much of the land broken after World War I proved to be unprofitable for production of wheat during periods of less favorable prices and rainfall, and it was abandoned. During the 1930's much of this land reverted to grass through natural reseeding, and large acreages were artificially seeded to such grasses as crested wheat in the North and native grasses in the South. Thousands of these acres in different stages of recovery, in addition to large acreages of virgin range, have been broken and seeded to wheat during this decade. These changes have occurred in the wheat areas of the northern and southern Great Plains, the Columbia River drainage basin of Oregon, Washington, and Idaho, and the dry-land wheat areas of southeastern Idaho and northern Utah.

With a decline in the heavy European demand for wheat and a return to more normal weather conditions, we may reasonably expect that much of this marginal land will again become unprofitable for production of wheat. Alternative uses for this land include seeding to a permanent or rotation grass cover for use either as pasture or hay for livestock and, to a limited extent, the production of commercial grass seed.

PROBLEMS IN EXTENDING FORAGE USE IN GREAT PLAINS FARMING SYSTEMS (*As Illustrated by Studies of Case Farms*)

In a number of areas in the wheat regions of the West both wheat and livestock are important sources of income on the same operating units. Over much of the northern Great Plains wheat land is often adjacent to or interspersed with range land. In such areas livestock frequently offer good possibilities of bolstering and stabilizing agriculture against the effects of dry weather and a reduced market demand for wheat. Here livestock must be fed in the winter, but during drought years little or no winter feed is produced. To overcome this obstacle part of the wheat land may be used either for growing feed crops on summer-fallow or seeding to such drought-resistant grasses as crested wheat for hay or early spring and fall range, to complement the native range short, warm-season grasses (fig. 7).

Farmers frequently delay such stabilizing adjustments because it is difficult to visualize the various steps involved in making the necessary changes over periods of several years and their probable effects, both on current and longer term farm incomes. Effects of seeding wheat land to crested wheat grass on the organization, production, and income of a wheat-cattle ranch located in southwestern North Dakota are illustrated in table 12. The data are adapted from actual operations of a ranch representative of many in the area. The operator of this ranch has seeded 90 acres of his wheat land to crested wheat grass. In addition to the organization and income possibilities under both the former and present systems, this table also includes an al-

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FIGURE 7.—Cattle grazing crested wheat grass.

ternative ranch plan in which the entire 280 acres of wheat land is seeded to crested wheat grass.

Under the alternative and present plans cattle numbers have increased to utilize the increased feed provided by the crested wheat grass. Under the former plan breeding cows numbered 92, under the present system 100 head, and under the alternative system 126 head. Sixty yearlings were sold under the old plan, 66 under the present, and 84 head under the alternative plan. The 90 acres of wheat land seeded to crested wheat grass under the present plan included the poorest wheat land, averaging 10.9 bushels of wheat per acre as compared to an average of 12 bushels for the remainder of the wheat land. Wheat is seeded on summer-fallow, and oats and barley on corn ground. Acreages and yields of corn, oats, and barley remain constant under all three plans.

TABLE 12.—*Effects of permanent seeding of wheat land to crested wheat grass on the organization, production, and income on a wheat-cattle ranch in southwestern North Dakota*

Item	Former plan		Present plan—90 acres wheat and summer-fallow land seeded to crested wheat grass		Alternative plan—all wheat and summer-fallow land seeded to crested wheat grass	
	Acreage	Production	Acreage	Production	Acreage	Production
Crops and land use:	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Wheat	140	1, 526	95	1, 140		
Summer-fallow	140		95			
Corn	90	1, 800	90	1, 800	90	1, 800
Oats	50	1, 750	50	1, 750	50	1, 750
Barley	40	1, 000	40	1, 000	40	1, 000
		Tons		*Tons*		*Tons*
Wild hay	300	100	300	100	300	100
Crested wheat grass hay			10	9	32	35
		AUM's[1]		*AUM's*[1]		*AUM's*[1]
Private range	600	240	600	240	600	240
Crested wheat grass pasture			80	115	248	449
Crested wheat grass aftermath				5		16
Grazing permits held		1, 080		1, 080		1, 080
Total	1, 360		1, 360		1, 360	
	Inventory	Sold	Inventory	Sold	Inventory	Sold
Livestock:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Cows	92	12	100	13	126	16
Heifers 2 years (replacements)	15		16		20	
Yearlings, heifers, and steers	78	60	85	66	107	84
Bulls	3		3		4	
Horses	4		4		4	
Hens	50		50		50	
Net cash income:	*Dollars*		*Dollars*		*Dollars*	
With high price level	6, 904		7, 009		7, 044	
With medium price level	3, 968		4, 021		3, 960	

[1] Animal unit months of grazing.

With the high level of prices and costs used in this study (see pp. 14 and 15) slight increases in income are indicated under both the present and alternative plans, when compared with the former plan of farm operation. With a medium price and cost level a slight increase in income is shown for the present plan and very little change is indicated in the alternative plan. Ranchers who operate units of this type in the northern Great Plains apparently can shift a part of their wheat land to grass with very little change in income.

However, some sacrifice in income is to be expected during the 3 years required to establish stands of crested wheat grass and to build up numbers of breeding stock necessary to utilize the increased acreage of grass. During these intervening years the net cash income will be less than under the former plan (table 13).

In shifting to the present plan accrued reductions in cash income of $996 with the medium price level and $1,565 with the high price level are indicated. In shifting to the alternative plan with no receipts from wheat, reductions ranging from $3,924 to $6,233 might be experienced. These temporary reductions in income are caused by holding back from market more cows and breeding heifers to build up breeding cow numbers, and by purchasing the additional feed needed in increasing livestock numbers before the crested wheat grass is in full production. Additional cash expenses also are incurred during this period. Crested wheat grass, which is drilled in wheat stubble and summer-fallow during the fall, must be purchased. Another bull must be added to service the additional cows. But these reductions in net cash income are partially compensated by increases in livestock inventories. When these are considered, actual reductions in reaching the present plan are cut to $110 under the medium price level and $162 under the high price level. These amounts could be retrieved in from 1 to 3 years of full production after adjustment has been completed.

TABLE 13.—*Reductions in net cash income and increases in livestock inventories that occurred during establishment of crested wheat grass on a wheat-cattle ranch in southwestern North Dakota*

Item	Present plan—90 acres wheat and summer-fallow land seeded to crested wheat grass		Alternative plan—all wheat and summer-fallow land seeded to crested wheat grass	
	Medium price level	High price level	Medium price level	High price level
Reductions in net cash income:	*Dollars*	*Dollars*	*Dollars*	*Dollars*
First year	334	503	1, 535	2, 436
Second year	422	674	2, 273	3, 526
Third year	240	388	1, 162	1, 683
Total reduction accrued	996	1, 565	4, 970	7, 645
Increases in livestock inventories	886	1, 403	3, 924	6, 233
Extent total accrued reductions exceed increases in livestock inventories	110	162	1, 046	1, 412

The sacrifice this rancher has undergone in shifting about a third of his less productive wheat land into forage production apparently has been justified. Marginal wheat land has been taken out of production, thus reducing the production of wheat for sale by a fourth. The livestock enterprise has received additional emphasis; the feed base for livestock has been stabilized; and the labor requirements have been lessened.

When inventory increases are applied to reductions in income incurred in shifting to the alternate plan with no wheat, such losses are cut to $1,046 under the medium price level and $1,412 under the high price level. Ten years of full production are required to offset this loss under the high price level. With medium prices it would be impossible to recoup these losses inasmuch as the income is slightly less per year than under the former plan.

Shifts to the alternative plan, especially under a medium price level, may appear prohibitive at first. However, these losses are minimized in part by reductions in annual cash operating expenses of $383 under the high level and $308 with the medium level. Moreover, the income under this system can be expected to be more stable. In this area precipitation varies greatly from year to year and severe droughts are a frequent occurrence, resulting in low yields and failures. Because grass is less subject than wheat to the hazards of drought, a shift in the direction of more grass and storage of high-quality hay as a feed reserve would reduce risk and give greater stability to income.

In addition, these ranchers are primarily livestockmen, most of whom appear to be only fair farmers, and such adjustments in organization and operations would place the ranch more in line with the operator's capabilities. Although the proper balance between enterprises and the extent to which forage may be profitably increased varies from ranch to ranch, it is apparent that wheat-cattle ranches, such as the one discussed here, can profitably use excess wheat acreage for production of additional forage.

Details of year-to-year changes in reorganization, expenses, and income necessitated in shifting from the former to the present and alternative plans, are presented in tables 19 and 20 (pp. 82–87).

CRESTED WHEAT GRASS IN CROP ROTATIONS

For many years the conservation of cropland in the drier areas of the northern Great Plains has been a recognized problem. It has been difficult to develop rotations for this area capable of maintaining soil fertility and soil structure and, at the same time, of preventing wind and water erosion. Thus far no legume has been developed which is practicable for widespread use in rotations for the northern Great Plains. Many now feel that crested wheat grass may provide the basis for a crop rotation that will help to conserve the soil of this region. It is ideally suited to the northern Great Plains as it does well in cool areas with limited rainfall. Its widespreading and penetrating root system helps to improve the soil structure and to increase its humus content. Although experimental data are lacking, a number of research workers and farmers believe that a rotation of crested wheat grass and wheat results in higher yields for both crops.

Table 14 illustrates the effects of including crested wheat grass in the crop rotation on the organization, income, and production of a wheat-cattle ranch in southwestern North Dakota. For the last 20 years the operator of this unit has used crested wheat grass in rotations with wheat. On 650 acres of his cropland he has followed a 13-year rotation which includes crested wheat grass for 7 years, followed by wheat, corn, wheat, summer-fallow, wheat, and barley. In the fall of the thirteenth year crested wheat grass is drilled in the barley stubble. This rotation has increased crop yields about 20 percent.

TABLE 14.—*Results of including crested wheat grass in part of the crop rotation on the organization, production, and income of a wheat-cattle ranch in southwestern North Dakota*

Item	Former plan—before inclusion of crested wheat grass in crop rotation		Present plan—after inclusion of crested wheat grass in rotation on 650 acres of cropland		
	Total acreage	Production	Total acreage	Acreage under crested wheat grass rotation	Production
Crops and land use:	*Acres*	*Bushels*	*Acres*	*Acres*	*Bushels*
Wheat	500. 0	5, 150	390. 0	150. 0	4, 317
Summer-fallow	500. 0	--------	340. 0	50. 0	--------
Oats	90. 0	2, 394	100. 0	--------	2, 660
Barley	120. 0	2, 400	100. 0	50. 0	2, 170
Corn	182. 4	3, 338	136. 7	--------	2, 501
		Tons			*Tons*
Corn silage	57. 6	144	63. 3	50. 0	183
Oats cut for hay	30. 0	15	--------	--------	--------
Crested wheat grass hay	--------	--------	98. 0	98. 0	120
Wild hay	100. 0	25	100. 0	--------	25
		AUM's [1]			*AUM's* [1]
Native grazing land	2, 580. 0	1, 720	2, 580. 0	--------	1, 720
Crested wheat grass pasture	--------	--------	202. 0	202. 0	412
Crested wheat grass seeding	--------	--------	50. 0	50. 0	--------
Aftermath crested wheat grass	--------	--------	--------	--------	65
Aftermath wild hay	--------	46	--------	--------	46
Total	4, 160. 0	--------	4, 160. 0	650. 0	--------
	Inventory	Sold	Inventory		Sold
Livestock:	*Number*	*Number*	*Number*		*Number*
Cows	125	16	160	--------	19
Heifers 2 yrs. (replacements)	20	--------	24	--------	--------
Yearling heifers and steers	106	83	136	--------	108
Bulls	5	--------	6	--------	--------
Horses	3	--------	3	--------	--------
Hens	100	--------	100	--------	--------
Net cash income:	*Dollars*		*Dollars*		
With high price level	11, 006		12, 207		
With medium price level	5, 901		6, 623		

[1] Animal-unit months of grazing.

Of the 350 acres devoted to crested wheat grass, 202 acres are used as early spring and fall pasture to supplement the native range and 98 acres are cut to provide hay for winter feed. The remaining 50 acres of crested wheat grass is new, first-year seeding that furnishes little forage. This increased pasture and hay makes it possible to increase the breeding cow herd from 125 to 160 head. Under the former plan 83 yearlings and 16 cows were marketed each year as compared with 108 yearlings and 19 cows under the present plan. With the high price level net cash income increases from $11,006 under the former plan to $12,207 under the present plan. With the medium price level the cash income increases from $5,901 to $6,623.

Mainly because of the inclusion of crested wheat grass in the crop rotation and the greater winter feed requirements, cash income from crops would decrease 13 percent in shifting from the former to the present system. Income from livestock would increase 22 percent under the high price level. Under the present plan acreage of wheat is reduced 22 percent but because of increased wheat yields on land in the crested wheat rotation, total production of wheat would decrease only around 16 percent.

Cash operating expenses decrease from $9,340 to $9,134 under the high price level and from $8,091 to $7,913 under the medium level. Because of increases in livestock numbers, interest on investment, a noncash expense, would be increased $160 with the medium price level and around $300 under the high-level situation.

This stability in farming, increased income, decreased cash operating expenses, and increased soil productivity cannot be achieved without considerable temporary sacrifice in income. As in the case of the North Dakota wheat-cattle ranch, previously described, on which wheat land was permanently seeded to crested wheat grass, some income from livestock must temporarily be sacrificed in order to build up breeding herds to utilize the crested wheat after it is established. Crested wheat grass seed must be bought and additional fencing around the pastures probably will be necessary.

Before establishing such rotations considerable planning of field boundaries and cropping systems must be accomplished. Many ranchers, as this one has done, may find it desirable to limit the crested wheat grass rotation to only part of their cropland, as the inclusion of all cropland may present difficult adjustment problems. Acreage of crested wheat grass must increase in proportion to acreage of land placed under rotation. In this example, larger acreages would have made it necessary to forego marketing of even more heifers in order to build up cattle numbers and this would have resulted in even heavier temporary reductions in livestock receipts. Other ranchers may find that the inclusion of all their cropland in the rotation would leave them short of feed grains. The proportion of cropland which should be placed under rotation must be determined individually for each ranch.

Farmers and researchers are cautioned that the increases in crop yields used here are based on limited experience within a particular area, and that the effect of including crested wheat grass in crop rotations may vary in other areas. Reliable and complete data on this subject are not yet available. However, the experience of the rancher discussed here indicates that crested wheat grass in the crop rotation represents another means of profitable utilization of forage on excess wheat land in the northern Plains. The advantages of using crested wheat grass in rotation with crops in the northern Plains appears to be duplicated in the southern Plains through the use of native grasses in rotation, according to investigations conducted at Woodward, Okla., by the United States Southern Great Plains Field Station.

GRASS AND LEGUMES IN THE EASTERN PLAINS

In much of the main corn-producing areas of the eastern portion of the Great Plains, rainfall is relatively high and the topography rolling. The present land use pattern includes large acreages of intertilled crops. All of these factors accentuate soil damage from water erosion. Inclusion of grasses for pasture and hay as feed for livestock has helped to maintain soil fertility, improve soil structure, prevent erosion, and stabilize income.

Illustrating the types of problems encountered in shifting from the customary production of cash grain and hogs to that of forage crops and their utilization through livestock is a farm in southeastern Nebraska that formerly was badly eroded (table 15). In 1936 the operator initiated a program of grassland farming and began shifting from a rotation which had consisted mainly of corn, wheat, and oats to one in which major emphasis was placed on bromegrass and alfalfa for hay and pasture. Under the former farm plan this operator kept 7 brood sows and milked 6 cows. Now he raises no hogs and milks 14 cows. Shifting to grassland farming involved the enlargement and improvement of the dairy barn at a cost of approximately $1,000, based on high-level prices. He also bought a milking machine. Number of chickens kept and raised remained the same for both farm plans. Production of butterfat per cow is assumed to remain the same, 160 pounds per head, under each plan.

As table 15 indicates, net cash income with the high price level would remain approximately the same when shifting from the former to the present plan, even though the acreage in the farm is reduced by the sale of 3 acres for roads and by not renting 40 acres of pasture. With the medium level, however, the income decreased $54 in shifting to more grass and more milk cows. Cash expenses decreased under both price levels; 11 percent under the high level and around 9 percent under the medium level.

Farmers within this area apparently can increase their production of forage without undue sacrifice in income. Soil productivity and hence land values have been increased. Yields of corn on this farm increased from 20 to 35 bushels per acre. The previous severe soil losses from erosion have been reduced to a minimum. Moreover, if this shift had not been made and the previous farming practices which encourage erosion had been continued, crop yields and land values would have decreased instead of increasing. Some such type of conservation and livestock farming must be established and maintained if farming is to be continued in the area, inasmuch as many of these soils will not withstand continuous cropping systems of farming. Increases in production of butterfat should not affect the broad market structure for this product to an appreciable degree. On the other hand, if many farmers turn to production of whole milk in this area with its limited market, milk prices would probably be lowered.

TABLE 15.—*Effects of shifting emphasis from grain and hogs to grass and milk cows on the organization, production, and income of a badly eroded farm in southeastern Nebraska*

Item	Former plan—emphasis on grain and hogs		Present plan—emphasis on grass, legumes, and dairy cattle	
	Acreage	Production [1]	Acreage	Production
Crops and land use:	*Acres*	*Bushels*	*Acres*	*Bushels*
Corn	50. 0	1, 000	23. 0	805
Oats	7. 0	301		
Wheat	7. 0	175		
		Tons		*Tons*
Oats for hay			5. 0	10
Alfalfa hay	14. 0	28		
Alfalfa brome hay			18. 5	32
Bromegrass			12. 5	19
Alfalfa brome, timothy, and lespedeza pasture			24. 0	
Bromegrass pasture			16. 0	
Bluegrass pasture	77. 0		13. 0	
Farmstead and roads	5. 0		5. 0	
Total [2]	160. 0		117. 0	
	Inventory	Sold	Inventory	Sold
Livestock:	*Number*	*Number*	*Number*	*Number*
Milk cows	6	1	14	2
Replacement heifers	2		4	
Calves	6	4	13	10
Bulls	1		1	
Brood sows	7	7		
Pigs	42	31		
Horses	2		2	
Hens	200	80	200	80
Chickens	275	145	275	145
Livestock products produced:		*Pounds*		*Pounds*
Butterfat		960		2, 080
		Dozens		*Dozens*
Eggs		2, 400		2, 400
Net cash income:	*Dollars*		*Dollars*	
With high price level	1, 612		1, 598	
With medium price level	1, 054		1, 000	

[1] During this period oats and wheat were seeded on the better soils and corn was planted on the poorer soils.

[2] Under the former system this unit included 120 acres of owned land, of which 3 acres were subsequently sold to the county for roads, and 40 acres of pasture which were rented from a neighbor. No pasture is rented under present system.

In adjusting to this system there would be some reduction in cash income during the first few years. Inasmuch as such systems generally result in more cattle, some farmers may find it necessary to build new or to enlarge present barns, as on this farm on which $1,000 was spent on enlarging the dairy barns. As was also the case with this farmer others may find it desirable to buy a milking machine. In order to increase the number of cows from 6 to 14 head, additional heifer calves would have to be retained and this in turn would decrease receipts from livestock during the first years. On many farms it would be necessary to remove old fences and build new ones to conform with new field boundaries.

MORE LEGUMES IN THE FARMING SYSTEM

Although the inherent productivity of the loess soils in the corn-producing areas of the eastern Great Plains is relatively high, much of this land is yielding less than it is capable of producing. Relatively high rainfall, rolling topography, and too large an acreage of intertilled crops have contributed to lowering the fertility of these soils. Some of this land has been severely damaged by soil erosion. Fortunately, such depleted soils respond favorably to crop rotations which include legumes. Because of the high lime content, legumes do well on these soils, increasing fertility within relatively few years.

Table 16 illustrates some of the effects of giving greater emphasis to legumes and to the adoption of certain conservation practices in improving the soils and increasing and stabilizing income on a farm located in the loess-soil area of eastern Nebraska. In 1933 this farmer initiated a program of farm improvement through the inclusion of legumes in the crop rotation and the adoption of soil conservation practices. Eighteen acres of low-producing native pasture along a creek were seeded to alfalfa and brome pasture. Seven acres of wild hay land were broken and are now included in the legume crop rotation. An increase in corn yields from 30 to 40 bushels and in yield of oats from 28 to 38 bushels per acre were considered to be a reasonable long-time expectancy. There are 13,000 feet of terraces on the farm, all of which were constructed by the operator with a two-bottom tractor plow. The farmer has discontinued growing wheat, decreased acreage of corn by 29 percent, and increased acreage of grass and legumes from 37 to 67 acres, or 80 percent. Under the high price level cash income increased $726, or approximately 20 percent, and even with the medium level the increase would be $553, or around 26 percent. In making these adjustments, cash expenses remained about the same.

In both the former and the present plan, 25 head of 400-pound calves were bought each fall and, along with 5 head raised on the farm, were grain-fed in dry lot for 225 days. During this period the calves made average gains of 425 pounds. In the future this farmer intends to buy calves of the same weights and quality; however, they will be fed in dry lot during the winter months for a period of 150 days only on a ration of legume hay, cottonseed cake, corn, and a small quantity of oats. (See table 16, alternative plan.) The calves will be turned out on alfalfa brome pasture in the spring and grain-fed for a period of 170 days. It is estimated that they will gain an average of 250 pounds during the first 150 days and 400 pounds during the next 170

TABLE 16.—*Effects of increasing legumes on the organization, production, and income of a grain-livestock farm in east central Nebraska*

Item	Former plan—minor emphasis on legumes with calves fed in dry lot		Present plan—increased emphasis on legumes with calves fed in dry lot		Alternative plan—increased emphasis on legumes with calves grain-fed on pasture	
	Acreage	Production	Acreage	Production	Acreage	Production
Crops and land use:	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Wheat	12. 0	144				
Corn	81. 0	2, 430	57. 5	2, 300	57. 5	2, 300
Oats	18. 0	504	28. 7	1, 092	28. 7	1, 092
		Tons		*Tons*		*Tons*
Sorghum	5. 0	15				
Alfalfa	12. 0	24	10. 0	20	10. 0	20
Wild hay	7. 0	7				
Permanent alfalfa and brome hay			18. 0	27		
Red clover						
Hay			14. 4	25	14. 4	25
		Bushels		*Bushels*		*Bushels*
Seed				14. 4		14. 4
Permanent alfalfa and brome pasture			10. 0		28. 0	
Native pasture	18. 0					
Sweetclover pasture			14. 4		14. 4	
Farmstead and roads	7. 0		7. 0		7. 0	
Total	160. 0		160. 0		160. 0	
	Inventory	Sold	Inventory	Sold	Inventory	Sold
Livestock:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Cows	7	1	7	1	7	1
Heifers	2		2		2	
Calves	6	5	6	5	6	5
Feeder calves purchased [1]	25	25	25	25	25	25
Brood sows	8	8	8	8	8	8
Pigs	48	37	48	37	48	37
Horses	2		2		2	
Hens	100	90	100	90	100	90
Chickens	200	80	200	80	200	80
Livestock products produced:		*Pounds*		*Pounds*		*Pounds*
Butterfat		1, 400		1, 400		1, 400
		Dozens		*Dozens*		*Dozens*
Eggs		1, 200		1, 200		1, 200
Net cash income:	*Dollars*		*Dollars*		*Dollars*	
With high price level	3, 660		4, 386		4, 774	
With medium price level	2, 087		2, 640		3, 028	

[1] Under former and present plans 400-pound calves fed in dry lot for 225 days gain 425 pounds. Under the alternative plan, 400-pound calves fed 150 days during the winter and grain-fed on pasture for 170 days during summer gain a total of 650 pounds.

days while they are grain-fed on pasture (*26, p. 9*). Because of the higher finish resulting from the longer feeding period it is estimated, using the high price level, that the cattle grain-fed on pasture will bring $1.93 more per 100 pounds than will the calves fed only in dry lot: using the medium prices, the difference would be $1.46. Net cash income under the high price level would increase approximately 9 percent from the present plan as compared to an increase under the medium level of around 15 percent.

In this example cattle numbers are not increased, hence there would be no decrease in livestock sales due to the necessity for holding back additional heifers. However, in appraising this example of increasing legumes in the light of their own farming operations, farmers on similar soils should consider the problems involved in planning and establishing the rotations mentioned in the preceding cases.

Grain-feeding of cattle on pasture, like that described in the alternative plan, is becoming an increasingly popular practice in this portion of the Corn Belt. Cattle fattened on grass require little hay: hence the arduous labor of hauling hay is reduced to a minimum, as is manure spreading. Likewise, less labor is required for putting up hay. Cattle fed on clean grass sod can be maintained in better condition than those fed in dry lots, which become muddy and heavy in wet periods during the late fall, winter, and spring months. Stockmen find caring for stock on grass sod easier and more pleasant than wading through heavy sloppy feed yards. However, in feeding cattle on rotation pastures provision must be made for water. The cost of digging wells or piping water may be prohibitive in some cases.

Thus far four farms representing different situations in the Great Plains, two in the subhumid and two in the more humid areas, have been analyzed to determine a few of the possibilities of expanding production of forage. In general, it would appear that forage production could be increased in these areas without undue sacrifice in farm income, and that in some cases substantial additions to income could be obtained. In most cases, however, there will be temporary losses of income during the earlier years of the adjustment period. Additional heifers must be held back: grass seed must be bought: additional fences, and in some cases buildings for livestock must be built, or existing buildings enlarged. In some cases, fencing costs may be reduced by using electric fences.

For units on which it is impracticable to add livestock enterprises or increase present livestock numbers, commercial production of grass seed may be a possible adjustment, particularly in the less humid areas of the Plains where most of the land is devoted to production of wheat and where few livestock are kept. The present strong demand for grass seeds of all kinds will probably continue for some time. Interest shown by farmers throughout the United States in increasing grass acreages and by ranchers in reseeding badly deteriorated range, coupled with the demand from farmers in both new and established irrigation areas for more pasture has created a substantial deficit in the supply of commercial grass seed. However, if large numbers of farmers were to produce seed, supplies could eventually outrun demand.

Increasing Forage Production on Range Lands in the West

Agriculture on western ranges is already a "grassland" type. Ranchers and researchers constantly seek means of maintaining or improving the grass cover (fig. 8). The practices employed to achieve

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Figure 8.—Carrying capacity of this range was increased by good management, including rotational grazing and gully control.

these ends have a direct impact on the rancher's purse. One of the more important of these is range reseeding, which may be accomplished either by artificial or natural means, depending upon condition of the range and type of herbage present. Artificial reseeding is generally used when most of the vegetation is gone or when the present cover consists mostly of undesirable species. Natural revegetation may be used in areas which still have enough topsoil and organic matter to furnish the water-holding capacity to insure forage recovery, and which still contain a sufficient stand of desirable perennials so that revegetation will be accomplished in a reasonable period of time. This is accomplished by practicing a very conservative system of grazing or one of deferred and rotation use.

Artificial range reseeding is relatively new, nearly all cultural practices, methods, and techniques having been developed in the last 15 years. The Intermountain Forest and Range Experiment Station at Ogden, Utah, began intensive studies of artificial range reseeding in 1935. Their early research showed that the simple act of scattering seed on the ground usually resulted in failure and that coverage of the seed of most species was an absolute necessity. It is for these reasons that airplane reseeding so often has resulted in failure except on very light sandy soils, on burned-over areas with plenty of ash, and in aspen stands where leaf fall serves to cover the seed. They have concluded that reseeding ordinarily is a desirable and economic practice only if good stands can be established by a single seeding.

In almost all of the cool dry areas of the West, where precipitation is the principal limiting factor, crested wheat grass has proved highly adaptable for range reseeding (fig. 9). It withstands grazing well and supplies feed in early spring and fall at a time when it is most needed to supplement the native range. It is resistant to drought and cold and has a tremendous root system. However, it becomes tough when dry.

In the southern Great Plains natural revegetation through either conservative or deferred grazing appears to be the most practicable method of restoring depleted ranges. Artificial reseeding has been difficult in this area due to competition from weeds, and when it is necessary to use this practice, the grasses seeded should be those best able to withstand this competition. Crested wheat grass and western wheat grasses are recommended for the cooler or higher altitudes. Both of these grasses are early-cool-season grasses and stands are established before weeds became numerous. At the United States Southern Great Plains Field Station, Woodward, Okla., sand love grass has been found to be the best grass for range reseeding on light sandy soils at lower altitudes, although many other native grasses may be used successfully (*30*).

A range-improvement practice known as "pitting" has been developed in the Plains area of eastern Wyoming. An eccentric disk gouges out pits in waffle-like patterns, cutting out about a third of the short grass cover, which is composed mainly of buffalo and blue grama grasses. These depressions hold moisture from heavy rains, stimulating the growth of western wheat, a tall midseason grass which in turn gives greater protection against evaporation, and helps to hold the snow in place, thereby furnishing an increased supply of early grass (fig. 10). Results of a 5-year experiment at Archer, Wyo., indicates that this practice increased the grazing capacity about a third and that about 50 percent more grass was left each year during the 1942–47 period (*3*).

FIGURE 9.—Crested wheat grass is successfully seeded in many areas of the northern Plains. The crested wheat grass on the left of this picture is on range which before reseeding was infested with sagebrush and cacti like that on the right.

FIGURE 10.—On Wyoming short-grass range, pitting stimulates growth of tall midseason grasses which hold the snow in place, furnishes greater protection against evaporation, and increases the supply of early grass: *A*. This retaining snow cover is on a pitted range; *B*, this picture, taken the same day, shows the absence of snow on an adjacent tract that was not pitted.

Because of climatic conditions, experimental research on range reseeding in the Southwest has been slow, tedious, and often disappointing. Many methods of range reseeding have been tried and discarded. This is an area of relatively poor soils and extremely low precipitation, most of which occurs during the summer months. Large areas of range have been overgrazed and since the turn of the century extensive areas of range in west Texas, New Mexico, and Arizona have been invaded by such shrubs as mesquite, juniper, cholla cactus, and burroweed. Most of these are tree- or wood-type plans that require considerable moisture. By reducing the stands of forage they have accelerated soil erosion and reduced grazing capacity. "Various methods, all comparatively expensive and only partially effective, for controlling and eradicating noxious range plants have been attempted during the last 10 or 15 years in the Southwest; but basic research as to how these plants grow and the processes by which they are able to invade and develop into stands on grassland areas has been mainly lacking."[8] Many of these areas are so badly deteriorated that natural revegetation is not practicable and they must be artificially reseeded but procedures which give assurance of success at reasonable cost are not yet available for most of these ranges.

An important range grass in the semidesert areas of New Mexico and Arizona is black grama, a native species. Its greatest draw-back is its poor seeding habits, which make restoration of deteriorated range of this type through natural revegetation difficult, inasmuch as it is necessary to depend almost wholly on the establishment of runners. These ranges may be restored by reseeding to Lehmann lovegrass or

[8] Letter from the Director, Southwestern Forest and Range Experiment Station, Tucson, Ariz., July 6, 1948.

Boer lovegrass. Successful stands of Lehmann lovegrass have been established in Arizona in recent years by seeding with the eccentric disk developed in Wyoming in connection with the pitting practice described. A cultipacker-seeder is attached to follow the eccentric disk. This equipment prepares a good seedbed, covers and packs the seed, cuts out many of the undesirable shrubs and cactus, and conserves the moisture by retaining part of the runoff from the infrequent summer rains in the waffle-like depressions. Unlike most other grasses Lehmann lovegrass greens up early in the spring and in mild winters it remains green and furnishes feed during the winter months. It is recommended for the southern third of Arizona and New Mexico. For the higher areas within these States which have between 15 and 30 inches of average annual rainfall, crested wheat grass is recommended.

One of the main segments lacking in research on reseeding of ranges is an economic appraisal of the effects of this practice on organization, production, income, and expenses of individual ranches. Even though agronomic research has demonstrated the technical feasibility of range reseeding on several range types, private owners have reseeded only very small portions of the depleted range. A large share of this depleted range is spring-fall range. Increasing its productivity would reduce the pressure on summer ranges and shorten the winter feeding period.

Table 17 illustrates some of the economic effects of natural revegetation versus artificial reseeding on a representative cattle ranch in the intermountain area (*17*). In this illustration comparisons are made between the artificial reseeding of 160 acres of depleted range located on relatively good soils with the natural reseeding of 400 acres, containing remnants of the various species of bluegrasses, bluebunch and bluestem wheatgrasses, needlegrasses, and Idaho fescue. Acreages seeded by the two methods have been allowed to vary so that the animal-unit months of grazing supplied by the combination of 1,247 acres of unseeded and reseeded private range are the same in both instances. Thus the same number of livestock are carried regardless of the method of reseeding used.

The original carrying capacity of the 1,247 acres of private range averaged one animal-unit month per 4.36 acres. After reseeding it was assumed that 2.20 acres of artificially reseeded and 3.12 acres of naturally revegetated range were required to produce one animal-unit month of grazing. In evaluating these examples ranchers and range-management workers are cautioned that these assumptions are based on but limited amounts of research and rancher experience. They are used here primarily to illustrate a method of appraising the effects of reseeding on individual ranches. Because each area suitable for reseeding presents different physical features, it is difficult to make average estimates with any degree of accuracy.

Under this plan it would be possible to increase the number of breeding cows from 78 to 80 head and to allow for the sale of 2 more 2-year heifers or steers, with average selling weights increased from 949 to 964 pounds. It was estimated that growing cattle would gain an additional pound per day while on crested wheat grass. Four years were required to establish the stand of crested wheat grass. Inasmuch as the seedbed is prepared and seeded in the fall, there would be no reduction in the original grazing capacity for the first year. During

TABLE 17.—*Comparative effects on artificial reseeding and natural revegetation of range on the organization, production, and income on a family-size cattle ranch in the Intermountain area*[1]

Item	Former plan—Before reseeding		Artificial reseeding—160 acres range improved by artificial reseeding to crested wheat grass		Natural revegetation—400 acres of range improved by natural reseeding	
	Acreage	Production	Acreage	Production	Acreage	Production
Crops and land use:	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Oats	7	216	7	216	7	216
Barley	8	164	8	164	8	164
Wheat	7	136	7	136	7	136
		Tons		*Tons*		*Tons*
Wild hay	99	94	99	94	99	94
Alfalfa hay	29	62	29	62	29	62
Other tame hay	40	57	40	57	40	57
		AUM's[2]		*AUM's*[2]		*AUM's*[2]
Unseeded private range	1, 247	286	1, 087	249	847	194
Reseeded private range			160	73	400	128
Crop aftermath		167		167		167
Grazing permits		1, 147		1, 147		1, 147
Ranch headquarters	32		32		32	
Total	1, 469		1, 469		1, 469	

Item	Former: Inventory	Former: Sold	Former: Sale weights	Artificial: Inventory	Artificial: Sold	Artificial: Sale weights	Natural: Inventory	Natural: Sold	Natural: Sale weights
Livestock:	*No.*	*No.*	*Lbs.*	*No.*	*No.*	*Lbs.*	*No.*	*No.*	*Lbs.*
Cows	78	12	1, 018	80	12	1, 018	80	12	1, 018
Heifers and steers, 2-year	62	46	949	64	48	964	64	48	949
Heifers and steers, 1-year	65			67			67		
Bulls	4			4			4		
Horses	16	1		16	1		16	1	
Hens	41			41			41		
Milk cows	3			3			3		
Net cash income:									
With high price level	*Dollars* 4, 878			*Dollars* 5, 116			*Dollars* 5, 018		
With medium price level	2, 701			2, 841			2, 777		

[1] Because of differences in soil, topography, and plant cover, artificial reseeding and natural revegetation may not be alternative methods of range improvement on the same ranch.

[2] Animal-unit months of grazing.

the second year it would not be feasible to turn the cattle on the new seedlings, but in the third year it was assumed that one animal unit per month of grazing could be obtained from 2.35 acres. During the fourth and subsequent years 2.20 acres would be required per animal unit per month of grazing.

During this period income deferments of $616 under the medium and $777 under the high price levels were indicated (table 18). These are results of holding back additional heifers, rental of more range to replace the reseeded area while the stand is becoming established, and building necessary fences. Crested wheat grass seed must be bought; the range must be disked, and the grass seed drilled, and these operations mean additional gas and oil. These temporary reductions in net cash income, however, are partially minimized by livestock inventory increases. When these are considered, the reductions would be $340 and $404 under the medium and high price levels. Moreover, once the new grass is established, an expected increase in income would offset these temporary losses in about 2 years. With these preliminary calculations artificial reseeding increases the net cash income under the high price level from $4,878 to $5,116 in the fourth and subsequent years, an increase of 4.9 percent; and at the medium price level, from $2,701 to $2,841 or 5.2 percent.

TABLE 18.—*A comparison of income deferments and livestock inventory increases occurring during natural revegetation and artificial reseeding on a family-sized cattle ranch in the Intermountain area*

Item	Artificial reseeding—160 acres range improved by artificial reseeding to crested wheat grass		Natural revegetation—400 acres range improved by natural revegetation	
	Medium price level	High price level	Medium price level	High price level
Deferments in net cash income:	*Dollars*	*Dollars*	*Dollars*	*Dollars*
First year	537	691	604	760
Second year	66	79	117	138
Third year	13	7	139	165
Total reductions accrued	616	777	860	1,063
Increases in livestock inventories	276	373	276	373
Extent total accrued losses exceed increases in livestock inventories	340	404	584	690

During the first year cash expenses increased under the high price level by $472. Expenses for seeds increased $136, gas and oil $55, labor $35, and fencing $257, whereas shipping expenses decreased by $11. One mile of fencing was constructed around two sides of the reseeded area. If additional fencing were required the cost would be proportionately higher. During this year livestock sales decreased

$219. Deferments during the second and third years are substantially lower and are largely represented by rent of private range.

Under natural revegetation it is assumed that the 400 acres of range would be deferred for 3 years, the length of deferment required depending upon plant cover, quality of soil, and precipitation. Extended waiting periods would affect the economic feasibility of this method. During the fourth and subsequent years, it was assumed that 3.12 acres of natural revegetated range will be required to furnish one animal unit per month of grazing. During the 3 years of total deferment additional private range is leased to offset the range deferred. If additional range cannot be leased it may be necessary to begin winter feeding earlier. However, this probably would be more costly than leasing range, particularly if the feed must be purchased.

With natural revegetation, income increased from $4,878 to $5,018 in the fourth and subsequent years under the high price level and from $2,701 to $2,777 under medium prices, an increase of approximately 3 percent for each price level (table 17). Breeding cows were increased from 78 to 80 head. Two more 2-year-old steers would be sold at the same weight as under the former plan.

Deferments of $860 in income under the medium price level and $1,063 with high prices are indicated during the transitional period (table 18). The greater share of the loss would be incurred during the first year when, under high prices, the income from livestock sales would be decreased $219 because of the necessity of holding back two 2-year-old heifers; cash rent would be increased $82 to provide additional range to replace forage from the deferred range; and building a fence around two sides of the deferred range would require $436 for material. But, when increases in livestock inventories are considered these temporary losses would be reduced to $584 under the medium and $690 under the high price level (table 18).

As previously indicated, economic as well as physical research on the effects of natural revegetation and artificial reseeding is relatively new and inadequate. Although decisions regarding whether to reseed and the method to be used must be determined individually for each site, both natural revegetation and artificial reseeding have their places as ways of improving range. Lands heavily infested with sage brush often make ideal sites for artificial reseeding because they are generally located on good soils with adequate moisture conditions to grow adapted grasses. Natural revegetation of such sagebrush areas is frequently not practicable because of the sparseness of perennial grasses. Areas which have some perennial growth, although located on poorer soils, may be improved through natural revegetation. Natural revegetation generally involves larger acreages and hence larger expenditures for fencing than artificial reseeding but this is partially offset by the expenditures for seed and seedbed preparation required in artificial reseeding.

In the preceding sections preliminary economic analyses of reseeding cropland and ranges have been presented. The sections that follow discuss a few of the other important practices that need economic appraisal in different parts of the West. To date it has been possible only to discuss these problems with State and Federal agricultural workers and to review the results of research in these fields.

It is planned to make an economic analysis of the more important problems in subsequent work.

BROMUS TECTORUM

During the last quarter of a century bromus tectorum, a European species of annual bromegrass commonly known as broncho or cheat grass, has invaded and replaced perennials on extensive areas of western range. When young the plant is quite palatable to livestock; however, it completes its growth in early summer and the dry unpalatable herbage furnishes little, if any, feed from that time until the next spring. Because of its sharp points and rough beards, livestock avoid the dry plant. Also, dry cheat grass is highly inflammable; it constitutes a serious fire hazard. There are wide differences of opinion as to what can and should be done to improve range infested with this annual. Some authorities indicate that they know of no practicable method for replacing cheat grass on the vast areas of range it now occupies. The Nevada Agricultural Experiment Station reports poor results in reseeding such ranges with crested wheatgrass and some of the native grasses.

Experimental work conducted in Oregon on the effectiveness of deferred and rotational grazing on cheat-grass stands has not reached the stage at which definite conclusions are available. However, in areas from which desirable perennials are gone, and it is deemed advisable to replace cheat-grass cover, artificial reseeding is the only recourse. When possible, the land should be plowed, but if this is impracticable the cheat grass may be burned before the seed drops to the ground and the ash used as seedbed. Restoring cheat-grass range is expensive. Even at prewar prices, "Usual costs have varied from $1.50 to $2.50 an acre, depending upon the intensity of seedbed preparation, method of seeding and cost of seed" (*28*).

BURNING BRUSH

Results of burning brush to facilitate natural restoration of the range or to provide a seedbed for artificial reseeding vary under different physical conditions. In most of the high-rainfall areas along the coast of northwestern California reseeding on burned areas has been successful, while in other areas of the State failures have generally resulted.

Burning brush before seeding has been relatively successful in western Oregon where a million and a half acres of cut-over land suitable for pasture are not utilized to the fullest extent. In establishing stands of grass on such lands the brush should be burned and grass seeded in the ashes as soon as they have cooled. The ideal time to seed is immediately following logging operations when the ground is torn up and in a loosened condition. Sub-clover and Alta fescue are recommended in this area for spring and fall pasture, with Lotus Major as a source of summer pasture.

Irrigated Pasture and Range

Greater emphasis on irrigated pastures seems likely both in the new and in the older irrigated areas of the West. A substantial portion of new irrigation is to be developed in the subhumid parts of the

Plains now predominantly devoted to extensive types of farming. It is unlikely that these newer areas will shift to the production of specialty crops to the extent that is true of the older irrigated areas. Physical and economic limitations are likely to mean a greater proportion of forage and feed crops and more livestock production in such areas. Much of the newly irrigated land will be integrated with the economy of surrounding or adjacent dryland areas on which livestock are important sources of farm income. The rapidly expanding population in the far West, together with its increasing demand for livestock and livestock products coupled with a decreasing postwar market for certain specialty crops, will also help to encourage larger acreages of irrigated pastures in the West Coast States.

In the arid regions of the West soils are usually low in organic matter, nitrogen, and phosphorus. Mixed grasses and legumes supply organic matter and nitrogen and render such soils less susceptible to crusting under irrigation. Inclusion of forages in irrigated crop rotations is an absolute necessity if soil structure and fertility are to be maintained and improved. In the past farmers have not been fully aware of the value of irrigated pastures in crop rotations. Many have relied largely on unirrigated range and low, wet areas for grazing. In range areas irrigated pastures may be used to supplement range-improvement practices. They may be grazed while portions of the range are rested or artificially reseeded. After desirable perennials have set seed, livestock may be turned back on the range to scatter and trample the seeds into the ground.

ON THE PACIFIC COAST

Irrigated pastures in California have increased from only a few small acreages in the 1930's to around 500,000 acres in 1948. On land unsuited for alfalfa, such as hardpan soils, irrigated pastures provide good-quality forage at low costs. Many California farmers on the better soils have developed irrigated pastures after seeing what could be done with them on the poorer soils. In anticipation that lower postwar prices for fruits, beans, and other specialty crops may attract additional farmers to irrigated pastures, research is under way on the development of grass mixtures that will utilize the better and deeper soils to a maximum degree. Only improved pastures of high productivity will be able to compete with the more intensive uses of high-priced irrigated land.

Production of range beef in California has decreased due to reductions in quantity and quality of the range. This, combined with large increases in population, has made California a deficit beef-producing State. At the same time the demand for beef of better quality has increased. This State is presently importing 500,000 head of cattle and around 1,000,000 sheep annually. Irrigated pastures may contribute toward making up this deficit and much range in the State is capable of irrigation. It is estimated that the carrying capacity of the 500,000 acres of irrigated pastures in California is somewhat greater than the 8,868,000 acres of national forest land grazed in that State. Large numbers of cattle and lambs are shipped into California to be finished on irrigated pasture before slaughter.

In the valleys of western Oregon and Washington, although average annual precipitation is relatively high, the summer months are usually dry. Pastures dry up and furnish very little feed until late in September. According to farmer experience and experimental results, summer irrigation of pastures increases production of forage from 25 to 50 percent during the dry period (*22*). Many farmers use sprinkler irrigation to increase forage production. At present prices, costs of equipping and installing the more common designs of sprinkler irrigation systems vary from $40 to $100 per acre. The economic feasibility of such installations must be determined for each individual farm. In general, sprinkler irrigation is adapted to shallow soils which do not hold water well, and to areas in which the topography is such that leveling the land is too expensive and the supply of water for border irrigation is limited. Sprinkler irrigation requires considerably less water than does the open-ditch method.

IN THE SOUTHWEST

Development of suitable grasses with limited water requirements will have to precede any substantial expansion of irrigated pastures in the Southwest. One of the chief difficulties connected with pastures in the irrigated valleys and scattered pump-irrigation areas of New Mexico and Arizona is the lack of sufficient water. In the irrigated areas of the southern portion of these States at present, irrigation farming is devoted primarily to production of cash crops, cotton and alfalfa, and some specialty crops. Alfalfa is often included in crop rotations mainly to improve soil structure and fertility and to increase cotton yields. Despite relatively high-water requirements, alfalfa is often used for pasturing and feeding cattle and sheep. The Arizona Agricultural Experiment Station is conducting research on the development of grass and grass mixtures that will do well on the limited amount of water available to farmers in the State. Cotton will produce good crops on about 3 acre-feet of water, but pastures require at least 5 to 6 acre-feet.

The increasing demand on West coast markets for more and better quality beef has increased the returns from finishing of cattle on western irrigated pasture. An example is a year-round beef-finishing irrigated ranch located in a mountain valley of southern Arizona. The present operator bought this 700-acre unit in 1946. At that time it included 70 acres of cropland, of which 20 were irrigated. The remainder was very poor mesquite range of little or no value for grazing. Approximately 225 acres of this mesquite land has been cleared, grubbed, and leveled at an estimated cost based on today's prices of $65 per acre. Water for irrigation is supplied by three wells which, equipped, cost from $1,200 to $1,500 each.

The 70 acres of former cropland, in addition to the newly improved land, have been seeded at the rate of 22 pounds per acre with a pasture mixture known as Arizona No. 1 which is composed of the following grasses: Perennial ryegrass, 3 pounds; Alta fescue, 5 pounds; orchard grass, 4 pounds; Dallis grass, 6 pounds; alfalfa (Southwest type), 2 pounds; annual sweetclover (Emerald), 1 pound; and bur-clover, 1 pound.

Six hundred yearlings weighing around 450 pounds are bought each year from ranchers in Arizona and New Mexico and, after finishing on these irrigated pastures, are sold on the Los Angeles market. The yearlings are pastured 120 days; they gain from 180 to 240 pounds, or from 1½ to 2 pounds per day. Their only feed is pasture—no hay or concentrates of any kind are fed. The operator has averaged a 2-cent-per-pound margin above his purchase price.

Irrigated pasture is divided into five beef pastures of 60 acres, each of which is further divided into three units of 20 acres each. These 20-acre units are irrigated and grazed in rotation. The pastures are mowed before each irrigation to concentrate available moisture in the tender new growth. The only machines used are a tractor and mower. Three men are employed year-round on this ranch.

The operator plans to renovate his pastures with a custom-hired chisel renovator every 3 or 4 years at a cost of from 50 to 75 cents an acre. Realizing the limitations of desert soils under irrigation he recognizes that fertilizer must be applied to his pastures sometime in the future.

This illustration is included only to show the possibilities of developing irrigated beef-finishing ranches on which sufficient capital and other resources can be combined with the superior managerial ability required for large-scale operations of this type. Capital requirements would be high. Cost of the three pumps, grass seed, building fences and corrals, and preparing the 225 acres of range for irrigation would be between $24,000 and $25,000. Adding to this the value of the land and of the 600 cattle bought yearly gives some idea of the high investment necessary to develop and carry on such an operation. Considerable ability in buying and selling cattle, and a good knowledge of livestock and range management is required if a unit of this type is to be operated and solvency is to be maintained.

Tentative Conclusions

Tentative observations arising out of the reconnaissance work in Western States may be summarized as follows:

(1) Possibilities exist to maintain incomes and at the same time to add to the stability of wheat-cattle ranches in the northern Great Plains by shifting lower yielding wheat acreages to crested wheat grass and utilizing the increased forage in livestock production.

(*a*) Such adjustments involve a minimum of 3 years' time during which temporary reductions in net cash income are likely to be incurred. Heifers or cows must be held back and cattle numbers increased to take advantage of the increased grass. Receipts from sales of cash grain will be reduced. New investments for crested wheat-grass seed and fencing would be necessary. Some feed may need to be purchased. Increases in livestock inventories would partially offset these temporary losses in income.

(*b*) The economic feasibility of such adjustments is influenced by the prevailing level of prices. In general they are made more easily at high price levels than at medium or lower levels.

(*c*) Hours of labor saved in seeding and harvesting wheat and in tilling summer fallow is greater than that expended in caring for the additional livestock made possible in the shift. Annual cash operating expenses are also reduced.

(*d*) Feed supplies are made more certain and soil resources are conserved to better advantage as a result of the shift.

(*e*) The extent to which it is economically feasible to substitute crested wheat grass for production of cash grain is a matter for determination on each individual ranch, but tentative indications are that crested wheat grass represents a feasible alternative in this area for a substantial acreage now used for production of cash wheat.

(2) A few farmers are experimenting with long-time rotations involving cash-grain crops and crested wheat grass. Preliminary results indicate that yields of both are increased as a result. Less cash wheat is produced but incomes are increased by production and sale of additional cattle. Problems involved in ranch organization and operation are similar to those where crested wheat is seeded down permanently.

(3) Rolling topography, relatively high rainfall, and large acreages of intertilled crops make the Corn Belt portion of the eastern Plains susceptible to erosion.

(*a*) By increasing grasses and legumes along with livestock many farmers within this area have been able to retard erosion, increase soil fertility, improve soil structure, and stabilize income. A substantial reduction in production of cash grains accompanied these adjustments on some farms.

(*b*) In making such adjustments these farmers have encountered many of the same problems found by wheat-cattle ranchers of the more arid portion of the Plains in seeding wheat land to crested wheat grasses, and have experienced income reductions during the transition period.

(*c*) Considerable planning for changes in field boundaries and crop-rotation systems must be accomplished during the earlier years. Old fences may need to be moved or new ones built in order to conform with new field boundaries.

(4) As the present strong demand for grass seed will probably continue for some time, a limited number of farmers who find it difficult to increase livestock numbers may find the commercial production of grass seed profitable.

(5) Throughout much of the West ranchers may profitably increase the productivity of their ranges through natural revegetation or artificial reseeding.

(*a*) As in the case of a reseeding wheatland to crested wheat grass these adjustments involve a minimum of 3 years' time during which temporary reductions in net cash income are likely to be incurred. Additional female stock must be held back and the size of the herd increased to take advantage of the additional grass.

(*b*) With artificial reseeding, grass seed must be bought and additional cash expenditures must be made to prepare a seedbed and for drilling. On many ranches additional private range must be leased or feed bought while a stand of grass is established. In most cases it will be necessary to build additional fencing to protect the new grass seedings.

(*c*) With natural revegetation, no expenditures are required for grass seed or seedbed preparation. However, because of the larger acreages which usually are involved, larger cash expenditures may be incurred for fencing and for rental of additional range to replace the deferred range or for buying feed to lengthen the winter feeding period.

(*d*) Economic and physical research on the merits of artificial reseeding and natural revegetation are relatively new. Because of varying physical characteristics such as moisture, soil type, condition and type of cover, the decision as to whether to reseed and how must be determined individually for each site. Although both types have their places in improving the range, artificial reseeding is generally used where most of the desirable vegetation is gone while natural revegetation is used in areas which still have a sufficient stand of desirable perennials and enough topsoil and organic matter to furnish the water-holding capacity that will insure forage recovery.

(6) It is anticipated that acreages of irrigated pastures will continue to expand in the West. The newly irrigated areas in the Plains will probably not shift their present extensive farming systems to production of specialized crops to the extent found in the earlier irrigated areas. Other factors that encourage production of forage include the expanding population on the West coast, with its increasing demand for meat and livestock products, together with a declining postwar market for some specialty crops. Irrigated soils, especially those in more arid areas, require a rotation which includes grasses to maintain and improve soil fertility and structure. Additional physical and economic research is necessary to appraise accurately the need for and the advantage of including grasses in irrigated farming systems.

TABLE 19.—*Organization, production, receipts, and expenses of a wheat-cattle ranch in southwestern North Dakota under former and present plans*

Item	Former plan		Present plan—90 acres of wheat and summer-fallow land seeded to crested wheat grass							
			First year [1]		Second year		Third year		Fourth and subsequent years	
	Acreage	Production	Area	Production	Area	Production	Area	Production	Area	Production
Crops and land use:	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Wheat	140	[2] 1,526	140	[2] 1,526	95	[3] 1,140	95	[3] 1,140	95	[3] 1,140
Summer-fallow	140		140		95		95		95	
Corn	90	1,800	90	1,800	90	1,800	90	1,800	90	1,800
Oats	50	1,750	50	1,750	50	1,750	50	1,750	50	1,750
Barley	40	1,000	40	1,000	40	1,000	40	1,000	40	1,000
		Tons		*Tons*		*Tons*		*Tons*		*Tons*
Wild hay	300	100	300	100	300	100	300	100	300	100
Crested wheat grass hay							8	5	10	9
		AUM's [4]		*AUM's* [4]		*AUM's* [4]		*AUM's* [4]		*AUM's* [4]
Private range	600	240	600	240	600	240	600	240	600	240
Crested wheat grass pasture					90	32	82	89	80	115
Crested wheat grass aftermath										5
Grazing permits held		1,080		1,080		1,080		1,080		1,080
Total	1,360		1,360		1,360		1,360		1,360	

	Inventory	Sold	Inventory	Sold	Inventory	Sold	Inventory	Sold	Inventory	Sold
Livestock:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Cows	92	12	92	10	94	9	99	11	100	13
Heifers, 2-year old	15		15		17		15		16	
Heifers, 1-year old	39	22	39	20	39	22	40	22	42	24
Calves born	78		78.		80		85		85	
Steers, 1-year old	39	38	39	38	39	38	40	39	43	42
Bulls	3		3		3		3		3	
Horses	4		4		4		4		4	
Hens	50		50		50		50		50	
Receipts (high price level):		*Dollars*		*Dollars*		*Dollars*		*Dollars*		*Dollars*
Wheat		2, 049		2, 049		1, 538		1, 538		1, 538
Other grains		1, 814		1, 814		1, 779		1, 722		1, 670
Cows		1, 199		999		899		1, 099		1, 299
Yearling heifers and steers		5, 315		5, 154		5, 315		5, 408		5, 849
Total high price level		10, 377		10, 016		9, 531		9, 767		10, 356
Total with medium price level		7, 033		6, 819		6, 453		6, 600		6, 983
Expenses (high price level):										
Taxes, rent, and grazing fees		500		500		502		504		506
Marketing costs		336		318		320		334		382
Veterinary expenses		11		11		11		12		12
Feeds		378		402		446		381		410
Seeds		71		199		71		71		[5] 92
Gas and oil		224		232		189		191		192
Machinery and building repairs		222		222		222		222		222
Automobile and truck expenses		480		480		449		445		440
Labor		372		372		372		372		372
Custom threshing and twine		879		879		719		719		719
Total high price level		3, 473		3, 615		3, 301		3, 251		3, 347
Total with medium price level		3, 065		3, 185		2, 907		2, 872		2, 962

See footnotes at end of table.

TABLE 19.—*Organization, production, receipts, and expenses of a wheat-cattle ranch in southwestern North Dakota under former and present plans*—Continued

Item	Former plan	Present plan—90 acres of wheat and summer-fallow land seeded to crested wheat grass			
		First year [1]	Second year	Third year	Fourth and subsequent years
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dallors*
Net cash income (high price level)	6, 904	6, 401	6, 230	6, 516	7, 009
With medium price level	3, 968	3, 634	3, 546	3, 728	4, 021
Noncash farm expenses (high price level) [6]	1, 298	1, 298	1, 313	1, 334	1, 354
With medium price level	970	970	980	992	1, 006
Amount available to labor and interest on land (high price level)	5, 606	5, 103	4, 917	5, 182	5, 655
With medium price level	2, 998	2, 664	2, 566	2, 736	3, 015

[1] 90 acres crested wheat grass seeded, 45 acres in wheat stubble, and 45 on summer-fallow during fall of first year.

[2] Wheat yield: 7 bushels per acre on 60 acres, 12 bushels on remainder of wheat land.

[3] Wheat yield 12 bushels per acre.

[4] Animal unit months of grazing.

[5] Includes necessary crested wheat grass seed for reseeding. In the northern Plains a reduction in forage production of crested wheat grass often occurs after the fourth year, necessitating some kind of renovation. This is generally accomplished by plowing the sod and reseeding at the end of the sixth year. In some instances the land is seeded to cash crops for a couple of years before reseeding to crested wheat grass.

[6] Noncash farm expenses include depreciation on buildings and machinery and interest at 4 percent on inventory value of livestock, machinery, and buildings.

TABLE 20.—*Organization, production, receipts, and expenses of a wheat-cattle ranch in southwestern North Dakota under former and alternative plans*

Item	Former plan		Alternative plan—all wheat and summer-fallow land seeded to crested wheat grass							
			First year [1]		Second year		Third year		Fourth and subsequent years	
	Acreage	Production	Acreage	Production	Acreage	Production	Acreage	Production	Acreage	Production
Crops and land use:	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*	*Acres*	*Bushels*
Wheat	140	[2] 1,526	140	[2] 1,526						
Summer-fallow	140		140							
Corn	90	1,800	90	1,800	90	1,800	90	1,800	90	1,800
Oats	50	1,750	50	1,750	50	1,750	50	1,750	50	1,750
Barley	40	1,000	40	1,000	40	1,000	40	1,000	40	1,000
		Tons		*Tons*		*Tons*		*Tons*		*Tons*
Wild hay	300	100	300	100	300	100	300	100	300	100
Crested wheat grass hay							28	23	32	35
		AUM's[3]		*AUM's*[3]		*AUM's*[3]		*AUM's*[3]		*AUM's*[3]
Private range	600	240	600	240	600	150	600	240	600	240
Crested wheat grass pasture					280	127	252	343	248	449
Crested wheat grass aftermath										16
Grazing permits held		1,080		1,080		1,080		1,080		1,080
Total	1,360		1,360		1,360		1,360		1,360	

See footnotes at end of table.

TABLE 20.—*Organization, production, receipts, and expenses of a wheat-cattle ranch in southwestern North Dakota under former and alternative plans*—Continued

Items	Former plan		Alternative plan—all wheat and summer-fallow land seeded to crested wheat grass							
			First year [1]		Second year		Third year		Fourth and subsequent years	
	Inventory	Sold	Inventory	Sold	Inventory	Sold	Inventory	Sold	Inventory	Sold
Livestock:	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Cows	92	12	92		104		126	13	126	16
Heifers, 2-year-old	15		15		25		17		20	
Heifers, 1-year-old	39	22	39	12	39	20	44	22	53	31
Calves born	78		78		88		107		107	
Steers, 1-year-old	39	38	39	38	39	38	44	43	54	53
Bulls	3		3		3		4		4	
Horses	4		4		4		4		4	
Hens	50		50		50		50		50	
Receipts (high price level):	*Dollars*		*Dollars*		*Dollars*		*Dollars*		*Dollars*	
Wheat	2,049		2,049							
Other grains	1,814		1,814		1,540		1,091		1,096	
Cows	1,199						1,299		1,599	
Yearling heifers and steers	5,315		4,509		5,154		5,781		7,439	
Total high price level	10,377		8,372		6,694		8,171		10,134	
Total with medium price level	7,033		5,848		4,524		5,419		6,717	

Expenses (high price level):					
Taxes, rent, and grazing fees	500	500	509	521	528
Marketing costs	336	235	265	377	485
Veterinary expenses	11	11	12	15	15
Feeds	378	485	751	557	516
Seeds	71	469	71	71	[4] 137
Gas and oil	224	251	117	124	126
Machinery and building repair	222	222	222	222	222
Automobile and truck expenses	480	480	347	309	307
Labor	372	372	372	372	372
Custom threshing and twine	879	879	382	382	382
Bull			268		
Total high price level	3, 473	3, 904	3, 316	2, 950	3, 090
Total with medium price level	3, 065	3, 415	2, 829	2, 613	2, 757
Net cash income (high price level)	6, 904	4, 468	3, 378	5, 221	7, 044
With medium price level	3, 968	2, 433	1, 695	2, 806	3, 960
Noncash farm expenses (high price level)[5]	1, 298	1, 298	1, 382	1, 489	1, 547
With medium price level	970	970	1, 022	1, 087	1, 127
Amount available to labor and interest on land (high price level)	5, 606	3, 170	1, 996	3, 732	5, 497
With medium price level	2, 998	1, 463	673	1, 719	2, 833

[1] 280 acres crested wheat grass seeded, 140 acres in wheat stubble, and 140 on summer-fallow during fall of first year.

[2] Wheat yield: 7 bushels per acre on 60 acres, 12 bushels on remainder of wheat land.

[3] Animal-unit months of grazing.

[4] Includes necessary crested wheat grass seed for reseeding. In the northern Plains a reduction in forage production of crested wheat grass often occurs during the fourth year, necessitating some kind of renovation. This is generally accomplished by plowing the sod and reseeding at the end of the sixth year. In some instances the land is seeded to cash crops for a couple of years before reseeding to crested wheat grass.

[5] Noncash farm expenses include depreciation on buildings and machinery and interest at 4 percent on inventory value of livestock, machinery, and buildings.

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