11-1953

Economic Analysis of Forage Production and Utilization in Dakota and Dixon Counties, Nebraska

Howard W. Ottoson

UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION

W. V. LAMBERT, Director M. L. BAKER, Associate Director

Research Bulletin 173

Economic Analysis of Forage Production and Utilization in Dakota and Dixon Counties, Nebraska

HOWARD W. OTTOSON
Department of Agricultural Economics

LINCOLN, NEBRASKA
NOVEMBER, 1953

UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

W. V. LAMBERT, Director M. L. BAKER, Associate Director

Research Bulletin 173

Economic Analysis of Forage Production and Utilization in Dakota and Dixon Counties, Nebraska

HOWARD W. OTTOSON

Department of Agricultural Economics

LINCOLN, NEBRASKA

NOVEMBER, 1953

CONTENTS

ACKNOWLEDGMENTS

Acknowledgment is made of assistance provided by John Elder of the Conservation and Survey Division, University of Nebraska and Soil Conservation Service, A. R. Aandahl, Soil Conservation Service, and Harold F. Rhoades, Agronomy Department and John Matsushima and M. L. Baker, Animal Husbandry Department, University of Nebraska. A. W. Epp, T. S. Thorfinnson, and others of the Agricultural Economics Department, and Philip Henderson, University Development Farms, assisted in planning and field work. Mrs. Ray Bentall assisted with the statistical analysis. This study was concurrent with a somewhat similar study carried on in western Iowa by Ross Bauman, Production Economics Research Branch, Agricultural Research Service, and Earl O. Heady, Iowa Agricultural Experiment Station, and benefited therefrom.

SUMMARY

1. This study was an analysis of some alternative farming opportunities in the steeper part of the east loess hills region of northeastern Nebraska. The analytical emphasis was on the costs and returns associated with alternative soil management and feed utilization systems under erosion conditions.

2. Empirical data were obtained from a ramdom sample of hilly 160-acre farms located on Moody-Crofton and associated soils in Dixon and Dakota Counties.

3. The analytical procedures were carried on in two steps: (1) description of sample characteristics and relationships by use of tabular and regression analysis; (2) budget analysis of alternative soil management and feed utilization systems for the sample farms.

4. Several tests were made to determine the homogeneity of the sample with respect to factors which might otherwise influence the results. The farms did not have significantly different acreages of the major soil types. Practically no fertilizer had been used up to 1950. Substantial contouring and terracing had been done on only one farm.

5. Corn yields were significantly related to forage index (percentage of rotation acres in forage) among the 30 sample farms. With an average of 19 fewer acres of grain, 15 high-forage farms produced slightly more grain and 255 more feed units in 1950 than 15 low-forage farms. Actually, the relationship between feed production and forage index was curvilinear, with feed production being less beyond a forage index of 35.

6. Low-forage farms sold somewhat more grain for cash than those in the high-forage group. High-forage farms had greater investments in forage-consuming livestock and smaller investments in hogs. The two groups of farms did not differ significantly in investment in all livestock, machinery, and land. The labor use was about the same in both groups. High-forage farms had larger volumes of business as well as larger net incomes under both 1939-44 and 1950 prices.

7. A budgeting analysis was made of three alternative soil management systems for the 30 sample farms. The systems would achieve erosion control by: (a) the use of rotations only; (b) rotations plus contouring and terracing; and (c) rotations plus contouring, terracing, and fertilizer. Under (a) a drastic reduction in grain acreage would be necessary to control erosion, varying from 85 to 65 acres per farm. With contouring and terraces the reduction would be decreased to 35 acres on low-forage farms. Scarcely any change would be needed on farms with highest forage indexes. The additional fertilizer would again reduce the necessary adjustment in grain acreage.

8. The sample farms would produce less feed with the adoption of soil management system (a). The adoption of system (b) would increase feed production an average of 125 units. Under (c) an additional 1260 feed units would result from specified applications of fertilizer. It appears that erosion control itself would not necessarily increase farm returns. Alternative farming systems which control erosion may vary considerably in their financial results. Too, in addition to changes in annual costs and returns, the changes in resource investments—capital, labor, and management—associated with alternative systems must be considered.

9. Analysis was made of nine systems of feed utilization in conjunction with soil management systems (a) and (c). They were: dairy cows; beef cows; three calf feeding systems; three yearling steer feeding systems similar to the calf systems; and a two-year feeding system. It was assumed that sufficient livestock would be kept under each system to utilize all of the forage, plus grain as needed. Any remaining grain would be fed to hogs.

10. On the average, an increase in livestock investment would be necessary on all farms to utilize the forage produced under the alternative systems. Within the livestock system, the dry lot systems would require higher capital investments than beef cows or dairy cows, or the high-roughage feeding systems. Larger increases in livestock housing would be necessary under soil management system (c). Dairy cows would need more additional housing investment than other systems. Likewise, dairy cows would require more additional hired labor than the other systems.

11. Under soil management system (a) the calf feeding systems would be most profitable with 1950 prices; dairy and beef cows would rank lowest, resulting in a decrease in income from the present level on the farms. Under 1939-44 prices, all livestock systems except the pasture calf feeding systems would result in income decreases. With soil management system (c) there would be increases in net incomes for all livestock systems under both sets of prices. Beef cattle and the pasture systems show highest income increases with 1950 prices; dairy cows occupy a more favorable position under 1939-44 price relationships.

Economic Analysis of Forage Production and Utilization in Dakota and Dixon Counties, Nebraska[1]

HOWARD W. OTTOSON [2]

INTRODUCTION

SOIL EROSION remains a serious problem on many Nebraska farms despite programs of financial assistance, technical aid, and education by several national and state agencies. One reason that soil conserving adjustments in land use have not been made by farmers is that considerable uncertainty surrounds the economics of soil erosion control on the farm level. This study is an attempt to increase knowledge and reduce some of the uncertainty with regard to the economics of erosion control in a specific area.

The economics of soil erosion control is essentially a type of farm production economics. The control of erosion is not an end in itself. Rather, for society, an optimum level of erosion control maximizes in the long run the agricultural product desired by mankind from a given fund of the resources land, labor and capital. Likewise, for the farmer it maximizes his long run returns (financial and other) from the resources he controls.[3]

The study was directed at the individual farm, and the maximization of its profits. The impossibility of separating erosion control as an economic problem from the whole problem of farm production organization is recognized. On the other hand it would be difficult

---

[1] This report summarizes the results of a study carried on under Project 354, Nebraska Agricultural Experiment Station.

[2] Assistant Agricultural Economist, Agricultural Economics Department, University of Nebraska.

[3] Although the terms "erosion control" and "soil conservation" are often used synonymously, the former, more restrictive term is used in this discussion. The term "soil conservation" has come to include a wide variety of land use practices, including erosion control practices, agricultural drainage, irrigation practices, lime and fertilizer use, and the like. (See, for example, Robert M. Salter, *The Job Ahead.* Mimeographed copy of address given at the National Association of Soil Conservation Districts, Cleveland, Ohio, February 28, 1952, p. 1.)

In this study have been analyzed alternative systems which would control erosion in a specific area, as well as some of the farming adjustments which would be associated with the adoption of each.

to attempt to solve all of the economic problems relating to erosion control in a single study. Other related problems are leasing arrangements, credit and capital rationing, machinery economics, labor efficiency, and economic instability, as well as crop and livestock combination. The major focus in this study was on crop and livestock combinations as related to erosion control, for several reasons. First, crop and livestock combinations are basic to the farm organization; the kind and intensity of erosion control practices will be influenced by their effect on the returns from crop and livestock production. Second, much uncertainty surrounds the subject of crop and livestock organization under erosion conditions. Especially uncertain is the economic position of forage in crop combinations. Some persons tend to minimize its value; at the other extreme are others who would credit to forage the entire net return resulting from the livestock to which it is fed.

Objectives and Economic Setting

The general objectives of this study were to analyze the economics of soil erosion control insofar as it is a long-run problem of crop and livestock organization of individual farm units. More specifically, an attempt has been made to estimate: (1) the optimum combinations of forage and grain under alternative systems of soil management, and (2) the relative profitability of utilizing feed through alternative livestock systems. In order that more effective attention could be given to the basic variable, crop combination, the study was restricted to a specific soils area in Nebraska, and to farms of specific size and soil pattern.

The analysis of crop combinations can occur as two general cases with respect to the proportion of forage acreage to grain acreage. First, if farmers are operating with a crop combination in which forage is complementary to grain, the production of grain as well as of forage may increase if the rotation is adjusted so as to include more forage. This can be true whether the criterion for a desirable crop rotation is that of maximizing grain production, maximizing total digestible nutrients, or maximizing the net monetary returns from the rotations. In the second case, if farmers are operating in the competitive range between forage and grain, the production of one will be increased only by sacrificing part of the other; increasing the forage acreage will result in a decreased total production of grain for the farm as a whole. The desirable combination of forage and grain to produce will depend partly upon whether farmers are more interested in the cash value of the crops, or in their feeding value. In this analysis, the market value of crop production was used as a guiding criterion for the selection of crop combinations. This procedure is appropriate even on livestock farms since farmers have the opportunity to sell part of or all of the crops they raise and to buy other feed if price relationships are such that this is most profitable.

In a study involving the economics of crop rotations, a divergence of interests between society as a whole and individual farmers may offer difficulty. Some individual farmers who desire quick returns may exploit their soil resources at the expense of future production either during their own tenure or when they have passed their farms on to others. Other farmers, and society as a whole, may have longer term interests in maintaining a certain level of soil productivity. Certain rotations might result in greater soil loss per acre annually than is consistent with the interest of the latter. Therefore, in the analysis, a maximum allowable soil loss per acre was used as a second, limiting criterion in evaluating rotations.

An analysis of crop combination is modified by the consideration of practices like terracing and contouring which also prevent erosion. One phase of this investigation was the analysis of alternative soil management systems; these included a system relying on crop combinations containing sufficient forage acreage to control erosion with no additional practices, a second system which utilizes terracing and contouring in addition to forage acreage, and a third system similar to the second except for the addition of fertilizer.

The method of disposal of crops may be a source of uncertainty. Of course, grains grown in this area may be sold for cash at prices which, in the long run at least, reflect their feeding value. On the other hand, forages commonly sell at lower prices relative to their feeding value. Therefore it may often be more profitable to feed forages to livestock. There are many possible livestock systems which are adapted to the utilization of varying quantities of forage. Each of these systems is characterized by certain requirements of labor and capital. Most of them require some grain in addition to forage. In this study, attention was given to several alternative systems of utilizing the feed produced under two of the above soil management systems.

Sampling Area and Procedure

The study area is in the steeper part of the loess hills of northeastern Nebraska, as shown in figure 1. The principal soils—Moody and Crofton—formed under a grass vegetation from the thick limy loess of the area. The topography is hilly with slope gradients usually ranging from 8 to 20 per cent. The natural drainage pattern is well established with a tendency to form deep channels or gullies in places.

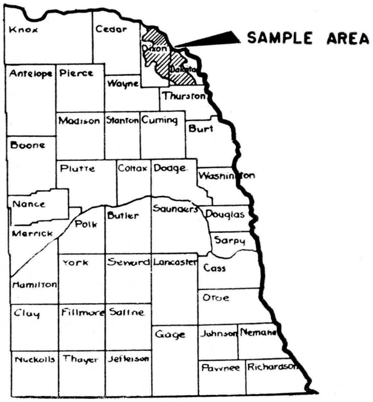

FIGURE 1.—The northeastern section of the east loess hills area of Nebraska, and the sample area.

The steepest hills, making up the rough broken land along the Missouri River, were not included in the sample. Although the study was confined to Dixon and Dakota Counties, the results should apply to similar farms with the same soil patterns elsewhere.

The control of erosion is a major problem in the area, and the study therefore emphasized farm production under erosive conditions.

Soil Characteristics

Moody silt loam is the principal soil of the study area. It developed from loess and is dark-colored and medium-textured. The topsoil is very dark grayish-brown friable silt loam, 10 to 12 inches thick, well supplied with organic matter. In some places, especially on the steeper slopes, erosion has removed the dark-colored topsoil. The subsoil is a grayish-brown or brown silt loam or silty clay loam which becomes lighter in color and coarse in texture with increasing depth. It is limy below a depth of 3 to 4 feet and contains some hard, lime concretions about one fourth to one half inch in diameter.[4]

Associated with Moody soils is Crofton silt loam. It also developed from loess but differs from Moody in having a thinner topsoil and a very limy subsoil. The topsoil consists of a 6- or 8-inch layer of very dark grayish-brown mellow silt loam underlaid by a 12-inch layer of light grayish-brown friable silt containing numerous hard lime concretions. Beneath this layer is the loose, gray-yellow or nearly white parent material which continues to a depth of many feet. Much of the Crofton soil has developed on areas having hilly and steep topography and is not suited to cultivation. In cultivated fields most of the topsoil has been removed by erosion. The topographical relationships of Moody and Crofton silt loams are indicated in figure 2.

[4] A complete discussion of Moody and the soils associated with it is given in A. W. Goke and L. A. Brown, *Soil Survey of Dixon County, Nebraska,* U. S. Dept. of Agr., Bureau of Chem. and Soils, and Nebraska *State Soils Survey, Series 1929,* N. 4, 1932.

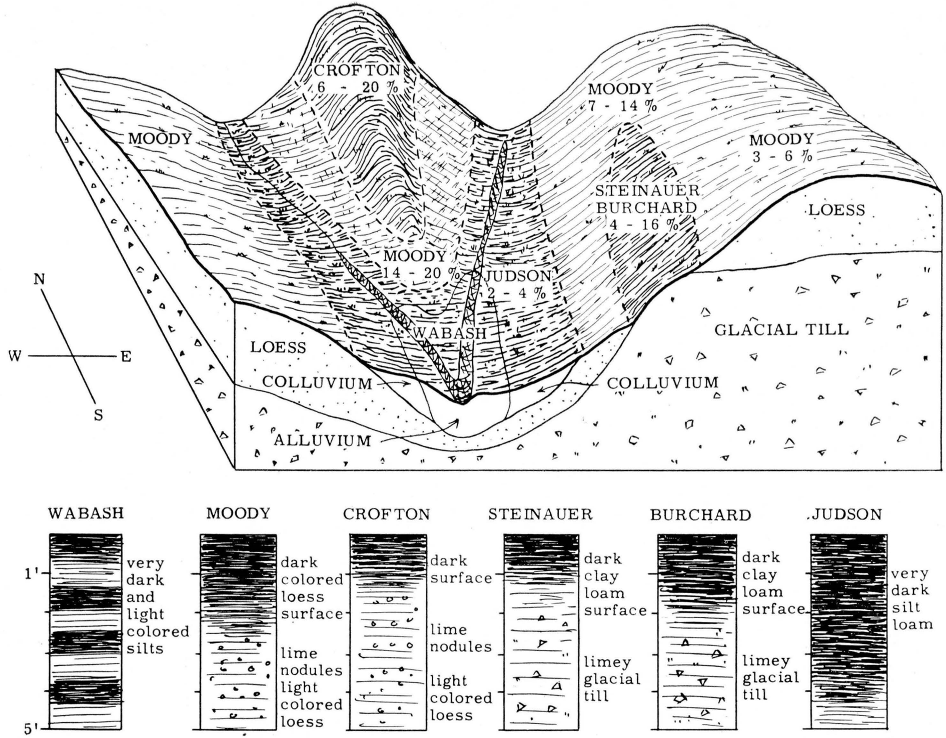

FIGURE 2.—Relationship of principal soils of northeastern Nebraska to parent material and topography. (Prepared by Soil Survey, Soil Conservation Service.)

Judson silt loam occurs at the foot of long slopes and in narrow, sloping valleys. The land surface slopes gently down the valleys and toward the drainageway. The soil is developed from a mixture of dark-colored sediments from the soils of the uplands, transported by surface wash and colluvial action and deposited within narrow stream valleys. The upper layer, about 5 or 6 feet deep, is a very dark grayish-brown silt loam of uniform nature containing large amounts of decomposed plant remains.

Small acreages of four other soil types—Waukesha silt loam, Burchard clay loam, Steinauer clay loam and Wabash clay loam—also occur in the area. The Waukesha soils occupy terrace positions along the larger streams; below them are found the Wabash soils. Burchard and Steinauer soils have developed from outcrops of glacial till.

The rainfall in Dixon County is typical of that of the study area. The mean annual rainfall is about 26 inches, with about 76 per cent of this amount falling during the growing season, from April to September. The precipitation varies greatly from year to year within a maximum range of 17 to 43 inches.

Method of Sampling

The sample was drawn from farms of 160 acres, the modal size of farm in the sample area. A list of all farms of 150 to 170 acres in size in townships wholly or partially included in the sample area was secured from the state office of Agricultural Estimates, Lincoln, Nebraska. Next, the legal descriptions of these farms were provided by the County Extension Agents and the Production and Marketing Administration offices of the two counties. The location of each farm was checked on county soil maps. Where a farm contained more than 10 acres of soil other than Moody, Crofton, or Judson, it was removed from the list. In addition, farms containing not more than 10 acres of gently sloping land (4 per cent slope or less) were eliminated. Some farms not conforming in this respect were eliminated by inspection of the soil maps.

From the final list, 60 farms were selected at random. These farms were visited in January, 1951.[5] At this time information concerning crop and livestock organization income and expenses on the sample farms was obtained. All remaining farms not conforming to slope specifications were eliminated from the sample during these visits.

The farms of the sample were then classified according to the proportion of their rotation land in forage over a three-year period. After

[5] Actually, an additional sample of 240- and 320-acre farms was visited at this time. Information was obtained from them with which to study relationships of income to size of farm. The results have not yet been published.

they were lisited in the order of the proportion of forage in the rotation, a second sample of 30 farms was drawn from the group by choosing every other one, the first choice being determined randomly. This group was again visited in May and June, 1951. Information was then obtained concerning the crop sequence by fields for the past five years, yields by fields for two years, the allocation of feed to classes of livestock during 1950 and information on available housing for livestock.

Using Production and Marketing Administration aerial photographs a soil surveyor, John Elder, of the Conservation and Survey Division, University of Nebraska, and Soil Survey, Soil Conservation Service, made soil maps of the sample farms in August and September, 1951.

Research Methods Used

The procedures used included two major steps. They were (1) a description of the sample by means of tabular and regression analysis, and (2) budgeting analysis of financial changes which would accompany shifts in crop and livestock production in the sample farms.

The budgeting analysis indicated the income possibilities for the sample farms if they were to shift to alternative systems of soil management and feed utilization. The types of organizational adjustments which would be necessary in making such shifts were also studied. The entire sample of 30 farms was used in budgeting, enabling inferences applicable not only to "average" or "typical" farms, but to others along the range of the independent variable "forage index."

DESCRIPTIVE ANALYSIS [6]

Classification of Farms

Since the major emphasis in this study was on forage production and use, the farms were classified according to the proportion of the rotation cropland devoted to forage production. Included as rotation forage were legumes, legume-grass mixtures, and nonlegumes which appeared to be part of the regular cropping system, even though some fields were "left down" for a number of years. Not included as rotation forage were acreages of native grass used for pasture, and occurring along creek and stream bottoms or in wooded or otherwise nontillable areas.

The proportion of rotation cropland devoted to forage, called the forage index, was computed by dividing the average acres of rotation forage for five years by the average acreage of all rotation cropland

---

[6] The framework of logic guiding the following analysis is presented in Appendix A.

on each farm. This index put all the farms on a comparable basis with respect to crop combination, despite some variation in the crop acres per farm in the sample. The range in forage index among the sample farms was from 5.5 to 52.9; the average for the sample was 23.8.

The forage index was used in two ways. First, individual farm indexes comprised the independent variable in several regression analyses. Second, the sample farms were divided into two groups of equal number on the basis of the size of their forage indexes. The group at the high end of the range, the high-forage farms, had an average forage index of 32.3; the average for the low-forage group was 15.2. These two groups were used as the basis for comparing certain of the empirical data presented.

This forage index would have had limitations if the sample farms had differed significantly in nonrotation forage acreages. However, the difference of 5 acres between the two groups was not statistically significant. As an additional test, the proportion of all cropland devoted to forage (including nonrotation forage acres) was computed for each farm. Both the regression coefficient and the coefficient of correlation between this ratio and the above forage index were significant within the one per cent level of probability. Thus the inclusion of the nonrotation forage would not improve the forage index appreciably for analyzing investment and income variables. On the other hand, its exclusion facilitated the analysis of the effect of rotation forage on crop yields and production.

Not included in computing the forage index was sweetclover planted with oats and plowed under the following spring, a practice performed quite uniformly among the farms of the sample. An average of 27.9 acres of first-year sweetclover was plowed under per year by all of the farms; the low-forage farms plowed under 4.4 acres more than did the high-forage farms. This difference, and the regression coefficient between the forage index and the per cent of the total rotated acres plowed under with sweetclover, were not statistically significant. Differences in yields of crops between high- and low-forage farms were not influenced greatly by differences in the amount of sweetclover plowed under.

Comparability of the Sample Farms

Several tests were made to determine the extent to which the sample farms were comparable with respect to certain physical or economic attributes which might confound the relationships analyzed.

The homogeneity of the soils resources on the sample farms was tested by means of regression analysis between the forage index and the acreage of each of the three main soil groups on these farms. The linear regression coefficients were not significant within the 5 per cent level of probability. The differences in acreages of the three groups of soils between high- and low-forage farms were then tested. The average acreages of the three soil groups per farm are shown in table 1. These differences were not statistically significant. If anything, the low-forage farms had slightly better soil resources than the high-forage farms. It can be assumed that the farms represent a single population with respect to their soil resources.

TABLE 1.—Average acreages of three principal soils on high- and low-forage farms.

Forage class	Acres of stated soil groups per farm			
	Moody silt loam and Moody silty clay loam	Crofton silt loam	Judson, Wabash, and Waukesha silt loam	Total[1]
High-forage	68.6	67.0	16.9	152.5
Low-forage	70.3	60.0	19.6	149.9

[1] Not included are areas of land in farmsteads, roads, fence rows, and streams. The acreages presented include only land actually available for cropping, including permanent pasture.

An attempt was made to test the homogeneity of the sample farms with respect to management. It is recognized that the conclusiveness of these tests is limited.

Accurate data were available for one physical ratio on the sample farms, namely, hogs saved per litter during 1950. The regression coefficient between forage index and hogs saved per litter was not significant. Insofar as this ratio reflects management, the farms were drawn from a homogeneous population with respect to management.

An attempt was also made to estimate a management rating for each operator in the sample. This rating was made by persons interviewing the operators, and was of a purely subjective nature. The operators were rated on a scale of 1 to 10, and analysis was made of the relationship between forage index and management rating. The regression coefficient was not significant.

Land Use and Present Cropping Systems

A comparison of high-forage and low-forage farms in the various organizational attributes relating to land use and crop production is presented in table 2. It is to be noted that the data presented in this table are averages, and as such do not indicate the ranges occurring in the sample data. Nor do they indicate the actual relationship which may exist between forage acreages and the various dependent attributes. However, statistical tests of the differences between the various pairs of means do evaluate the importance of these differences. Regression analyses then enable more precise definition of the nature of relationships where they exist.

TABLE 2.—Land use and crop production on sample farms.

Characteristic	High-forage farms		Low-forage farms	
Land use[1]				
Acres row crops	57.9		65.9	
Acres small grain	39.7		50.6[4]	
Acres all grain		97.6		116.5[5]
Acres of first-year sweetclover plowed under	35.1		39.5	
Acres hay	17.9		8.4[5]	
Acres rotation pasture	29.5		13.1[5]	
Acres rotation forage		47.4		21.5[5]
Total rotation acres		145.0		138.0
Acres permanent pasture	5.1		10.2	
Acres all forage		52.5		31.7[5]
Other land	9.7		11.7	
Total		159.8		159.9
Yields and feed production, 1950				
Corn yield per acre	39.1		33.9[4]	
Oats yield per acre	31.0		25.6	
Hay yield per acre	1.7		1.4	
Feed units of grain produced[2]	2894		2852	
Feed units of forage produced[3]	1135		922	
Total feed units produced		4029		3774
Feed units per acre of hay and grain	30.4		25.7[5]	
Per cent of total feed produced as forage	28.1		24.4	

[1] Based on five-year average acreage, 1947-1950.
[2] One feed unit equivalent to a bushel of corn on the basis of total digestible nutrients.
[3] Includes estimated production on rotation and permanent pasture.
[4] Indicates significant differences between high- and low-forage farms within 5 per cent level of probability.
[5] Indicates significant differences within 1 per cent level of probability.

TABLE 3.—Proportion of crop acres devoted to row crops, small grains, and forage on sample farms.

Class of crop	Per cent of rotation acres	
	High-forage farms	Low-forage farms
Row crops	40.0	47.8
Small grains	27.4	36.7
Total grain	67.4	84.5
Sweetclover plowed under	(24.2)	(28.6)
Rotation forage	32.6	15.5
Total, all rotation crops	100.0	100.0

The general nature of the crop combinations on the two groups of farms, in terms of percentages of the rotation acreage, is shown in table 3.

A large part of the rotation forage consisted of alfalfa, alfalfa-brome, or brome hay or pasture. In general, the two groups of farms did not differ greatly in the method of handling rotation forage acreages. Most of the hay and pasture acres are "left down" for a number of years. On the average, the high-forage farms plowed up only 5.1 acres of forage in two years or less; this represents about 10 per cent of the total acres of their rotation forage. Similarly, the low-forage farms plowed up an average of 2.8 acres in two years or less, or about 13 per cent of their rotation forage acreage.

Crop Yields and Feed Production

Yield data were obtained for the years 1949 and 1950 for the sample farms. However, some of the farms suffered extensive hail damage in 1949 and had considerably lower yields. Therefore, only 1950 yields were used in the analysis.

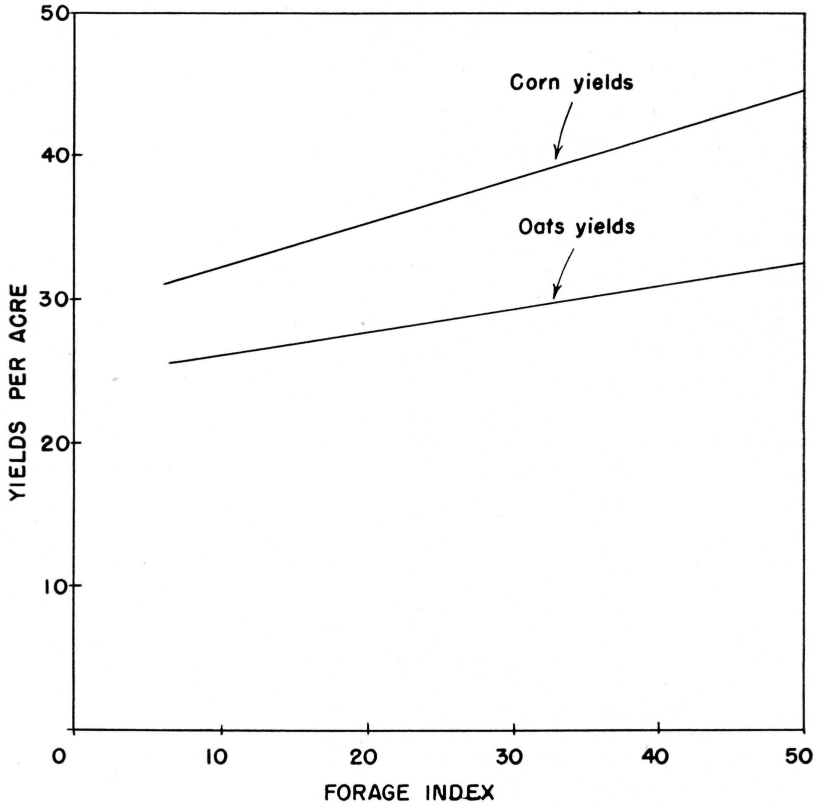

FIGURE 3.—Relationship between yields of corn and oats and forage index (1950 data).

Corn yields averaged 5.2 bushels per acre higher on the high-forage farms. However, a range of 14 bushels per acre was indicated by the linear regression between forage rating and corn yield within the range of the sample, as shown in figure 3. The linear regression coefficient between forage index and corn yields per acre was significant within the 1 per cent level of probability. The regression equation is $Y = 29.5 + .292x$. The second degree curvilinear regression coefficient was also tested but did not reduce the variance significantly.

An increase in corn yields associated with higher proportion of forage acres is to be expected for two reasons: (1) the direct effect of forage on grain in the rotation due to nitrogen fixation, addition of organic matter, erosion reduction, and improvement of tilth, and (2) the indirect effect of manure produced by livestock kept to utilize forage. It is to be expected that farms with low-forage acreage will have less manure to return to the land. This might result because of higher cash sales of grain on low-forage farms, or a higher investment in grain-consuming livestock and less forage-consuming livestock on low-forage farms. Due to methods of handling, less of the fertilizer constituents of manure produced by grain-consuming livestock, especially hogs, may be recovered and returned to the land. Among the sample farms, high-forage farmers estimated that they hauled out an average of 14 tons more manure per year than those on the low-forage farms. The linear regression coefficient between forage index and loads of manure hauled per year was significant within the 1 per cent level of probability, the regression equation being $Y = -9.3 + 2.65$. (See figure 4.)

It might be expected that the relationship between forage acreage and corn yields should be nonlinear; as greater acreages of forage are included in the rotation, the associated increase in corn yields per acre would become progressively less as the direct and indirect (manure) benefits of forage diminished. Agronomic research bears this out.[7]

There are several possible reasons for the apparent lack of significant curvilinearity among the data of the sample. First, the range in the forage indexes was comparatively short, with most of the cases falling within limits of 10 to 40 per cent. Second, the variation in data among the farms in the sample was quite high, reducing the significance of the relationship expected between these two variables.

---

[7] See: (a) Iowa Agr. Exp. Sta. annual reports of studies at the Soil Conservation Experimental Farm, Page County, Iowa. In cooperation with Iowa Agr. Ext. Serv., Soil Cons. Serv., Bur. of Plant Ind., U.S.D.A., Washington, D.C. Agron. 23, 40, 61, 88, FSR 5, 1932-1949.

(b) Earl O. Heady and Harold R. Jensen, *The Economics of Crop Rotations and Land Use*. Iowa Agr. Exp. Sta. Res. Bul. 383, 1951.

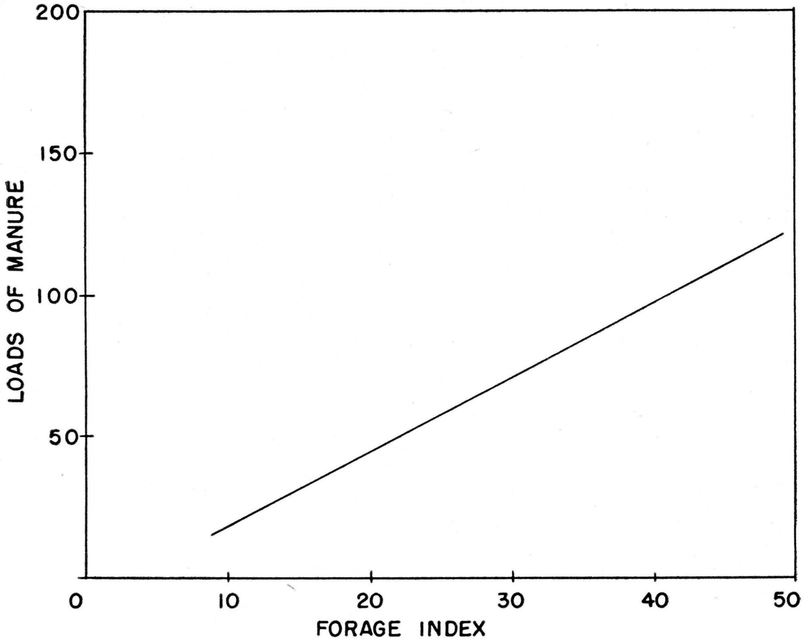

FIGURE 4.—Relationship between loads of manure applied annually on farms and forage index.

The regression coefficient between forage rating and oats yield was significant within the 20 per cent level of probability. The regression equation was $Y = 24.4 + .16X$.

With 18.5 fewer acres of grain in 1950, the high-forage farms produced an average of **42 feed units** more of grain than the low-forage farms.[8] Inspection of a scatter diagram of total grain production as related to forage index suggested that the relationship might be curvilinear. However, neither the curvilinear nor linear regression coefficient was significant. The variance among the data was quite high.

Analysis was made of the total feed units of grain and forage as related to the forage index. The curvilinear regression coefficient was significant within the 20 per cent level of probability. This

[8] To provide a standard basis for measurement all feeds were converted to corn equivalents on the basis of total digestible nutrients, with one bushel of corn equal to a feed unit. The source of the necessary data was F. B. Morrison, *Feeds and Feeding,* 20th edition (Ithaca, N. Y., The Morrison Publishing Co., 1936), pp. 954-993.

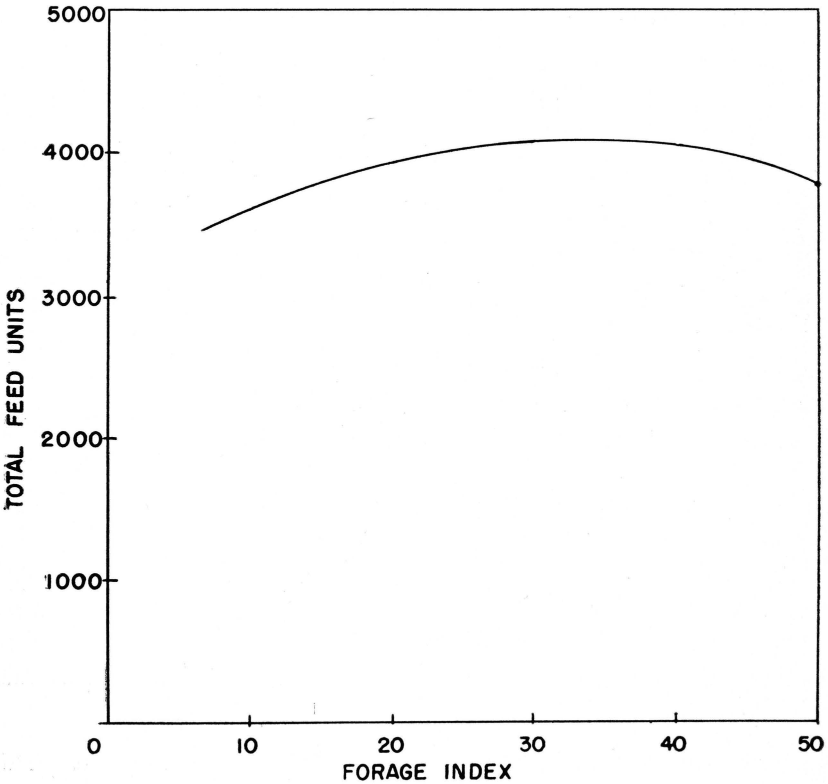

FIGURE 5.—Relationship between total feed units produced and forage index (1950 data).

relationship is shown in figure 5.[9] It is logical to expect that a curvilinear relationship would exist between forage acreage and feed production. Again, the limited range and high variance of the data limited the precision of the results.

Analysis was also made of the relationship of forage index on feed produced per acre of rotation hay and grain, thus eliminating the uncertain quantity produced on rotation pasture. The coefficient of linear regression between forage index and feed units per acre was significant. The relationship is shown in figure 6.[10]

---

[9] The curvilinear regression equation was $Y = 3075.66 + 62.58X - .961X^2$.

[10] The linear regression equation for the relationship between feed units per acre and forage index was $Y = 23.6 + .185X$.

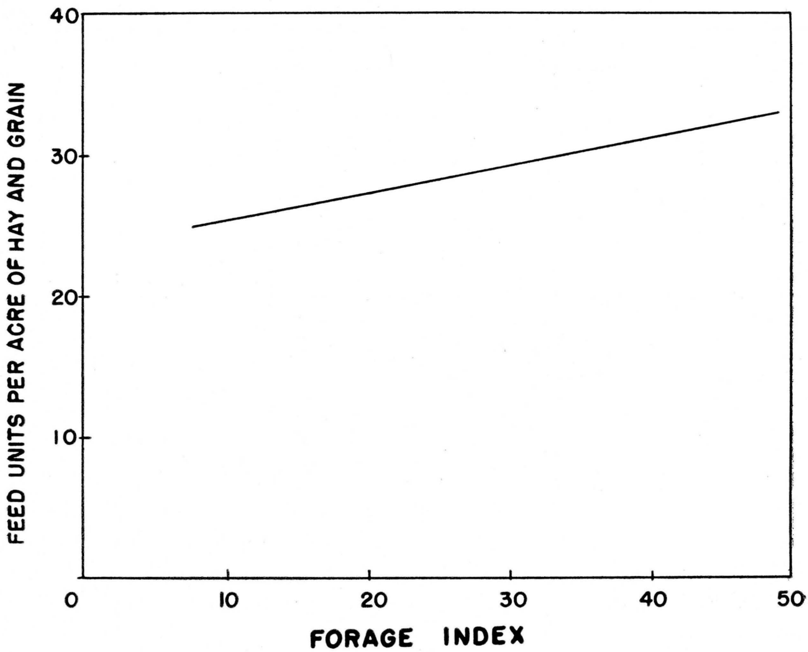

FIGURE 6.—Relationship between feed units per acre of hay and grain and forage index.

Feed Utilization and Livestock Types

The over-all combination of the feeds fed to livestock did not differ significantly between the two groups of farms. Forage comprised 25 per cent of the feed fed on high-forage farms, as compared with 18.5 per cent on low-forage farms. The higher proportion of feed fed as forage than that produced as forage results from the cash sales of grain, predominately corn, as well as from small purchases of hay. The net movement of corn (bushels sold less bushels purchased) from low-forage farms was 602 bushels; on high-forage farms the comparable figure was 401 bushels. There was a small net movement of .8 ton of alfalfa hay to the latter. The average net purchases of hay by high-forage farms was significantly greater than on low-forage farms.

In view of the similarity in feed utilization it is to be expected that the types of livestock raised on the sample farms would not be greatly different. High-forage farms tended to have slightly larger investments in milk cows, as shown in table 4; low-forage farms had

TABLE 4.—Average inventory of livestock on sample farms.[1]

Type of livestock	Value	
	High-forage farms	Low-forage farms
Milk cows	1,304	1,089
Other cattle except purchased feeders	1,115	1,049
Purchased feeders	371	459
Sheep	17	36
Hogs	881	1,431
Hens	135	114
Horses	33	33

[1] Average inventory values January 1 and December 31, 1950.

higher investments in hogs. In general, however, the pattern of livestock production was similar on the two groups of farms.[11]

Capital Investment

The amounts of capital invested in various types of resources are shown in table 5. The average amounts of capital invested in livestock did not vary greatly between low- and high-forage farms, and were not satistically significant. The variation in livestock investments on individual farms was quite high, however, ranging from $1,772 to $12,907.

TABLE 5.—Capital structure of sample farms.

Characteristic	High-forage farms	Low-forage farms
	(Dollars)	
Capital invested in grain-consuming livestock[1]	983	1,515
Capital invested in forage-consuming livestock	2,728	2,592
Capital invested in machinery	3,199	2,939
Capital invested in buildings	7,292	6,061
Capital invested in land	10,956	10,584
Total capital invested	25,158	23,691

[1] All livestock investment figures are averages of the opening and closing inventories, 1950.

[11] Excluded from the data in table 4 are the inventories of one high-forage farm in the sample. This farm had an average inventory of feeder cattle on hand of $7,200 in 1950. The operator of this farm owns two other farms of similar size which he leases on a crop-share basis. His share of the crops is fed on the home farm to feeder cattle which he customarily keeps as a means of disposing of the grain from the three farms. Because of the atypical nature of this operation, its data were excluded from the descriptive analysis of capital, volume of business, and income, as well as the budgeting analysis.

Also not significant were regression coefficients between investments in all livestock, in forage-consuming livestock, and in grain-consuming livestock and forage index. It would appear that any difference in income between the two groups of farms does not originate to any great extent from difference in investment in livestock.

High-forage farms had a slightly higher average investment in machinery than did low-forage farms, although not significantly so. In general, the types of machinery on the farms were quite uniform.

The investment in buildings was associated with the acreage of forage raised. The high-forage group had an average of $1,200 more invested in buildings; the regression coefficient between building investment and forage index was significant at the 5 per cent probability limit. This may be explained in part by the larger proportion of owner-operator farms among the high-forage group. These operators probably give greater attention to upkeep and repair, and invest more capital in building additions. The regression equation between space available (in square feet) for forage-consuming livestock and forage index was: $Y = 956 + 16.1X$. This coefficient was significant at the 10 per cent level of probability.

The investment in land on the sample farms was arrived at indirectly, by subtracting the value of the buildings from the total value of the farms as estimated by operators. There was little difference between the two groups in the resulting value estimates. If this estimate is a valid rating of the land resources, differences in income between high- and low-forage farms cannot be attributed to differences in soil productivity, insofar as the value estimates reflect productivity.

Labor Use

The amounts of labor used per year were uniform among the sample farms, varying from an average of 15 months per year on the high-forage farms to 17.1 months in the low-forage group. The variation among individual farms was from 12 to 24 months per year. The greater part of the labor used was supplied by the operator and his family. No year-round labor and only a small amount of seasonal help was hired. Although the difference in labor on high-forage farms and low-forage farms was not significant, it is of interest to note the somewhat lower average requirements on high-forage farms. At any rate, differences in income between the two groups are not attributable to differences in labor input. The regression coefficient between months of labor and forage index was not significant.

Income Analysis

Analysis was made of the volume of business and net income on the sample farms for 1950. Of course, the results relate to the future only insofar as price relationships and physical production characteristics represented by these data are indicative of future price and production conditions in the sample area.

The year 1950 was one of varying economic trends in agriculture. In the early months of the year the prices of goods sold by farmers were decreasing as compared with the prices paid by farmers. Had these trends continued, it is likely that the economic condition of farmers would have been much less favorable by the end of the year. In mid-year, however, the Korean War reversed the farm price trend; while supplies purchased by farmers strengthened moderately in price, the prices of farm products rose rapidly for a time, and at the end of the year were considerably above those of the earlier months. Also characteristic of 1950 were relatively higher prices for forage-consuming livestock and their products, especially beef, than for grain-consuming livestock, as compared with the years during and immediately following World War II.

In order to show the effect of different relative prices of farm commodities and costs, a second set of prices, namely, those of 1939-44, was applied to the production data for 1950. During this period farm prices were at first relatively low as compared to the prices of goods bought by farmers, but by the end of the period the situation was reversed. Thus, in terms of prices, the period was a mixture of depression and prosperity for agriculture. In addition, the prices of grain-consuming livestock were relatively higher compared with those for forage-consuming livestock than in the recent postwar years. The various price indexes used in arriving at the financial results of this analysis are indicated in table 6.

TABLE 6.—Indexes of prices received by Nebraska farmers for certain commodities in 1950, and in the period 1939-1944 (1910-1914 = 100).[1]

Commodity	1950	1939-1944
Corn	231	130
Oats	206	122
Alfalfa hay	177	123
Wild hay	245	124
Milk cows	394	154
Cattle	441	183
Calves	394	167
Hogs	253	140
Chickens	189	167
Eggs	147	121
Butterfat	240	144

[1] Based on information provided by the State-Federal Division of Agricultural Statistics, Lincoln, Nebraska, July, 1951.

Several adjustments were made to the original data in computing income measures. To remove the income effects of price changes between the opening and closing inventories of crops on hand, the physical inventories of each crop were valued at the average prices received by Nebraska farmers in 1950. Beginning and ending inventory values for specific livestock were converted to average values for 1950. The values of sales and purchases during the year were not adjusted. The conversion to 1939-44 levels of prices and costs was made separately for items contributing to income or expenses.

Volume of business. High-forage farms averaged $641 higher volume of business (gross sales less cost of purchased feed and livestock) than did low-forage farms in 1950. Neither this difference, however, nor the linear regression coefficient between forage rating and volume of business was significant within acceptable probability limits. This lack of statistical significance may be attributed in part to the small size of the sample, with considerable variability between the farms. If this difference was indicative of a real difference in the population of all 160-acre farms in the area, it might be explained partly by the way in which feed is utilized. Although producing almost as much grain, low-forage farms sell more of it than do high-forage farms. The additional forage produced on high-forage farms, in addition to unsold grain, is processed by roughage-consuming stock.

On the low-forage farms a larger proportion of the unsold grain is processed through hogs than on the high-forage farms. This would also contribute to the difference in income, since the prices of hogs were relatively lower in both 1950 and 1939-44 than the prices of cattle, as compared with 1910-1914. A third source of gain on farms with forage-consuming livestock in 1950 was inventory gain on cattle sold during the year.

Net income. The deduction of operating expenses, depreciation on machinery, fixed expenses and depreciation on fixed assets from volume of business gives net farm income, a residual net return for a farm as a whole. The adjusted net farm incomes in table 7 are comparable for the two groups of farms.

The net farm income under 1950 prices was 51 per cent higher on high-forage farms; under 1939-44 price conditions this difference amounted to about 56 per cent. However, neither these differences nor the linear regression coefficients between income and forage index were statistically significant.

TABLE 7.—Income summary for sample farms, 1950 and 1939-44 price levels.[1]

Item	High-forage farms	Low-forage farms
	(Dollars)	
Volume of business, 1950[2]	4,821	4,180
Net crop sales, 1950[2]	1,407	1,222
Net livestock production, 1950[2]	3,414	2,959
Net farm income, 1950[3]	2,469	1,635
Net farm income, 1939-44[3]	1,296	828

[1] In order to put the sample farms on a common debtor-and-tenure basis for the above comparison cash rent and interest on borrowed capital have not been deducted as an expense. The landlord's share of the crops where the farm is under a crop share lease has been included as a crop sale. Income from custom work off the farm has been omitted. It is of interest to note the extent that increases in value of inventories of crops and livestock due to inflation contributed to the income actually received by the sample farmers in 1950. The net farm income unadjusted for change in inventory values averaged $3,358, or 66 per cent ($1,341) higher than that resulting when inventories were adjusted for change in prices between the beginning and the end of the year.

[2] Sales plus inventory increase less purchases of livestock and/or feed, and inventory decreases.

[3] Volume of business less operating expenses, depreciation on machinery, fixed expenses, and depreciation on fixed assets.

Miscellaneous Characteristics of Sample Farms

Three factors which may influence crop and livestock organization and production are conservation practices such as contouring and terracing, the use of commercial fertilizers, and tenure arrangements. Only two of the farmers in the sample were active participants in the program of the Soil Conservation Service at the time they were interviewed. One of them had adopted a complete program of soil conservation in 1949-50; the fields of his farm were laid out on the contour, a systematic rotation of crops was being followed and several miles of terraces had been constructed. This was the only sample farm which had any terraces. The other farmer planted row crops on the contour and had a comparatively high-forage acreage. Both farmers were classified in the high-forage group.

Two other high-forage farms had 94 acres contoured and seven low-forage farms had an average of 73 acres contoured. No attempt had been made to lay out fields with a level; corn rows were simply planted across the slopes of the steeper fields instead of following the field boundaries.

Only four sample farms applied any commercial fertilizer during the period studied. These applications were chiefly of an experimental nature. Very limited use of commercial fertilizer was characteristic of the entire sample area.

Leasing arrangements can affect the nature of agricultural production in several ways. Short-term leases may tend to encourage the production of quick return grain crops rather than slower return forage. Tenants are more likely to be short on capital than owners, and less able to raise forage-consuming livestock. Landlords may restrict the acreage of forage which can be produced. Three high-forage farms and eight low-forage farms were operated by tenants. These leases were all crop-share or crop-share-cash, except for one cash lease and 50:50 livestock-share arrangement.

BUDGETING ANALYSIS

The 30 farms analyzed in the previous section were also used in the budgeting analysis. An attempt has been made to show the changes in organization, amounts of resources, and income resulting from shifts of the sample farms to alternative crop and livestock systems. This analysis is in "long-run" terms; sufficient time is assumed for the effects of rotation, fertilization, and erosion control practices to be fully reflected in crop yields, and for alternative livestock systems with accompanying housing and feed storage facilities to be adopted.

It is to be noted that the necessary adjustments do not occur suddenly; the effects of erosion-controlling systems on yields will be reflected only after several years; further, most farmers cannot shift to such cropping systems in less than four or five years. Shifts in livestock systems are dependent somewhat on the changes in feed supply, as well as the resources limitations of the individual operator. These shifts will probably lag behind the shifts in the cropping system by a year or two. In this analysis, however, all the results represent the long-run possibilities, after sufficient time has elapsed for all shifts to have been made.

Systems of Soil Management and Rotations

The feed production potential under three alternative systems of soil management was estimated for the sample farms. These systems were:

1) The use of rotations only as a means of controlling erosion.

2) Rotations with terraces and contouring to control erosion.

3) The use of rotations, terraces, and contouring, plus fertilizers to produce feed within an acceptable degree of erosion control.

Feed production under these systems was based on long-run yield estimates made by specialists in soils and is thought to represent reasonable expectations under farm conditions.[12] The estimates were made for each major soil and for each of the alternative soil management systems. The estimates were based on available data such as the

[12] The detailed yield estimates were prepared by A. R. Aandahl, Soil Survey, Soil Conservation Service, and H. F. Rhoades, Agronomy Department, Nebraska Agricultural Experiment Station.

results of fertilizer trials in northeastern Nebraska, the rotation and yield data obtained from the sample farms, long-time aggregate yield data for Dixon County, and data from the Ida-Monona area of western Iowa. The yield estimates were confined to oats, corn and alfalfa-bromegrass hay. These crops are not the only crop alternatives for the sample area. However, they are the most important in the sample area at the present time. In the immediate future, at least, the most important management decisions with respect to cropping systems will relate to which combination of these crops is most desirable, rather than whether other crops or combinations should replace them.

Yield estimates were made for the six most important soil conditions in the Moody-Crofton soil association area of northeastern Nebraska.[13] These conditions were:

Crofton, 14 per cent slope, erosion class 3.[14]
Moody, 20 per cent slope, erosion class 3.
Moody, 14 per cent slope, erosion class 3.
Moody, 14 per cent slope, erosion class 2.
Moody, 6 per cent slope, erosion class 1.
Judson, 1-6 per cent slope, erosion class 1.

Yield estimates were made for six different alternative crop combinations for each of the soil conditions. These combinations were CCO_s, CO_s, CO_sCOMM, COMM, COMMMM, and M.[15] The estimates were based on the assumption that all of the grain and hay would be consumed on the farm, and that all manure would be applied to land being prepared for corn. In addition to manure, the application of specified quantities of nitrogen and phosphate fertilizers was assumed under the third soil management system.[16]

The 1950 crop yields and production on the sample farms approximated long-run averages in the area quite closely, and are comparable to the above yield estimates, which assume weather and technological conditions of 1939-50.

Two criteria were applied in selecting the economically optimum crop combinations used in analyzing the alternative soil management systems on the sample farms. These were (1) tons of annual soil loss per acre and (2) relative prices of crops.[17]

---

[13] For the average acreages of various soil type-slope classes on the sample farms see appendix B.

[14] Erosion class 1 is defined as none to slight erosion; class 2 is moderately eroded land; class 3 has severe to very severe erosion.

[15] C = corn, O = oats, Os = oats with sweetclover plowed under as a green manure crop, and M = rotation forage. Each letter indicates one year.

[16] See appendix C for assumed levels of fertilizer application.

[17] Further details of the procedure used in making *these selections are given in* appendix D.

A soil loss of 7 tons per acre annually is estimated to be the maximum allowable in order to prevent the development of new ditches and gullies, and to stabilize the present ones, as well as to prevent the deterioration of the land through sheet erosion. This figure is not supported by conclusive empirical evidence. It is a compromise between estimates of a number of technicians. These estimates ranged from 2 to 15 tons per acre. The assumption of a larger allowable loss would alter the results of the analysis accordingly. This amount represents an average over a long period of years; the soil loss in any single year will vary with the crop being raised. For example, the loss when corn is raised will probably be greater, while little erosion may take place when hay is raised.

Within the limits of an acceptable annual soil loss per year, the relative sale prices for grain and hay were used in selecting optimum crop combinations for budgeting. It was assumed that all home-raised feed would be fed; however, farmers do consider the relative prices for crops in planning their rotations. If prices for crops were not considered, the optimum combination on a given soil would be that for which the rate of substitution of forage for grain in production (pounds of grain sacrificed for each pound of forage gained) is inversely equal to the substitution rate of forage for grain in consumption by a certain type of livestock. This is efficiency in the physical sense. However, farmers can sell feeds of one kind and purchase feeds of another if the price relationship is different from the optimum rate of physical substitution. Thus the combination of forage and grain with the highest gross market value would be that combination where the forage/grain substitution rate is inversely equal to the forage/grain price ratio (amount of grain equal in value to one pound of forage).[18] The high gross value crop combination would not necessarily be the most profitable combination if the production costs per acre for forage and grain are different. However, among the broadly separated alternative crop combinations which were analyzed it is probable that combinations yielding highest gross values would also give highest net values on a given acreage.[19]

[18] An explanation of rotation substitution rates and crop price ratios is given in appendix A.

[19] In a study by the Iowa Station (Earl O. Heady and Harold R. Jensen, *The Economics of Crop Rotations and Land Use.* Iowa Agr. Exp. Sta. Res. Bul. 383, 1951) six sets of rotations under three different price situations showed very close correspondence of high gross return and high net return rotations. Under 1940-44 price conditions the total cost of producing hay, corn, and oats on Clarion Webster soils in Iowa has been estimated at $19.33, $13.07, and $9.93 per acre respectively. Under these price conditions, the crop combination which would maximize net income would include a somewhat higher grain acreage than the high gross value combination, within the competitive range between forage and grain.

TABLE 8.—Prices per pound of corn, oats, and alfalfa hay, and corn-alfalfa price ratios.[1]

Crops	Price period		
	1950	1938-44	1939-50
		(Cents)	
Corn	2.23	1.25	1.85
Oats	2.31	1.38	1.84
Alfalfa (loose)	.56	.50	.61
Alfalfa/corn price ratio	.25	.40	.23

[1] Computed on the basis of information published by the State-Federal Division of Agricultural Statistics, Lincoln, Nebraska.

The Nebraska prices per pound of corn, oats, and alfalfa hay for three price periods are shown in table 8. Under the average price relationships for the 12-year period 1939-50 the forage-grain substitution ratios between practically all alternative grain-alfalfa combinations were larger than the price ratios. In other words, in shifting from high grain acreages to combinations with greater proportions of total acres in hay the value of the hay gained would be less than the value of the grain replaced, in the short run. High grain combinations producing the highest poundage of grain, namely, CO_s or CCO_s, would give the highest gross value under these price conditions. They represent the limits of the complementary range between forage and grain among the combinations and alternative soil management systems studied. In no case does the complementary range extend into combinations where forage is harvested for hay. Of course, combinations such as CO_s and CO_sCOMM represent quite widely separated points on an isoland curve for forage and grain. Some combination between them might be in the complementary range. The high grain combinations do not control erosion on some soils, under the alternative soil management systems. Therefore, price relationships are a valid criterion for selection of combinations only within the limits of the assumed allowable soil loss. If the latter is a valid long-run limit, net returns from some high grain combinations could not be maintained indefinitely because of the deterioration of the land.

The rotations selected for the budgeting analysis are listed in table 9.

In estimating the production of corn, oats, and hay under the alternative systems of soil management, no attention was given to field arrangements. The selected crop combinations were applied to the various type-slope areas without regard to their shape or size. This is a compromise with reality. In planning rotations, farmers necessarily have to consider such details as size and shape of fields, location of

TABLE 9.—Crop combinations selected for budgeting analysis for various soil types and phases and soil management systems.[1]

Type of soil	Slope class	Degree of erosion	Soil management system R[2]	Soil management system RTC[3]	Soil management system RTCF[4]
Moody silt loam	3-6%	1	COMM[5]	CO$_s$	
and Moody silty	8-10	1		CO$_s$	CCO$_s$
clay loam	6-10	2	COMMMM		
	12-16	1,2		CO$_s$COMM	CO$_s$COMM
	10-16	3	M	COMM	
	20-25	1,2,3		COMMMM	COMM
Crofton silt	12-16	1			COMM
loam	12-16	2,3	M	COMMMM	
	20-30	1			
	17-30	2,3			COMMMM
Judson, Waukesha, and Wabash silt loams	1-6	1,2	CO$_s$	CCO$_s$	CCO$_s$
Burchard and Steinauer clay loams	6-16	2,3	M	COMMMM	COMM

[1] Yield estimates were not available for all of the soil type-slope classes listed. Yields were estimated in these cases by interpolation.

[2] Erosion is controlled by the use of forage in the rotation.

[3] The soil management system consists of terracing and contouring, in addition to the rotations indicated.

[4] Terracing, contouring and fertilizer application are practiced in conjunction with the selected rotations.

[5] C = Corn, O = Oats, Os = Oats plus sweetclover, M = Alfalfa-brome hay and pasture.

rotation pastures from the standpoint of fencing and convenience, as well as soil types and phases. However, the analysis does indicate the direction and relative magnitude of adjustments under alternative soil management systems.

Land use under alternative soil management systems. The major changes in land use with the adoption of each of the alternative soil management systems on the sample farms are shown in table 10. Reducing erosion to an acceptable level by including more forage crops in the rotation would result in rather extreme adjustments in the cropping system. The present crop combinations of from two thirds grain and one third forage on the high-forage farms to five sixths grain and one sixth forage on the low-forage farms would be altered to a combination of roughly one year of grain and five years of forage. Even with an assumed maximum soil loss per acre of 15 tons per year the grain acreages would not be much larger under this soil management system.

With the use of terracing and contouring in addition to rotations to control erosion, the acreage of grain could be greater than that under system R. The over-all crop combination would be approximately two years of corn, two years of oats, and three years of forage. With the

TABLE 10.—Land use under present and alternative soil management systems.

Item	High-forage farms Soil management system				Low-forage farms Soil management system			
	Present[1]	R	RTC	RTCF	Present	R	RTC	RTCF
				(*Acres*)				
Acres in row crops	57.9	10.2	43.2	52.6	65.9	13.6	46.3	55.5
Present rotation land in row crops	39.9	7.0	29.2	35.8	47.8	9.7	32.9	39.8
Acres small grains	39.7	10.2	39.0	41.5	50.6	13.6	41.0	41.1
Total grain acres	97.6	20.4	82.2	94.1	116.5	27.2	87.3	96.6
Per cent rotation land in all grains	67.3	13.8	55.5	64.0	84.4	19.3	62.0	69.3
Acres of hay and rotation pasture	47.4	127.2	65.7	52.9	21.5	113.4	53.3	42.8
Acres of permanent pasture	5.1	5.7	5.7	5.7	10.2	9.1	9.1	9.1

[1] Five-year average of acreages on sample farms.

addition of fertilizer in soil management system RTCF an additional increase in the acreage of corn would be possible, with the over-all crop combination approximating two years of corn, one year of oats, and two years of forage.

Because of their slightly larger acreages of Moody and Judson silt loams, and slightly smaller acreages of Crofton soil, the low-forage farms show a capacity for somewhat larger acreages of grain under each soil management system than the high-forage farms. Apparently, some part of the difference in the present forage acreage between the two groups of farms is due to recognition by the operators of soil differences, and the adjustment of crop combination in response to them.

The permanent pasture acreage would be practically the same in the budgeted systems as in the present system. Except for minor changes, no attempt was made to alter the areas considered by the farm operators to be fit only for permanent pasture.

The data in table 10 conceal the fact that not all farms would have decraeses in grain acreage with the adoption of soil management systems RTC or RTCF. This is shown by the regression lines in figure 7. A few farms with high-forage indexes could increase their present grain acreages and still prevent excessive erosion.

The regression line for system RTC indicates that a shift of 10 more acres to forage would be needed on farms with indexes of less than 35 than under system RTCF. A much more extreme shift away from grain would be necessary to control erosion through the use of forages only. The increase in forage acreage over that under system RTC would vary from 55 to 77 acres at the low and high extremes of the forage index, respectively. The regression equations shown in figure 7 were significant within the 1 per cent level of probability.[20]

Crop yields and production under alternative systems. The average yields under present and alternative soil management systems for the sample farms are indicated in table 11. The increase in yields of corn and oats under soil management system R would be due partly to the complementary effect of the larger proportion of rotation forage on grain on Moody soils. The increases would also result from the shift of most of the grain acreage to the more productive Moody and Judson silt loams; Crofton soils would be kept largely in meadow. Hay yields would be less than under the present system, due partly to the shifting of hay acreages away from Judson silt loam to the steeper Crofton. Here, hay would be "left down" continuously except for reseeding.

[20] The equations in figure 7 for the respective soil management systems are:

a) $Y = 101.5 - .762X$

b) $Y = 47.18 - 1.05X$

c) $Y = 36.72 - 1.090X$

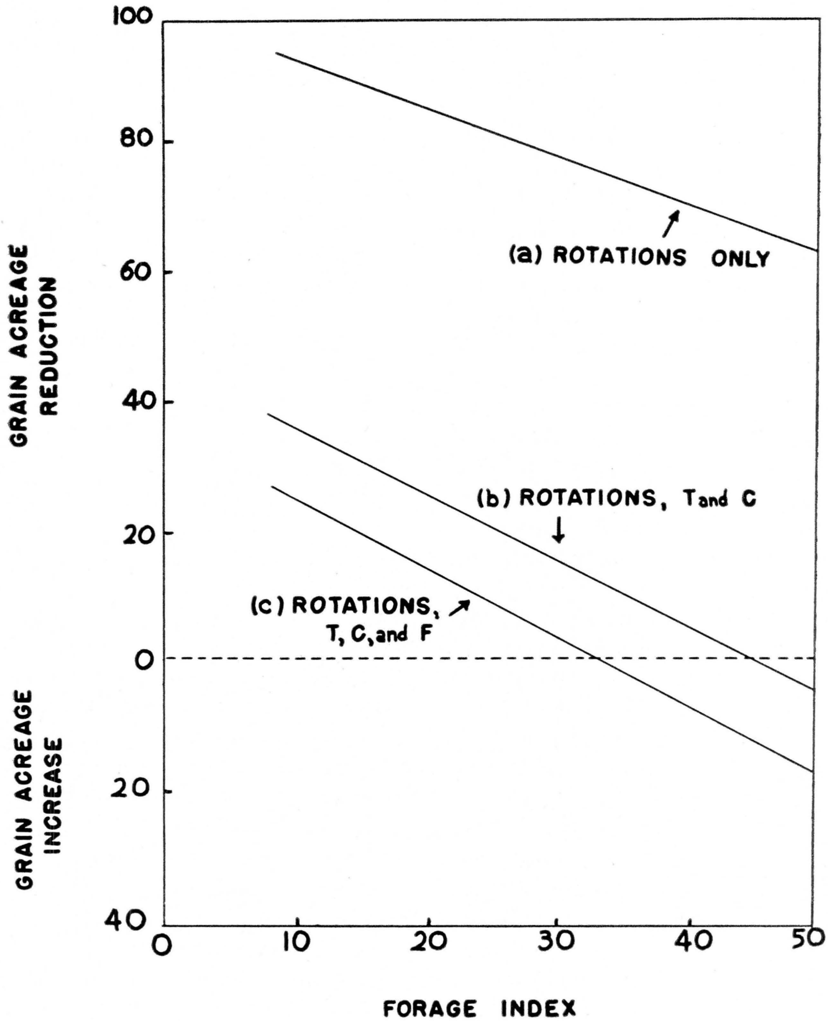

FIGURE 7.—Relationship between change in acreage of all grain under alternative soil management systems and forage index.

Under soil management system RTC the average yields of grain would be smaller than under system R. More grain would be raised on the steeper Moody and Crofton soils; in addition more intensive grain rotations would be used on the less sloping Moody areas. However, the average feed units (corn equivalents) per acre for all rotation land would be at about the present level on the sample farms. The

TABLE 11.—Crop yields and total production under present and alternative soil management systems.

Item	High-forage farms Soil management system				Low-forage farms Soil management system			
	Present	R	RTC	RTCF	Present	R	RTC	RTCF
Corn yield per acre (bushels)	39.1	51.8	42.6	47.5	33.9	52.1	44.1	49.1
Oats yield per acre (bushels)	31.0	43.7	35.2	41.4	25.6	44.8	35.8	42.2
Hay yield per acre (tons)	1.7	.9	.9	1.6	1.4	1.0	.9	1.6
Yield of grain feed units per acre of grain[1]	29.8	37.1	31.3	35.9	27.6	37.2	31.9	37.4
Yield of grain and rotation forage feed units per rotation acre	27.6	25.6	27.1	35.4	26.3	30.5	28.7	36.9
Total feed units of grain produced	2894	756	2577	3378	2852	1011	2787	3611
Total feed units of forage[2]	1135	2580	1430	1909	922	2574	1249	1666
Total feed units produced	4029	3336	4007	5286	3774	3585	4037	5278
Per cent of total feed produced as forage	28.1	77.4	35.6	36.1	24.4	71.8	30.9	31.5

[1] One feed unit equivalent to a bushel of corn on the basis of total digestible nutrients.
[2] Includes rotation forage and permanent pasture.

further addition of fertilizer under system RTCF would not result in an extensive change in the combinations of grain and forage, but would increase the yields of corn, grain and hay considerably. The assumed rates of fertilizer application are shown in appendix C. Analysis of alternative rates of application was beyond the scope of this study.

With a shift to soil management system R total grain production, as well as the total production of feed, would be decreased despite an increase in the total production of forage. In the aggregate, forage would be competitive to grain in this shift; as the acres of forage are increased, the yields of grain would also increase, but proportionately less than the decrease in grain acres.[21]

TABLE 12.—Changes in capital investment, and annual charges, and gross value of crops associated with alternative soil management systems, 1950.

Items	High-forage farms Soil management system			Low-forage farms Soil management system		
	R	RTC	RTCF	R	RTC	RTCF
			(Dollars)			
Capital investments						
Terraces	——	2805	2805	——	2549	2549
Waterways	64	64	64	59	59	59
Fencing	218	115	92	234	96	95
Additional feed storage						
Corn crib	25	524	890	41	646	803
Small grain storage	3	81	150	5	74	117
Hay storage	3235	1300	2150	2839	988	1570
Total	3545	4889	6151	3178	4412	5193
Annual charges						
Terraces & waterways	——	146	146	——	133	133
Fencing	16	9	7	18	7	7
Feed storage	166	97	163	147	87	127
Fertilizer	——	——	332	——	——	309
Seed, fuel, and custom charges	164	338	373	132	337	300
Total	346	590	1021	297	564	876
Change in gross value of crop	(2075)[1]	(346)	834	(1701)	120	1166

[1] ( ) indicates a decrease from the 1950 level.

[21] The possible error in yield estimations, particularly for hay, should be recognized. If the yield of hay would be 28 per cent (.24 ton) higher on high-forage farms under soil management system R, the total production of feed would equal the 1950 level. Also, it is possible that the sample farmers overestimated their hay yields, although this cannot be verified. Many farmers figure hay production on the basis of 1 ton to the load.

With a shift of soil management system RTC, the total production of feed would be somewhat higher than under the present system. The addition of fertilizer in system RTCF would produce about 1200 additional feed units per farm, on the average.

Capital requirements and expenses under alternative systems. The additional capital investments and annual expenses associated with the soil management systems are shown in table 12. Although each of these systems would control erosion, only part of the investments and charges shown are directly associated with erosion control. Feed storage and fencing costs are associated more directly with livestock production. Fertilizer contributes indirectly to erosion control; however, it results directly in increased feed production.

The capital outlay needed for terracing ranged from $1928 to $2995 on the farms; on the average the low-forage farms would require somewhat less terracing than the high-forage group because of the somewhat smaller acreage of steep land. This outlay represents the cost if the work would be performed by custom operators using specialized equipment; outlay would be reduced substantially if the operators would do at least part of the construction work themselves, using their own plows, power and labor.[22]

The outside boundaries of all the farms are fenced, in addition to the permanent pasture. The fences around rotated land, if they could be moved, were deducted from the estimate of the additional fencing necessary. However, the costs shown do not represent an absolute minimum. Electric fences might provide means of pasturing livestock on rotation forage more cheaply. The range in additional outlay for fencing among the sample farms was from 0 to $515 under 1950 prices.

Additional capital would be necessary for feed storage facilities. The sample farms possessed more adequate facilities for grain storage than for hay. Only three of the farms had facilities for storing more than 25 tons of hay; on 11 farms, storage was available for 10 tons or less. However, the capital outlay for loose hay storage could be reduced considerably below the levels shown in table 12. If the hay was baled it could be stored in a smaller space, or even without shelter. Baling would involve some increase in fixed and operating costs for

[22] The terracing costs shown in table 12 represent a maximum outlay since they are based on the terracing of all but level land on the sample farms. In practice the terracing of the steeper Crofton soil areas may be questionable. It might be more profitable to keep them under cover crops continuously, eliminating the occasional crops of grain which could be raised with terraces. The capital needed for terracing these areas might be more productively applied to other parts of the farm organization.

Payments by the Production and Marketing Administration for terracing were not deducted in estimating the costs of terracing.

hay production, with a decrease in labor, as compared to the present system of handling. If the operators erected storage facilities using their own labor, a saving of over 50 per cent in cash outlay would be possible. Finally, loose hay might be stacked either in the field or at the farmstead, at the expense of some waste. Field stacking would make possible the use of buck rakes and stacker, and minimize the use of hired labor during the harvest season. The hay could then be hauled to the farmstead during the fall and winter.

The annual charges on additional investments include interest, depreciation, taxes and upkeep. The charges for fertilizer are based on the average annual cost of fertilizer applied under soil management system RTCF. The charges for seed, fuel, and custom work represent the net increase in these items over the 1950 level on the sample farms.

The changes in the gross value of crops produced under the alternative systems were computed. Comparisons between these data and the changes in expenses under alternative soil management systems cannot be regarded as conclusive since all expenses and production data are based on the assumption of complete feed utilization by livestock. However, it appears that under 1950 prices the adoption of a soil management system which would control erosion by means of rotation forage would have greatly reduced the value of crop production and net returns on the sample farms. A system of contouring and terracing, plus necessary forage for erosion control would not have changed the value of crops produced on these farms. However, the annual charges on additional resource inputs would have affected net returns adversely. The productivity of funds invested in fertilizer would be high; the application of an average of $320 of fertilizer per farm under soil management system RTCF would result in an increase of $1120 in value of crops produced.

It must be recognized that farmers in the sample area probably cannot maintain crop production at the present level indefinitely in the face of erosion. The estimated annual soil loss per acre during the five-year period 1946-50 is estimated as 60 to 70 tons on the low-forage farms and 40 to 50 tons in the high-forage group. Therefore, the capital investments and annual inputs associated with erosion controlling systems of soil management represent the cost of maintaining the particular levels of production in the long run. However, the data in table 12 do not support the hypothesis that the process of erosion control will automatically result in large increases in farm returns. Rather, practices like terraces and contouring make it possible to raise greater acreages of grain with greater feed production than would otherwise be possible. The relative profitability of soil management systems controlling erosion will depend on other features of the farming systems associated with erosion control, including the types of livestock used to consume the feed. Livestock provide a means of converting low-value forage into a product of higher value per pound. They also furnish for smaller farms a means of enlarging the farm business and more efficiently utilizing available resources than might be true under a cash crop system.

Size of farm as an alternative organizational adjustment in northeast Nebraska cannot be overlooked. Instead of investing heavily in an intensive soil management system like RTC or RTCF, operators of 160-acre farms might advantageously secure control of additional acreage, and farm less intensively. The soils of lower productivity might be left under grass cover continuously, as in soil management system R. A type of cash grain farming might be done on level land; an extensive livestock system could utilize the forage raised on the hilly land.

Systems of Feed Utilization

Analyses were made of nine alternative systems of feed utilization in conjunction with soil management systems R and RTCF. No analysis was made of feed utilization under soil management system RTC. These livestock systems represent several levels of forage utilization, as well as varying considerably in their requirements for capital, labor, and management. A brief description of each follows:

Dairy cow system. Cows of medium level (320-pound) butterfat production were assumed; approximately 75 per cent of their total ration is composed of hay and pasture. The input-output relationships upon which this system is based are adapted from data reported by Heady and Olson.[23]

Beef cow system. In the beef cow system used in this analysis, the calves are born in February or March; good grade 400-pound feeder calves are marketed off grass in October. This system represents a comparatively high level of forage utilization, since approximately 93 per cent of the over-all ration is forage.[24]

Calf feeding systems. Three different calf feeding systems were analyzed; they represent three levels of forage utilization. In each case good grade 400-pound feeder calves are purchased in October and wintered on roughage plus 4 pounds of grain and supplement per day until May 1. Under system (1) the calves are then placed in dry lot and full fed until about October 30, when they are marketed

---

[23] Earl O. Heady and Russell O. Olson, "Marginal Rates of Substitution and Uncertainty in the Utilization of Feed Resources with Particular Emphasis on Forage Crops," *Iowa State College Journal of Science*, 26 (1) :49-70. October, 1951.

[24] Based on F. B. Morrison, *Feeds and Feeding*, 20th edition (Ithaca, N. Y., The Morrison Publishing Co., 1936) , pp. 700-4.

as choice grade 1075-pound cattle.[25] The proportion of feed units (besides supplement) fed in the form of forage is 30 per cent.[26] In system (2) the calves are pastured without grain for 56 days, full fed on pasture, finished in dry lot for six weeks, and sold as 1000-pound choice grade cattle late in October. Of the total feed fed about 54 per cent is roughage.[27] Under system (3) the calves are pastured until July 31; they are then placed in dry lot and full fed until December 15, being sold as choice grade cattle weighing 1025 pounds. Calves under this system consume 59 per cent of their ration in the form of roughage.[28]

Yearling feeding systems.[29] Three feeding systems based on yearling feeder steers were analyzed. They represent three levels of forage utilization corresponding to the calf systems. In each system 600-pound good grade steers are purchased about October 1; they are wintered on alfalfa-brome hay plus 1 pound of grain until May 1. In system (1) the steers are then placed in dry lot and full fed until October 1, and marketed as choice grade cattle weighing 1100 pounds. In system (2) they are placed on pasture without grain for 56 days, then full fed on pasture until November 1. They are then finished in dry lot for two weeks and marketed as 1150-pound choice grade cattle. Steers in system (3) are pastured from May 1 until September 5, full fed in dry lot until December 15, and sold as 1200-pound choice cattle. The proportions of the rations composed of forage for the three systems are 42, 60, and 67 per cent, respectively.

Two-year feeding system. Good grade 385-pound calves are purchased about December 15 and wintered on forage plus 1 pound of supplement per day; they are then pastured for 196 days, followed by a second wintering period on the same feed as above. They are pastured during the second summer for 56 days until July 21, finished in

---

[25] The slaughter grade "choice" used in this discussion is one of the revised Federal grades which came into effect on December 30, 1950. It is used to designate slaughter cattle formerly graded as "good." There was no similar revision of feeder cattle grades. Thus the marketing of choice fat cattle which are derived from good feeders represents no actual increase in grade in terms of the grading system used during and prior to 1950.

[26] This system is adapted from: Morrison, *op. cit.*, pp. 1005-6; and Johnny Matsushima, Animal Husbandry Department, Univ. of Nebr., oral communication, February, 1952.

[27] See R. H. Wilson and others, *Costs and Methods of Fattening Beef Cattle in the Cornbelt, 1919-23.* U. S. Dept. Agr. Tech. Bul. No. 23, 1927.

[28] Based on E. C. Conard, T. W. Dowe, and V. H. Arthaud, *Grazing and Management of Bromegrass-Alfalfa and Fertilized and Unfertilized Bromegrass Pasture.* Nebr. Agr. Exp. Sta. Cattle Progress Report No. 203, 1950.

[29] The three yearling systems are adapted from: Iowa Agr. Exp. Sta., *A Study of Three Methods of Utilizing Pastures and Grain in Production on Marshall Silt Loam in Southwestern Iowa.* Sup. Proj. Report, FSR-38S, June, 1951.

dry lot for 67 days, and sold as 1225-pound choice grade cattle. This system has the highest proportion of roughage in the aggregate ration of any of the feeding systems, 71 per cent.[30]

Application to sample farms. Certain assumptions were made in applying the alternative livestock systems to the sample farms. In the first place, no attention was given to personal preferences of the operators of sample farms. The objective of the analysis was to provide farm operators with information on resource use and income results of alternative systems on which to base their decisions.

Each livestock system was analyzed as the major system on the farms. Each farm was allowed a milk cow and necessary replacement stock to provide milk for the family. In addition the existing poultry enterprises on the farms in 1950 were left unchanged.

A sufficient number of head for each of the alternative livestock systems was kept to utilize the available forage according to the requirements outlined in appendix D. In addition, farm-produced grain was allocated to the forage-consuming livestock as required. Any grain remaining after the requirements of these livestock had been met was assumed to be fed to hogs. If an insufficient amount of grain would be raised for a particular livestock system, no hogs would be kept and the necessary aditional grain would be purchased. No forage was included in the hog ration. Thus the sample farms were provided with both grain-consuming and forage-consuming livestock, with hogs supplementing cattle in the utilization of existing labor, buildings, and feed.

Livestock numbers and investment. The numbers of alternative types of livestock (above basic livestock) that would be needed to utilize the feed produced under the alternative soil management systems are shown in table 13.

A larger number of cattle would be kept under soil management system R than under system RTCF, to use up the greater quantity of forage. In addition, large quantities of purchased grain would be needed for the calf and yearling steer feeding programs under soil management system R. Insufficient grain would be produced on most of the farms for the cattle. Under soil management system RTCF the farms would raise combinations of forage and grain more nearly corresponding to the combinations consumed by livestock; there would be little movement of grain onto the farms except under calf system (1).

The average number of livestock needed to utilize farm-raised feed, and the resulting livestock investment, are somewhat smaller than would be the case if all of the farms had been owner-operated. This is

[30] Based on M. L. Baker, unpublished data, Nebr. Agr. Exp. Sta., February, 1952.

TABLE 13.—Number of livestock needed to utilize feed under alternative systems of soil management and feed utilization.[1]

Feed utilization system	High-forage farms Soil management system				Low-forage farms Soil management system			
	R		RTCF		R		RTCF	
	Cattle	Hogs[2]	Cattle	Hogs	Cattle	Hogs	Cattle	Hogs
		(Number)				*(Number)*		
1. Dairy cattle[3]	17.5	.3	12.4	120.7	16.9	6.3	10.6	130.3
2. Beef cattle[3]	25.1	17.3	16.8	150.9	22.9	27.1	13.7	148.3
3. Beef calves								
a) Wintered, dry lot	67.8	——	48.1	18.0	65.1	——	39.6	23.9
b) Wintered, fed on pasture, dry lot	40.1	——	31.4	81.1	43.1	1.5	25.8	89.9
c) Wintered, pastured, dry lot	40.5	——	28.8	94.5	39.1	2.6	23.7	101.9
4. Yearling steers								
a) Wintered, dry lot	59.3	——	42.1	43.5	57.0	——	34.6	40.5
b) Wintered, fed on pasture, dry lot	41.9	——	22.2	98.4	41.3	3.3	18.3	104.9
c) Wintered, pastured, dry lot	29.1	——	20.6	113.7	28.0	4.6	16.9	117.8
5. Two-year program	48.4	8.6	34.4	140.5	46.4	17.9	28.4	139.8

[1] Numbers of basic livestock not included.
[2] Hog numbers do not include sows; one sow assumed per six pigs.
[3] Numbers of dairy and beef cattle do not include bull.

especially true of the low-forage group which included more tenant farms. The landlord's share of the crop production was credited as a cash sale in figuring income.

The additional investment in livestock needed under alternative soil management and feed utilization systems is indicated in table 14. The smaller additional investment on the low-forage farms is partly explained by the larger present livestock investment on low-forage farms. However, because of their present larger investment in hogs, the low-forage farms would experience more of a shift in the type of livestock which would be kept. The high-forage farms are already organized for a greater utilization of forage.

The averages in table 14 do not reveal the range in the adjustments among sample farms. For example, the change in livestock investment with the adoption of the dairy cow system under soil management system RTCF actually would vary from an increase of $3902 to a decrease of $4528 over the range of the sample. For calf system (1) the range would be from an increase of $5825 to a decrease of $3837. The ranges among the other systems are correspondingly great.

These investment data represent the most complete adjustment possible in the alternative feed use systems. The associated organizational changes, if made completely, would probably require a period of several years for accomplishment. Indeed, in the face of variability of crop yields and production it is questionable that farmers would ever go "all the way" in providing for the complete utilization of feed through livestock. Many farmers might instead keep enough livestock to use up the minimum quantity of feed which they consider likely in most years. This quantity might be somewhat below the average production for the long run.

The differences in capital requirements are of importance to the farmer who has limited capital at his command. He may choose a livestock system with a high capacity for forage utilization, such as calf feeding systems (2) or (3) or the comparable steer systems. He can then apply any remaining capital to other productive uses. Further, under soil management system R the amount of purchased grain needed to finish the cattle under the two high-forage calf and yearling steer systems is much less than that under the high grain feeding systems.

An important advantage of all the feeding systems studied is their flexibility. The methods of feeding can be easily adjusted by operators in the event of changes in the prices of cattle or purchased grain, or changes in the farm supply of feed. The wintering period can be shortened and the stock put into dry lot earlier than May 1 under

TABLE 14.—Increase in livestock investment under alternative systems of soil management and feed utilization (two price levels).[1]

Feed utilization system	High-forage farms Soil management system				Low-forage farms Soil management system			
	R		RTCF		R		RTCF	
	1939-44	1950	1939-44	1950	1939-44	1950	1939-44	1950
				(Dollars)				
Dairy cows	360	1402	534	1364	111	674	187	379
Beef cows	440	1372	689	1532	268	785	316	500
Beef calves								
a) Wintered, dry lot	2106	6608	1249	4132	1819	5730	714	2520
b) Wintered, fed on pasture, dry lot	959	3421	754	2441	754	2766	362	1232
c) Wintered, pastured, dry lot	785	2939	696	2212	554	2217	323	1059
Yearling steers								
a) Wintered, dry lot	2759	7845	1840	5238	2447	6919	1161	3361
b) Wintered, fed on pasture, dry lot	938	3053	794	2249	755	2453	401	1084
c) Wintered, pastured, dry lot	748	2552	769	2117	536	1871	381	1080
Two-year program	1176	3531	1178	3451	964	3456	757	2185

[1] Value under each system includes basic livestock, sows, and value of breeding cows or cost of feeder calves. Change in livestock investment computed by subtracting the beginning inventory on sample farms, adjusted to the average value of 1950, less the inventory of market hogs, from the investment in each alternative system of feed utilization.

system (1). The number of cattle can be reduced by sale in the spring in the face of decreased prospective summer feed supplies; or the enterprise can be quickly expanded at any time by the purchase of additional feeders. The high-forage systems furnish additional flexibility (postponement of decision) in that the commitment of stock to full feeding is deferred over two or three months in the early summer. The stock can be continued on a roughage ration through the rest of the summer and fall if changing conditions make such a course desirable. The postponement of the final dry lot period would be especially convenient in the high-forage calf system since the stock can easily be kept on roughage into the second summer, if necessary.

The rate of capital turnover is important in comparisons of dairy or beef cow systems with the feeding systems. Although the total capital requirements would be less, this advantage is nullified to some extent by the relatively slower turnover of capital. High turnover is of advantage especially where risk reduction is an important consideration to the operator.

The degree of diversification of livestock enterprises also affects the amount of risk. The systems under soil management system R are more specialized in that hog numbers are small. Under system RTCF hogs represent a larger part of the total livestock investment. Under changing price relationships the greater diversification under RTCF would be advantageous as long as hog prices do not follow the same trend as the prices of forage-consuming livestock and their products.

The additional investment in livestock under each of the alternative systems is also shown for the period 1939-44.

Investment in livestock housing. The alternative farming systems would require additional investments in livestock housing, as indicated in table 15. It is probable that these figures could be decreased on some farms. With cheaper construction labor than the skilled labor assumed in this analysis, construction costs could be decreased; further decrease in cash costs could be made if farmers erected needed housing themselves, in which case the cost of labor would be essentially an opportunity cost, but not a cash investment of capital. Labor accounts for about 35 per cent of the housing costs.

The housing requirements for alternative livestock systems in table 15 are as realistic as possible. The existing space available on each farm was first allocated to the fullest practical extent. Different types of livestock were "juggled" between various buildings insofar as possible. The costs of additional space that would be needed were based on simple, economical building plans designed as minimum housing requirements necessary for each type of livestock.

TABLE 15.—Total increase in livestock housing under alternative systems of soil management and feed utilization, two price levels.

Feed utilization system	Soil management system			
	R		RTCF	
	1950	1939-44	1950	1939-44
	(*Dollars*)			
Dairy cows	2114	1163	1954	1075
Beef cows	197	108	978	538
Beef calves				
a) Wintered, dry lot	523	288	200	110
b) Wintered, fed on pasture, dry lot	82	45	376	207
c) Wintered, pasture, dry lot	44	24	403	222
Yearling steers				
a) Wintered, dry lot	458	251	452	248
b) Wintered, fed on pasture, dry lot	80	44	445	244
c) Wintered, pasture, dry lot	15	9	541	298
Two-year program	9	5	1080	594

Feeder cattle and purchased grain. The capital expenditures necessary for the purchase of feeder cattle and grain under the alternative systems are shown for two price levels in table 16.

Labor requirements. The total hired labor required with the alternative farming systems is given in table 17. These data were estimated by deducting the present labor available on the farms, by months, from the monthly labor requirements for crop and livestock enterprises. Actually, only a small amount of hired labor was used in the sample farms in 1950. Most of the hired labor would be needed during June, July, and August except in the dairy system; here the requirements are distributed more uniformly over the year.

Income and expenses. The expected changes in income and expenses under alternative soil management and feed utilization systems, assuming price conditions of 1950 and 1939-44, are shown in table 18.

No charge was made for additional available family labor which would be used under alternative systems although the cost of additional hired labor has been deducted. The net income figures represent returns to the operator's labor and management, the labor of his family, and to the capital resources at his disposal in 1950, irrespective of ownership. The volumes of business include the value of livestock or livestock products sold, plus market value of the landlord's share of the crops on crop-share rented farms, less the cost of grain and livestock purchased and death loss.

Table 16.—Feeder cattle and grain purchased annually under alternative soil management and feed utilization, 1950 and 1939-44 prices.

Livestock system	Soil management system							
	R				RTCF			
	1950 prices		1939-44 prices		1950 prices		1939-44 prices	
	Feeder cattle	Grain	Feeder cattle	Grain	Feeder cattle	Grain	Feeder cattle	Grain
	(Dollars)							
Dairy cows	....	517	....	289	....	....	....	....
Beef cows	....	32	....	18	....	....	....	....
Beef calves								
a) Wintered, dry lot	8960	5435	3253	3044	5894	982	2139	550
b) Wintered, fed on pasture, dry lot	5884	1780	2136	997	3852	12	1398	7
c) Wintered, pastured, dry lot	5366	1333	1948	746	3530	....	1284	....
Yearling steers								
a) Wintered, dry lot	10,191	3310	3832	1854	6698	157	2518	90
b) Wintered, fed on pasture, dry lot	5536	1248	2082	699	3529	....	1328	....
c) Wintered, pastured, dry lot	4988	757	1876	424	3282	....	1233	....
Two-year system	3243	252	1122	141	2137	72	740	64

TABLE 17.—Total hired labor per year necessary under alternative systems of soil management and feed utilization.

Feed utilization system	High-forage farms		Low-forage farms	
	Soil management system			
	R	RTCF	R	RTCF
		(*Days*)[1]		
Dairy cows	60	71	42	39
Beef cows	19	25	12	9
Beef calves				
a) Wintered, dry lot	45	27	27	14
b) Wintered, fed on pasture, dry lot	32	21	18	9
c) Wintered, pastured, dry lot	21	16	11	6
Yearling steers				
a) Wintered, dry lot	52	37	37	14
b) Wintered, fed on pasture, dry lot	27	20	17	9
c) Wintered, pastured, dry lot	16	17	9	12
Two-year system	28	26	15	11

[1] Based on 10 hours per day.

Not reflected adequately in tabular presentation are the actual degrees of the changes in income and expenses among the sample farms over the entire range of forage index with the adoption of the alternative systems. Actually the change in net income associated with forage index would logically take the form of a negatively sloped regression line over most of the range of forage index, perhaps sloping positively at the higher end of the scale. Scatter diagrams of the changes in income from alternative systems plotted against forage rating did indicate this type of relationship. However, the wide dispersion of the data caused these relationships to be statistically nonsignificant within any acceptable degree of probability.

Further limitations of the data in the tables can be noted. The input-output relationships underlying the livestock alternatives were derived primarily from experimental data and are likely to represent comparable techniques. However, these techniques may not be entirely on a level comparable with the management efficiency found on the sample farms. Part of any increase in income may thus be due to a higher level of management efficiency introduced in the budgeting process rather than to the change in soil management system or livestock system per se. Accordingly the data should be looked upon as indicative of only the relative magnitude and direction of the changes resulting with the adoption of a specified system.

Income changes under alternative soil management systems. The financial disadvantage shown for soil management system R and the accompanying feed utilization systems, as compared with system

TABLE 18.—Changes in income and expenses under alternative soil management and feed utilization systems, 1950 and 1939-44 prices.*

Livestock system	High-forage farms					Low-forage farms				
	Volume of business	Operating expenses[1]	Fixed expenses	Net income		Volume of business[2]	Operating expenses[1]	Fixed expenses	Net income	
	(1950)	(1950)	(1950)	(1950)	(1939-44)	(1950)	(1950)	(1950)	(1950)	(1939-44)
				Soil management system R						
Dairy cows	(706)[3]	568	560	(1834)	(738)	348	452	540	(644)	(133)
Beef cows	(1367)	(6)	433	(1794)	(1379)	(519)	(18)	414	(915)	(845)
Beef calves										
a) Wintered, dry lot	3565	1421	750	1394	(698)	4357	1279	694	2384	(132)
b) Wintered, fed on pasture, dry lot	1166	61	526	579	(191)	2136	(13)	461	1688	396
c) Wintered, pastured, dry lot	2270	267	497	1506	(197)	3154	197	439	2518	369
Yearling steers										
a) Wintered, dry lot	1415	625	822	(32)	(627)	2320	489	748	1083	(32)
b) Wintered, fed on pasture, dry lot	(175)	84	503	(762)	(820)	848	44	442	362	(234)
c) Wintered, pastured, dry lot	(707)	10	471	(1188)	(982)	353	(24)	429	(52)	(377)
Two-year system	1470	571	563	336	(125)	2220	408	508	1304	276
				Soil management system RTCF						
Dairy cows	4272	1385	754	2133	1207	5201	1177	676	3348	1827
Beef cows	4739	1297	622	2820	1082	5285	1149	580	3556	1552
Beef calves										
a) Wintered, dry lot	5138	1562	770	2796	404	5266	1301	630	3335	886
b) Wintered, fed on pasture, dry lot	4768	933	677	3158	1281	5306	801	575	3930	1754
c) Wintered, pastured, dry lot	5718	1160	665	3893	1265	6190	1058	566	4566	1753
Yearling steers										
a) Wintered, dry lot	4175	1135	862	2178	628	4179	879	693	2607	948
b) Wintered, fed on pasture, dry lot	4117	1043	669	2405	870	4777	958	572	3247	1384
c) Wintered, pastured, dry lot	4981	1129	670	3182	1213	5494	1028	593	3873	1663
Two-year system	5778	1563	798	3417	1463	6270	1367	707	4195	1918

[1] Includes depreciation on machinery; however, since no machinery changes were analyzed, the increases in operating expenses shown are actually increases in cash operating expenses, including fertilizer purchases, but not including feed purchases.

[2] Includes depreciation, upkeep, and taxes on additional buildings and conservation installations, plus an interest charge on all additional investments.

[3] Figures in parentheses indicate a decrease; other figures are increases.

* All figures in dollars.

RTCF, is due largely to the smaller production of feed and consequently smaller volumes of business.

Reflected in the livestock systems under R are various quantities of purchased grain. An alternative to the purchase of grain could be a change of the assumed livestock rations to include a higher proportion of forage. With such an adjustment it is likely that incomes under soil management systems R would be even less because of the decrease in physical efficiency in feeding, as well as decreased volumes of business from smaller total quantities of feed processed through livestock.

Income and expenses under alternative livestock systems. The data shown in table 18 should not be interpreted as conclusive evidence for or against specific livestock alternatives. In the first place, the two price periods examined represent only two static periods of the past, and are not necessarily indicative of future conditions. Part of the differences between livestock systems are due to the relationships of the prices of hogs and dairy products to those for beef cattle, and between product prices and costs. Second, the personal preferences and skills of individual operators have not been analyzed. These systems vary in the degree of management skill required, and in the degree of risks which must be carried by farmers. Third, relaxing some of the assumptions might have changed the results. For example, selling the surplus grain for cash instead of feeding it through hogs might change the income comparisons between feeding systems. These systems as presented reflect the relative efficiency of hogs and beef cattle in converting grain to meat, as well as the relative prices of the two. The omission of purchased grain would also change these comparisons. For example, keeping only a sufficient number of calves under calf system (1), soil management system R, to utilize the farm-raised grain, and selling the surplus hay for cash would reduce net returns under 1950 prices. Finally, seasonal price differences affected the income comparisons between the various feeding systems.

Impediments To Adoption of Alternative Systems

It must be recognized that adjustments in soil management and feed utilization systems in the study area would be conditioned by factors other than knowledge about their relative profitability. The farmers of the study sample were questioned concerning organizational problems with which they were confronted, as well as possible impediments to their solution. The resulting information is not conclusive, but relates to the feasibility of recommendations resulting from this study. It also suggests other areas of possible investigation.

Organization Problems and Possible Solutions

The suggested organizational problems contributing to low farm incomes in the area were, in order of number of responses: (1) erosion and lack of conservation measures to prevent it (suggested by 35 out of the group of 53); (2) low level of fertility of the land; (3) ditches which impede field operations; and (4) short leasing tenure, especially one-year leases. Other problems mentioned were the weather hazards of drouth, flood, hail, lack of capital, difficulty of weed control, poor roads, and poor farming techniques.

The farmers were then questioned regarding the measures which might be undertaken by them to increase their incomes. They suggested numerous measures, including (1) terracing (23 responses); (2) contour farming (indicated by 21 farmers); (3) raising more livestock; (4) more grass in rotation, especially legumes; (5) farm dams; and (6) the use of more fertilizer. Other solutions mentioned were seeding hilltops down to grass permanently, less corn on steep land, and increasing the size of farms. One individual suggested that farmers ought to work harder. Several had no suggestions to offer. It is evident that the farmers of the area had formulated a number of tentative organizational solutions to the problems which they recognized. The reasons which they gave for not having adopted the measures they suggested are of interest.

Obstacles to Adjustment

Lack of capital was suggested by several farmers as the most important impediment facing them. Operators of high-forage farms in the budgeted sample owed an average of $535 on their land and buildings, and $879 of shorter term debts. Low-forage farms had $2298 of long term debts and $493 of other debts outstanding (not included in these estimates were a few operators who chose not to reveal their debt status). It appears that the low-forage farmers would be less able to secure the additional capital with which to adjust their organizations than the high-forage group which already had more profitable organizations.

In shifting to soil management and feed utilization systems conducive to erosion control it would be possible to hold some capital outlays at a lower level than that of the preceding analysis. Terracing may be done gradually, and on the steeper Moody slopes first. The addition of hay storage facilities may be postponed, or omitted, with some attendant loss of feed. Less avoidable would be outlays for livestock and livestock housing necessitated by an increase in hay and pasture acreage. Unfortunately, the nature of credit laws and practices may restrict the procurement of the intermediate credit which is needed to finance livestock operations, especially feeding enterprises. True, some banks successfully finance farmers' livestock operations by renewable short term loans. The lending of intermediate credit for the purchase of livestock, purchase or repair of machinery, or light buildings probably calls for more loan supervision than short-term or long-term credit. But the disinclination or inability of credit institutions to lend intermediate credit may be a serious barrier to adjustments of this type.

For renters, the lack of real estate equity as security is the source of a second form of capital rationing. Because of the lack of capital the common practice of selling part of the home-raised grain for cash may be a quite necessary procedure to furnish cash for current operations, and for family expenditures.

Leasing arrangements and landlord-tenant relations were also mentioned as an important obstacle to organizational adjustments. On one of the farms the landlord would not permit the adoption of any conservation measures. In two other instances the landlords were simply not interested. Several farmers indicated that landlords under crop-share leases want to keep large acreages in corn and oats production, rather than raise more hay and pasture. In other cases landlords had no objection to the adoption of conservation practices but would not finance the purchase of needed materials. It is probably the nature of traditional leasing practices rather than lack of rationality on the part of either tenants or landlords which impedes adjustments encouraging production efficiency. For example, under some cash rental arrangements the time preference of the tenant may be relatively short; he may recognize the possibility of greater eventual income through a crop combination which would produce more feed, but he feels it necessary to emphasize grain production because his prospective tenure may be quite short. To him, cash grain farming may be less risky. Likewise, a crop-share landlord may be entirely rational in hesitating to finance erosion control practices from which he will derive only part of the increased return. His tenant may hesitate to share even in the cost of applying phosphate to alfalfa because he may move before he receives any appreciable return. There is serious need for improvement in leasing arrangements and practices. The necessity of educational work with landlords as well as with tenants is to be emphasized.

Lack of knowledge concerning techniques of erosion control as well as its effects was recognized by some farmers. Several individuals were not sure that terracing and contouring were "good" or profitable. In fact one person suggested that these practices might encourage erosion, that erosion was more noticeable on land which had been contoured and terraced. Some farmers said they didn't know enough about conservation methods. Two farmers expressed reluctance to make changes as long as their neighbors did not. Of the entire group 19 farmers indicated that they were making some changes while 9 did not respond when asked why no changes had been made.

These farmer reactions emphasize that the problems of crop and livestock organization are actually co-existent with other problems on the sample farms. The nature of these problems, particularly those relating to credit and tenure arrangements, would impede some of the adjustments pointed to in this study.

APPENDIX A

Economic Hypotheses

An analysis of the problems of crop production and utilization may be made in two stages. The first relates to crop combinations, and the second to the utilization of the resulting feed through livestock. Analysis can first be made of crop enterprise combinations apart from livestock production; this is not unrealistic since farmers can sell their crops for cash if they choose. By assuming temporarily that they do, crop products can be considered as the end products in the first stage of the analysis.

Optimum Crop Combinations

An economic model useful in analyzing the profitability of alternative crop combinations is the isoresource curve.[1] An isoresource curve indicates all combinations of two products, such as forage and grain, which a farmer can produce with a given outlay of resources. The curve in figure 8 represents the quantities of forage and grain which could be produced annually on 100 acres of a certain soil type, plus a given stock of other resources. In hypothesizing a relationship such as this, sufficient time must be assumed to allow most of the rotation effects of forage and grain to have taken place. The range of the curve to the left of point X, which represents maximum grain production, is called the complementary range; if the forage output is increased from zero by devoting increasing quantities of land and other resources to forage production, the output of grain may also increase for a time. This may occur for several reasons, the most important of which is probably the addition of nitrogen to the soil by legumes, especially when large quantities of residue are plowed under.

The range of the curve to the right of point X is the competitive range between forage and grain; here increases in forage production are achieved only at the expense of certain quantities of grain. The percentage increase in grain yields per acre (due to the beneficial effects of legumes) is less than the percentage decrease in grain acreage with a shift to more forage.

Lines AB, CD, and EF are price lines; their slopes represent the ratio between the price per pound of forage and the price per pound of grain. Assuming that returns are to be maximized, the most profitable combination of forage and grain is indicated by the point

---

[1] For a more detailed discussion of crop rotation economics see: (1) Earl O. Heady, "The Economics of Rotations with Farm and Production Policy Applications," *Journal of Farm Economics*, 30:645-664, 1948. (2) Earl O. Heady and Harold R. Jensen, *The Economics of Crop Rotations and Land Use*. Iowa Agr. Exp. Sta. Res. Bul. 383, 1951.

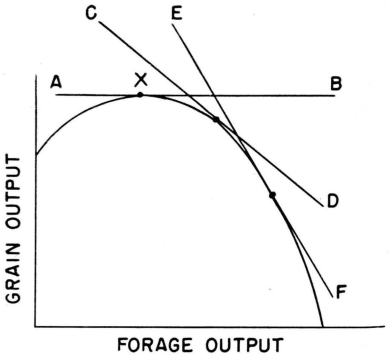

FIGURE 8.—High-return combinations of grain and forage under different price relationships.

where a given price line is tangent to the isoresource curve. Since a price line represents all combinations of two products which will bring a certain gross income, the higher the price line, the greater the total revenue it represents. The point of tangency between a given price line and the isoresource curve represents the combination of the two products which will give the highest return under the specified price conditions. At this point the marginal rate of substitution of forage for grain in production is equal to the inverse ratio of their prices. In figure 8 the three price lines represent three possible price relationships between forage and grain.

Grain-Forage Combinations with Erosion Control Practices

The effects of erosion and the need for practices for its control affect the relationship between forage and grain crop rotations. Erosion control practices such as contouring and terraces have been defined as "resource inputs (labor and capital) which are technical complements between time periods with resources which are transformed into products within single time periods."[2] For example, a given input of labor, fertilizer, seed, and other costs might result in 50 bushels of corn per acre on a given soil type in northeastern Nebraska in an early time period t_0. Due to erosion the product of the same resources might fall to 40 bushels in a later period t_n. However, the use of an additional input CT with the above resources might result in a yield of 50 bushels in period t_n, because it controls erosion.

The relationship of erosion control practices to crop combinations can be illustrated by the use of isoresource curves. In figure 9 the curve R_3L_1 represents the average total outputs of forage and grain in time period t_0 on erosive land. It indicates the combinations of forage and grain possible shortly after the virgin cover is broken, before much erosion has occurred.

[2] Earl O. Heady, "Efficiency in Public Soil Conservation Programs," *Journal of Political Economy*, 59:47-80, 1951.

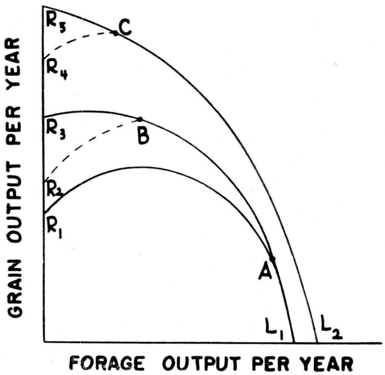

FIGURE 9.—The effect of soil erosion control practices on the production relationships between grain and forage.

The curve R_1L_1 represents the combination of grain and forage that could be produced with the same resources as in the case of R_3L_1, but in time period t_n after erosion has taken place. Crop yields and production have been decreased because of the loss of topsoil as well as reduction in tillable areas through ditches; the severity of erosion varies with different crop combinations along the curve R_1L_1. With a higher proportion of forage acres, the annual soil loss is decreased; the point A indicates the maximum amount of grain which can be produced if the annual soil loss is to be held within a maximum limit which might be specified by society (or individuals). This limit might be the annual soil loss allowable without affecting crop production appreciably between various time periods.

Curve R_2L_1 represents the combination of forage and grain which could be grown in the time period t_n with the same resources that are used in R_1L_1, except for an additional investment in contouring and terraces. With the use of these practices the soil loss is diminished; on some soils or slopes crop combinations consisting of grain only could be raised without resulting in soil losses in excess of an allowable limit. In figure 9 the point B represents the least forage which could be grown without causing excessive soil losses. To the left of B excessive soil loss might still occur, causing the long-run combinations in the sector to be actually represented by the segment R_2B.

The curve R_5L_2 may be the fairly short-run situation when nitrogen and phosphate fertilizers are added to the other resources used in connection with R_3L; forage and grain are competitive over the whole range of possible combinations. However, erosion control within acceptable limits occurs only to the right of C. In the range to the left of C, soil loss in the long run might cause the production curve to fall to R_4C, giving a short complementary range. On many soils no complementary range may be present.

The Utilization of Crops through Livestock

In northeastern Nebraska a large part of the grain and nearly all of the hay are fed to livestock on the farms *where they are produced.*

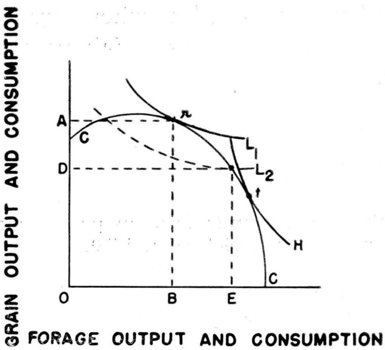

FIGURE 10.—Optimum output combinations of grain and forage for producing two kinds of livestock products.

Accordingly, in any analysis of rotations attention must be given to the production relationships in livestock production, as well as those of the cropping system.

Curve H in figure 10 is an isoproduct curve for a given type of livestock; it represents all combinations of two feeds (in this case forage and grain) which will produce a given quantity of livestock product, as for example, 100 pounds of good grade beef. Likewise, curve L_1 is an isoproduct curve for another type of livestock, say, pork. The higher these curves from the horizontal axis, the larger the quantities of livestock product they represent. The shape of these curves indicates feed substitution at a diminishing marginal rate.

The points r and t indicate situations in which the physical output of two kinds of livestock product from a given quantity of land and other resources would be maximized. At each of these points the marginal rate of substitution of forage for grain in production (represented by the slope of the isoresource curve) is equal to the marginal rate of substitution of the two feeds in producing a given livestock product. The production of any other combination of forage and grain, as for example, OE and OD respectively, and its utilization through livestock would result in a smaller livestock output, indicated by the lower level of curve L_2.

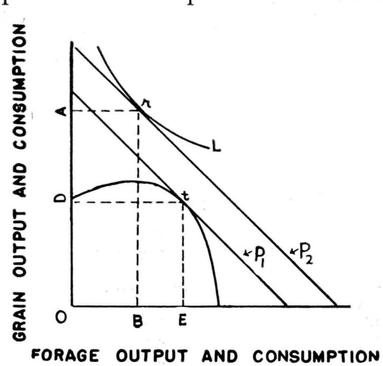

FIGURE 11.—High return combinations of grain and forage for farmer choosing between raising of livestock and selling crops for cash.

The high return adjustment for the farmer who chooses between the alternatives of feeding crop products to livestock and selling them for cash can be illustrated. One possibility is shown in figure 11. The high return crop combination under the price conditions represented by price line P_1 is OD of grain and OE of forage. However, for the type of livestock raised on this farm, the low cost ration is OA of grain and OB of forage. For maximum returns the farmer would sell BE of forage and buy DA of grain. This situation might arise on a farm on which the land is adapted to forage production, but where grain-consuming livestock, such as hogs, are raised because of high prices, personal preference, or other reasons.

APPENDIX B

Average acreages of various soil types and phases per sample farm in permanent and cultivated cropland, Dakota and Dixon Counties, Nebraska, 1950.

Soil type	Per cent slope	Degree of erosion	Acres per farm		
Moody silt loam and Moody silty clay loam	3-6	1	3.9		
	8-10	1	3.6		
	6-10	2	18.9		
	12-16	1,2	24.9		
	10-16	3	13.5		
	20-25	1,2,3	3.6	68.4	
Crofton silt loam	4-10	1,2,3	2.5		
	12-16	1	1.6		
	12-16	2,3	47.5		
	20-30	1	2.0		
	17-30	2,3	9.6	63.2	
Judson, Wabash, and Waukesha silt loams	1-6	1,2		18.2	
Burchard and Steinauer clay loams	6-16	2,3		.1	
Average cultivated and permanent cropland					149.9
Farmsteads, roads, fence rows and streams					10.1
Average acres in farms					160.0

APPENDIX C

Assumed rates of fertilizer application associated with soil management system RTCF.

Crop combination	Pounds of plant food per rotation cycle[1]	
	Nitrogen	Phosphate
CCO_s	60	40
CO_s	15	30
CO_sCOMM	20	90
COMM	10	60
COMMMM	10	90
M	0	22.5

[1] In addition to the rates shown some starter fertilizer might be necessary on corn when the rotations are established. These rates are associated with the crop production under soil management system RTCF. The same rates were used for all soils. They do not necessarily represent the most profitable level of application on a specific soil, or the most profitable allocation of fertilizer between soils.

APPENDIX D

Procedure Used in Selecting Crop Combinations for Budgeting Analysis

The main criteria used in selecting rotations for the budgeting analysis were (1) soil loss per acre and (2) grain/hay price relationships. The amount of feed produced by each rotation was also examined.

The soil loss per year was estimated for each rotation by the use of Browning's erosion factors.[1] These factors included (1) type of rotation, (2) soil type, (3) slope, (4) degree of erosion, (5) slope length, (6) soil fertility practices, and (7) supplemental soil practices. For budgeting, combinations which would give more than 7 tons of soil loss per acre annually were eliminated.

Net energy was used as a measure of the feed produced by each rotation. It is defined as "the amount of energy left after deducting from the metabolizable energy the energy lost in the so-called 'work of digestion' or 'heat increment'."[2] Net energy is expressed in therms, one therm being equivalent to 1000 calories.

The gross value of the crops produced by each combination was figured on the basis of 100 acres of land.

In the table on page 58 are illustrated the data which were computed for each soil as a basis for selection of crop combinations in budgeting.

---

[1] G. M. Browning, *et al.*, "A Method for Determining the Use and Limitations of Rotation and Conservation Practices in the Control of Soil Erosion in Iowa," *Journal of the American Society of Agronomy*, 39 (1):65-73, January, 1947.

[2] Morrison, *op. cit.*, pp. 49 and 995.

Grain and forage output, grain/forage substitution rates, feed production, soil loss and gross value of production on 14 per cent Moody silt loam, moderate erosion. All values are on the basis of 100 acres of cropland.

Rotations	Lbs. of corn	Lbs. of oats	Total lbs. of grain	Total lbs. of hay	Substitution rate—forage for grain (lbs.)	Total therms feed	Tons of soil loss annually per acre[1]	Gross value of production		
								1950 prices	1939-44 prices	1939-50 prices
					Rotations only					
CCO$_s$	134,406	31,997	166,403	....	....	127,216	79	3,736	2,122	3,075
CO$_s$	177,600	57,600	175,200	....	Complementary	130,522	59	3,953	2,259	3,235
CO$_s$COMM	83,992	40,529	124,521	119,988	.42:1	139,740	43	2,512	2,209	3,032
COMM	67,200	32,000	99,200	180,000	.42:1	154,450	35	3,246	2,182	2,930
COMMMM	44,809	22,404	67,213	240,012	.53:1	143,874	11	2,861	2,061	2,703
M	....	....	....	320,000	.84:1	125,120	3.9	1,792	1,600	1,952
					Rotations, terraces and contouring					
CCO$_s$	149,341	34,130	183,471	....	....	140,428	11	4,119	2,338	3,391
CO$_s$	128,800	60,800	189,600		Complementary	141,469	8.9	4.277	2,440	3,502
CO$_s$COMM	91,458	42,662	134,120	133,200	.42:1	151,251	6.5	5,477	2,394	3,289
COMM	72,800	33,600	106,400	200,000	.42:1	157,664	5.3	3,520	2,365	2,451
COMMMM	48,543	23,471	72,014	266,680	.51:1	157,951	1.7	3,118	2,264	2,957
M	....	....	....	360,000	.77:1	140,760	0.5	2,016	1,800	2,196
					Rotations, contouring and fertilizer					
CCO$_s$	179,209	46,929	226,138	....	....	172,391	8.3	5,080	2,888	4,179
CO$_s$	145,600	73,600	219,200	....	....	163,081	6.2	4,947	2,836	4,048
CO$_s$COMM	100,790	51,995	151,985	146,652	.45:1	170,392	4.6	5,270	2,703	3,716
COMM	78,400	38,400	116,800	220,000	.48:1	173,035	3.7	3,867	2,610	3,499
COMMMM	52,277	25,605	77,882	293,348	.53:1	172,720	1.2	3,400	3,474	3,228
M	....	....	....	400,000	.72:1	156,400	0.4	2,240	2,000	2,440

[1] Computed by use of Browning's erosion factors.

APPENDIX E

Livestock input-output data used for budgetary analysis.

Class of livestock	Feed per animal: Corn or corn equivalent (bu.)	Protein supplement (lbs.)	Hay and pasture (tons)	Feeding period (months)	Product
Dairy system					
Cow, replacement and veal	53.0	385	5.8	12	220 lb.-cull cow 321 lbs. butterfat 6,964 lbs. skim milk
Bull	17.0	200	2.0	12	105 lbs. veal
Beef cow system					
Cow and replacements	7.0	0	4.3	12	300 lb.-calf 170 lb.-cull cow
Bull	13.0	200	2.0	12	
Fattening calves					
1. Wintered, dry lot	73.7	410	1.5	13	676 lbs. gain
2. Wintered, fed on pasture, dry lot	45	0	2.4	12½	600 lbs. gain
3. Wintered, pasture, dry lot	40.0	150	2.6	14½	621 lbs. gain
Fattening yearlings					
1. Wintered, dry lot	55.0	148	1.8	12	492 lbs. gain
2. Wintered, fed on pasture, dry lot	49.0	39	3.3	13	543 lbs. gain
3. Wintered, pasture, dry lot	39.0	73	3.6	14½	585 lbs. gain
Two-year feeding program	18.5	400	4.6	23	849 lbs. gain
Hogs	18.1	100	0	6½	255 lb.-hog