3-1963

The Economics of Classifying Farmland between Alternative Uses

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Research Bulletin
208

March, 1963

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Economic Research Service
United States Department of Agriculture

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Issued March 1963, 3,000

ACKNOWLEDGMENT

This study was initiated by the Land and Water Economics Branch, Economic Research Service, U. S. Department of Agriculture and the Department of Agricultural Economics, Nebraska Agricultural Experiment Station, University of Nebraska. The study was also sponsored by the Land Classification Subcommittee of the Resource Economics Committee of the Great Plains Agricultural Council.

The author wishes to acknowledge the helpful suggestions, comments and assistance of the following persons: Harry Steele, Walter Chryst, James Anderson, Hugh Wooten, William Pendleton, and Howard Hill, Economic Research Service; John Muehlbeier, Secretary of the Great Plains Agricultural Council; Andrew Aandahl and Robert Eikleberry of the Soil Conservation Service, U. S. Department of Agriculture; Loyd Fischer and Howard Ottoson of the Nebraska Agricultural Experiment Station; Burl Back and Wilfred Pine, members of the Land Classification Subcommittee.

SUMMARY

At present some farm programs are aimed at reducing the acreage of land used for crop production. These programs have the objectives of reducing quantities of certain farm commodities and conserving land resources. By shifting land from the production of certain farm commodities to other commodities or to grass, total farm income may be raised and the costs of farm price support and storage programs reduced. In programs to shift land use a classification of land based on economic criteria would be useful. The primary concern of this study was with methods for identifying the economic margin between land uses; the emphasis is on identifying the crop-range margin in the Great Plains area.

The key to this land classification is the identification of soils on the break-even margin between alternative uses to which the land is suited. In this study the break-even margin between cultivated crops and range use was estimated for soils in Kimball County, Nebraska. The emphasis is on differences in soil productivity. The effect of locational differences on factor and product prices within the county were assumed to be negligible. Under present product prices and costs of production wheat was the tilled crop yielding the highest return.

The economic criterion used for determination of best land use for given soils was the highest return to land. Estimated total returns were divided among land and nonland resources for wheat and range cattle production.

Kimball County is located in the southwestern corner of the Nebraska panhandle. This county is part of the Great Plains area characterized by summer-fallow crop production. Wheat is the major crop. Range cattle production is also important. In Kimball County, 70 percent of the land is in cropland, 29 percent in rangeland and 1 percent in other uses. On the basis of the Land Capability Classification, 16 percent of the present cropland should not be tilled. However, on the same basis, 48 percent of the rangeland is suitable for cropping. Average size of farm in Kimball County in 1959 was 1,458 acres and the value of land and buildings was $54 an acre. In 1959, farmers drew the line between crop use and range use of land at soils yielding about 5.8 bushels of wheat per planted acre.

To compare wheat and range cattle returns average prices for 1955-1959 were used. Current costs were estimated. Costs vary between farms and between tracts within farms so a cost level 65 percent below average, as well as estimated average cost, was used in the comparisons. Forty-three soils were compared. The forty-three soils were classified by wheat yields into four classes.

At the highest cost level for both wheat and beef production, all soils compared returned more to land in wheat than beef production. With a low beef cost level, six soils in the lowest yield class were submarginal for wheat production. An average soil in the group yielding

6.3 to 8.4 bushels would become marginal for wheat production at a price of $1.72. At a low wheat cost and high beef cost the price of wheat would have to be reduced from $1.76 to $1.05 at the farm to make an average soil in the group yielding 6.3 to 8.4 bushels marginal as between wheat and grass. It is estimated that the group of soils with highest yields, 16.8 to 20.8 bushels, would become marginal at a price of about $0.54 for wheat.[1]

When the soil compared is being tilled the cost of regrassing is an obstacle to shifting to beef. In making decisions relative to land presently tilled, returns to beef use must cover not only the amortized cost of regrassing but also the returns to wheat use. Only actual costs of reseeding the land to grass and the opportunity cost of wheat returns were considered in estimating the effects of regrassing costs on land use decisions in this study. These two cost factors alone, however, were found to be relatively large barriers to shifting cultivated cropland to range. Reseeding may pay if a 20 year or longer planning horizon is assumed, the land yields a low return in wheat, the reseeding cost is reduced by subsidy, or costs of production for range cattle are relatively low.

Evaluation of the method of classification of land presented in this report should take into account that results were based on some simplifying assumptions. Success in applying the economic criterion of highest returns to land depends on the ability to reasonably separate the returns to the land and nonland inputs. Available data on costs of production for the two enterprises were not considered adequate for the best application of the criterion. Possible differences in risk and uncertainty between the enterprises were not considered adequately. There are undoubtedly limitations in yield data.

Classification of land based on economic criteria may be used for current problems other than determining best use of agricultural land. Some of these are:

1. Assessing the relative contribution of nonland resources between agriculture and other sectors of the economy.
2. Assessing the feasibility of altering existing institutions which affect land use in the Plains.
3. Aiding in setting real estate lending policies.
4. Aiding in setting assessments for equitable taxation of agricultural land.
5. Evaluating resource development projects.
6. Estimating sale or rental values of land in public purchase or lease programs.
7. Assisting in planning the organization and distribution of local governmental services.

In the implementation of land classifications, there will be areas

[1] Neither this price estimate nor the others given allow for land costs or land taxes. It is assumed that the land will be used for range cattle or wheat production.

of conflict between individuals and society. Socially desirable land uses may be uneconomical for the individual. Objectives of land use should be identified at both levels.

The Economics of Classifying Farmland Between Alternative Uses

With Special Reference to the Crop-Range Margin in Kimball County, Nebraska

Roger H. Willsie[2]

Reallocation of resources is a continuing process. Shifts in land use often are made in response to changes in prices and costs of alternative products and in response to governmental activities aimed at reducing or stimulating production of some product or service. Resources are reallocated as the margin of equal economic advantage between resource uses changes. Whether the land use decision is made by society or individuals it is based on an estimate of the relative advantage of possible alternative uses.

THE PROBLEM

Margins of land use occur between any two competing uses for land. Whether a given tract of land is supermarginal, marginal, or submarginal with respect to a use is determined by its physical characteristics, prices and costs of its products, location, tenure arrangement, temporal considerations, present use, and the cost of changing use. Examples are the rural-urban, rural-recreation, urban-recreation, and urban industrial-urban business margins. The problems of allocating uses and resources is essentially the same in each case—determination of the uses of the land and nonland resources that will give the highest return.

Projected land requirements indicate that over the next two decades about 11 percent less cropland will be needed in the U. S. (Table 1). Much of this land will be needed to meet growing demands for recreation, timber, urban uses and other nonagricultural uses.[3] Future cropland reductions will probably fall heavily on the Great Plains because its major crop, wheat, is in overabundant supply.

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[2] Agricultural Economist, Resource Development Economics Division, Economic Research Service, U. S. Department of Agriculture.

[3] In 1961 there were 25 million acres in the Feed Grain Program and 28.4 million acres in the Conservation Reserve Program. Both of these are temporary land diversion programs. *Land and Water Resources,* Washington, D. C. May 1962, page 57.

Table 1. Present and estimated required land uses in the U. S.[a]

Major use	Acreage in 1959	Projected net change by 1980
	——million acres——	
Cropland, including rotation pasture	458	–51
Grassland and range	633	+19
Forest land, except that primarily recreational	746	– 5
Primarily recreational or wildlife, including some forest land, urban, roads, military reservations, water supply reservoirs, etc.	157	+48
Miscellaneous nonagricultural and waste	277	–11
Total	2,271	0

[a] The data in this table are from the U. S. Dept. of Agr. booklet *Land and Water Resources, A Policy Guide,* Washington, D. C. May 1962, page 43.

In addition to the estimated need for less cropland to meet requirements for food and fiber, some 25 million acres of land now being used for cropland are considered unsuitable from a conservation standpoint. In 1958 there were 25.4 million acres of cropland in the U. S. which were classified in Land Capability Classes V through VIII.[4] The rate of physical deterioration of this land when used for the production of crops is considered too great under conservation criteria. The cost of crop production is also high on this land and much of it is undoubtedly submarginal for crop production. About 13.7 million acres of cropland in the 10 Great Plains states are in classes V through VIII.[5]

Land-use shifts from crops to grass in the Great Plains are difficult because (1) prices of wheat and beef have been characterized by large shifts resulting in land returning more profit to wheat for a series of years, then more profit to beef for a series of years, then higher wheat returns once more; (2) wheat production has been gaining relative to beef raising in labor-saving technologies; (3) the speed and low cost of shifting from grass to wheat has induced land users to break out permanent grass during periods favorable to wheat; and (4) the high cost of shifting from wheat to grass has favored continued wheat production even during periods favorable to beef raising.

An economic classification of farmland is needed so that farmers and the public can better assess the desired combination of resources applied to various grades of land and determine the most desirable use of land. By assessing the economic potential of lands of various grades and making this information available to farmers and govern-

[4] The land classes referred to are those of the Soil Conservation Service, U. S. Department of Agriculture. Source of the estimate of cropland in classes V through VIII is *Basic Statistics of the National Inventory of Soil and Water Conservation Needs* prepared by the Conservation Needs Inventory Committee of the U. S. Dept. of Agr. Statistical Bulletin 317, August 1962, Washington, D. C. page 18.

[5] Ibid, pages 112-138. States included are Colorado, Kansas, Montana, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas and Wyoming.

mental policymakers, rational shifts may be made in the use of resources. Farmers would have better information on which to make their production plans and thus could achieve higher net returns. Policy-makers could give weight in the formation of programs to shifting resources from uses with lower returns and could base resource-shifting programs on the economic productivity of land.

For example, in a program to shift land (and nonland) resources from a low value use, such as wheat on submarginal cropland, to a higher value use such as range, the poorest cropland should be shifted first for more efficient use of resources. Identification of these marginal or submarginal cropland areas could be made by an economic classification of the returns to resources.

A classification of agricultural land resources by economic criteria can be valuable for many purposes. In addition to its use in programs of land use adjustment, it can be used in valuation and assessment of agricultural land. A fundamental difficulty in classifying land resources for most economic use is the instability of the factors which must go into such a classification. Nonland resource costs and product prices change—over the long-run and from year to year—in response to changes in technology, techniques, tastes and desires of society, weather and other factors.

This report outlines the principles of efficient land use, presents a framework for a land classification system based on economic criteria, and applies this framework to soils in a county in the Central Great Plains.

ECONOMIC CRITERIA FOR EFFICIENT LAND USE AS APPLIED TO THE CROP-RANGE MARGIN

This report is concerned with efficient use of land. The question is: Given alternative yields, prices of products and factors and quantities of nonland factor inputs, what land use will result in the highest return to lands of differing physical characteristics? For simplicity only two land uses are considered—wheat and range cattle production. The costs of nonland factors are assumed to be the returns foregone from not using these resources in another alternative. The most efficient use of land is that use which results in the highest residual return to land.

Concept of Rent Applied to Choice Between Land Uses

Rent is the return to land which is required to keep it in its present use.[6] In general, assuming no locational effects, rent depends on quan-

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[6] This definition is similar to those used by Boulding, K. E., *Economic Analysis,* Third Ed., Harper and Bro., N. Y., 1955, pages 211-212, and Barlowe, Raleigh, *Land Resource Economics, the Political Economy of Rural and Urban Land Resource Use,* Prentice-Hall, Inc., Englewood Cliffs, N. J., 1958, pages 150-152.

tities of land available and differences in soil productivity. This theoretical criterion will be used to determine best land use. Taxes and maintenance costs are not considered; they are assumed to be equal among alternative uses for given land.

First, one use on one soil type is considered. Returns obtained from use of a particular soil for wheat production may be illustrated (Figure 1). The schedule of increases in total cost of producing additional bushels is **MC**, the schedule of average nonland cost per bushel of wheat produced is **AC**. For highest returns inputs would be added to the land until an output of **OE** bushels of wheat was obtained. At this point the additional cost of producing a bushel of wheat just equals the price of a bushel of wheat. If fewer or more inputs are added total profits are reduced. With a given land area the cost of nonland inputs would be **OBCE**, gross revenue **OADE**, and the return to land would be **ABCD**. This latter quantity is the residual return to land. Changes in returns to land will occur if the price of wheat changes or if the costs of nonland inputs change. Nonland costs could change because of changes in techniques or changes in prices of inputs. Rent to wheat use would arise for this land if the land returns in grass were less than **ABCD**. If the returns to land when used for grass were greater than **ABCD** a loss, in terms of opportunity cost, would be sustained by using the land for wheat. This loss would be the difference in land returns between the two uses.

If all land was of one kind, only one product was produced, and land was not limited in quantity all of the returns would go to nonland factors. Returns to land arise because of differences in productivity, alternative uses, and limited quantities of land. The alternative land uses, wheat and grass, may be used to illustrate returns to lands of differing productivity (Figure 2). Each kind of land is limited in quantity. On the horizontal axis is land productivity. Each point on this axis is a different grade of land and land increases in productivity

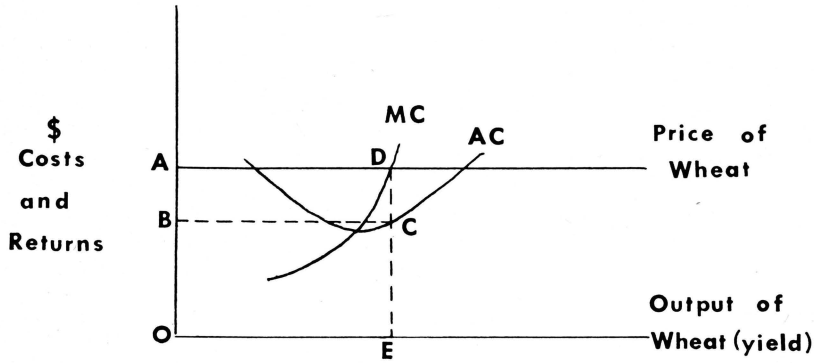

Figure 1. Hypothetical cost and returns schedules for wheat production for a given soil type and land area.

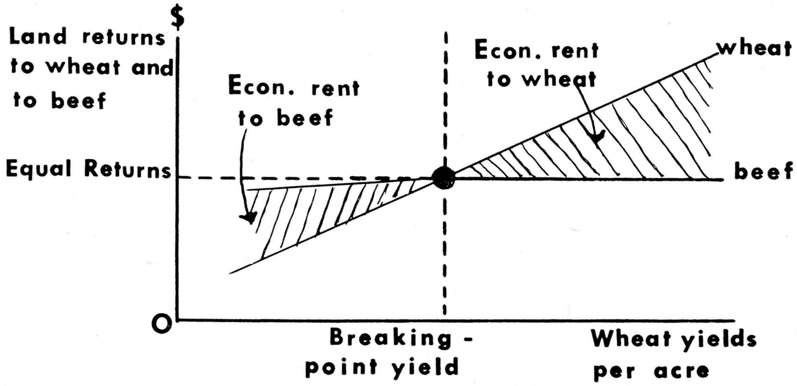

Figure 2. Relationship between land returns and land use by soil productivity.

from left to right. The breaking-point is the dividing line, or the wheat-grass margin, on the basis of returns to land under a given set of price and cost conditions. Returns to land of breaking-point yield will be the same if in wheat or grass. Alternatively, returns to more productive land will be greater if in wheat than if in grass.

The land returns in each case are the differences between revenues (prices times yields) and nonland costs of production (labor and capital). Assuming only the two uses, a different return, or rent to wheat use, arises only on soils of greater productivity than the breaking-point soil. Rent to beef use occurs on soils in the productivity range between **O** and the breaking-point soil.

Effects of Factors Other than Soil Productivity

Unfortunately, the problem of classifying land economically is not as simple as might be inferred from the model above. Soil productivity, although a major consideration, may not determine optimum land use. Cost structures vary between farms with the same kind of soil; costs for average farms do not accurately fit many farm situations. In addition, land use is affected by institutional arrangements on farms which result in income transfers between individuals involved or between an individual and future generations. Other considerations relevant in estimating returns to lands are:[7]

1. Size, shape and accessibility of tract. A high cost of production may be assessed against a tract of land of small size, irregular shape, or isolated position, and thus affect economic rent and optimum land use.

[7] Decisions on land use are often made on the basis of personal advantage or disadvantage. Thus, individuals may shift the cost of loss in soil productivity during their lifetimes to society; the tenure arrangement may bring about an income transfer in a particular land use; or knowledge and ability may determine use. In these instances, societal goals may be in conflict with the goals of the individual. But in 1), 4) and 7) incentives to the individual will also be in the interest of society.

2. Differences in knowledge, management ability and preferences of operator. An operator may not have knowledge of the relative advantage of alternative land uses. If he does have this knowledge, his choice of land use may be limited by his low management ability. Furthermore, an individual may have a decided preference for one enterprise over another. These considerations may affect the input-output relations and, therefore, economic rent.

3. Tenure arrangements. The parties to a lease of farmland contribute different types and quantities of resources to the production process. Typically, each party is more interested in the return to his resources. The arrangements under which costs and benefits are shared may make one use more profitable to one party and another use more profitable to the other. Also, the share of costs of a change in use may be higher to one party than to the other.

4. The present use. The cost of changing from one land use to another affects returns and, therefore, the decision on best land use. Cost of changing use for land near the economic break-even point may be too large to offset the difference in returns. In addition, the production relation for grass may be shifted due to the time required to regrass cultivated cropland.

5. Time incidence of costs and benefits. If some of the costs, such as soil erosion, associated with a certain land use, can be shifted beyond the planning horizon of the land user, the present returns to this use may be higher than those of alternative uses. Conversely, if some of the returns to an alternative use will not be realized within the planning period of the operator then this will not be an attractive use.

6. Time preference. Time preference is defined as a rate expressing the relative importance placed on present versus future incomes. If there is a strong preference for present income (a high time preference rate), land uses will be rejected which require the foregoing of present income even for a higher average income over a longer period of time.

7. Cost structures of farms and ranches. Differences in resource situations between farms give rise to differences in costs of production and differences in production response. The degree of employment of resources affects the values of resources and their costs. There are differences between farms in their adjustments of resources to a low-cost scale of operation. In addition, some resources are of a specialized nature and cannot be shifted between enterprises.

Each of the above conditions affecting production or cost could give rise to nonland cost differences and could result in differences in returns to land independent of soil productivity.

In summary, the variables used in this report to compute returns to land are yields and prices of products, and nonland costs. Yields alone are usually not adequate to determine best land use. Best use instead may be more dependent upon such factors as present use of land and cost structure of the farm. Prices of products may be considered constant for different soils if location with respect to markets does not differ. Classification of soils for a large area would require differential pricing because of differences in marketing costs. Nonland costs may vary within or between soils due to differences in levels of labor and capital costs. Steps required to classify land economically are:

1. Classify the land into homogeneous groups with respect to yields of products.
2. Estimate the quantities and costs of nonland inputs, taking into account relevant differences in costs.
3. Price the products.
4. Estimate the best use of land by the criterion of the highest return to land over nonland costs.

Recent Economic Research Related to the Crop-Range Margin

Any study of best land use or optimum farm organization deals with economic margins with respect to the use of resources. In effect, resources are placed in various combinations within and between uses and the returns are estimated. Conclusions are then made as to the highest return use of resources under the normative or average uses and organizations. An economic margin exists when resources receive the same return in more than one use.

Studies made in western Nebraska, Colorado, and Montana were of particular interest as sources of data and ideas on the nature of farming in the area and for methodology. In a study by Vlasin and Epp[8] of the farm returns from wheat and alternative cropping systems in Kimball County, the frame of reference was the farm unit. Detailed budget analysis was used to estimate the returns to different cropping systems for an average size farm in the county. Break-even yields of wheat and alternative uses were estimated for various prices of products. Although their concern was with crop alternatives to wheat rather than comparison of wheat and range, the budgeting coefficients for wheat and the methodology used were valuable in approaching the problem of the present study. Vlasin-Epp found that production of wheat grown under a summer-fallow system was a higher return use than production of alternate crops considered. Crops included in this study were barley, grain sorghum, proso, safflower, and oats. More recent estimates indicate that this conclusion is still true.[9]

Another study, more closely related to the present study in terms of problem reference, was made by Sitler.[10] The area studied by Sitler was

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[8] Vlasin, R. D., and Epp, A. W., *Alternative Cropping Systems for Southwestern Nebraska*. Nebr. Agr. Exp. Sta. Bul. 443, Lincoln, Nebr., 1958.

[9] Epp, A. W. and Stalling, J. L., unpublished estimates of returns to crops for Kimball County made in 1960 and 1961. Dept. of Agr. Econ., Univ. of Nebr., 1961.

[10] Sitler, H. G., *Economic Possibilities of Seeding Wheatland to Grass in Eastern Colorado*, ARS 46-64, USDA, Washington, D. C., 1958.

in eastern Colorado, a farming area near Kimball County and similar in type of farming. Sitler also focused attention on the farm firm rather than on differences in soil type but the results could be carried over to the making or recommendations of best land use by soil types, given wheat and beef yields. Sitler was particularly interested in the costs and returns resulting from seeding cropland to grass. He found that net income was maximized when all land yielding less than 5 bushels of wheat per seeded acre was reseeded to grass. This study is perhaps the best reference available regarding the problems of regrassing cropland in the Plains and the economics of this practice from the standpoint of the individual farm.

Saunders County, Nebraska, was the location for a study made in 1954 by Ottoson, Aandahl and Kristjanson.[11] In this study the concern was with improving assessment of farmland and the authors dealt with principles and procedures. Economic ratings were estimated for soil types in the county for both crop and pasture use. Net income per acre was used as the criterion for economic ratings. A "balance point," the conditions under which returns to crops and pasture are equal, was estimated for the soils in the county. This concept of balance or breaking-point between crop and pasture use is valuable in determining best land use as well as in estimating relative assessed values for farmland.

Q. R. Lindsey[12] studied the solution of problems of assessing farmland for tax purposes. The methodological approach was similar to that needed for the determination of best land use. In his study "best" land use was estimated for croplands to arrive at an assessed value for the land. Net returns for lands of varying productivities were estimated and capitalized to estimate total land value. Net returns were estimated by deducting all nonland costs from gross income of the dominant use. Lindsey used Harlan County, located in south central Nebraska, for his study.

There has been work in Montana dealing with identifying characteristics of farms which are subject to shifts between wheat and beef and with determining the conditions needed for shifts from cultivated crops to range. The major emphasis has been on farm firm characteristics and factors other than soils. Blood and Baker[13] were concerned with classifying farms into wheat farms, range farms, and those subject to shifts in use. The discriminant analysis technique was used as a

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[11] Ottoson, H. W., Aandahl, A. R., and Kristjanson, C. B., *Valuation of Farmland for Tax Assessment.* Nebr. Agr. Exp. Sta. Bul. No. 427, Lincoln, Nebr., Dec. 1954.

[12] Lindsey, Q. R., *A Procedure for the Equitable Assessment of Nebraska Farm Land.* Nebr. Agr. Exp. Sta. Bul. 400, Lincoln, Nebr., 1950.

[13] Blood, D. M., *Delineating Firms Sensitive to Shifts Between Wheat & Range Forage in the No. Great Plains,* Montana State College, Mimeo Circ. #84, Sept. 1954. Blood, D. M., and Baker, C. B., "Some Problems of Linear Discrimination," *Jour. of Farm Econ.,* Vol. XL, No. 3, Aug. 1958.

classification device. Terry Norman[14] studied those farms subject to shifts with respect to forage-crop substitutions. C. A. Carpy[15] made a study in which he was concerned with prices of calves, and time considerations necessary to make it profitable to shift from cropland to range production. The discriminant analysis technique used by Blood and Baker should be examined further for use in determining best land use. The farm firm framework cannot be ignored in land classification and studies such as these provide insights needed to link soil characteristics to firm considerations in determining best land use.

The studies mentioned are only a few of those that have been made which relate to the problem at hand. The intent here is not to make a complete review of the work on land classification. Work done by Wilfred H. Pine[16] on classifying Kansas land and the general problems of land classification should also be mentioned. Pine has considered most types of physical and economic land classifications and applied some of them to Kansas land.

RETURNS AND COMPARATIVE ADVANTAGE OF WHEAT AND BEEF PRODUCTION BY SOIL TYPE IN KIMBALL COUNTY

The discussion and analyses which follow include description and land use in the area, yields of wheat and beef for selected soils, method of computing returns, production costs, and comparative returns.

Description and Land Use in the Study Area

Kimball County is located in the southwestern corner of the Nebraska panhandle in a region of the central Great Plains descriptively referred to as the Summer Fallow Subregion (Figure 3). Winter wheat production predominates in this region, with other generally less well suited feed grains grown on acres diverted from wheat to comply with acreage control programs.

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[14] Norman, Terry, *Forage-Crop Substitution on Dryland Units Sensitive to Shift.* Montana State Mimeo Circ. #92, March 1956.

[15] Carpy, C. A. "Inducing Shifts from Crop Production to Beef on Dryland Farms in Montana." Unpub. M.S. Thesis, Montana State Col. Library, Bozeman, Montana, 1957.

[16] "Methods of classifying Kansas land according to Economic Productivity." Unpub. Ph.D. Thesis. Univ. of Minn. 1948. Chapter 2 of his thesis, *A Review of Land Classifications in the U. S., 1947,* was published by the Kansas Agr. Exp. Sta. in 1961. Also, see *A Study of the Productivity of Selected Soils in Western Kansas,* by J. H. Fritschen and W. H. Pine. Rpt. of Progress 24, Kans. Agr. Exp. Sta., Manhattan, June 1958.

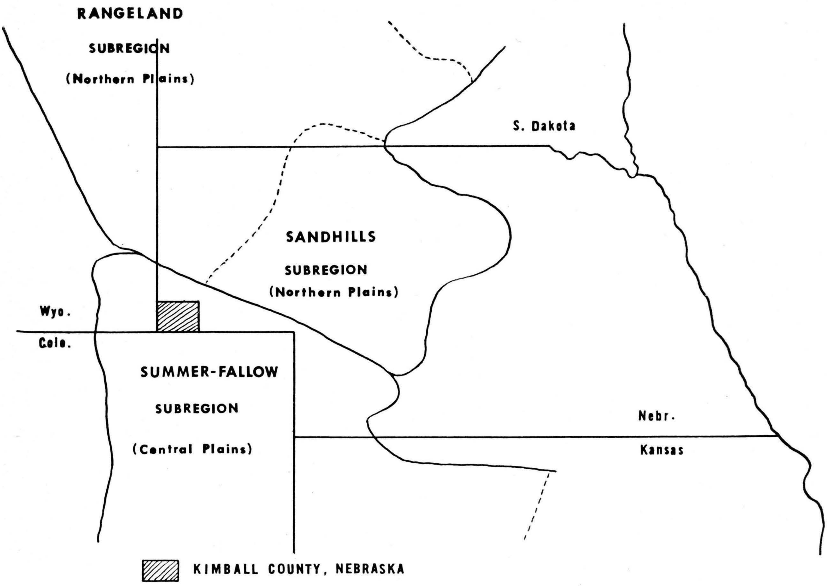

Figure 3. Generalized land-use regions in Northern and Central Great Plains. This figure is a reproduction of portions of maps given in *Soil,* 1957 Yearbook of Agriculture, Washington, D. C., pages 495 and 507.

Soils in this part of the Plains are predominately Chestnuts and Browns. Major soil series are Keith, Rosebud and Canyon. In Kimball County, soils vary from deep silt loams on relatively level surfaces to shallow soils on steep slopes. Rocky soils are common in some parts of the county, as well as sandy soils and shallow ones overlaying gravel. Wind and water erosion are farming hazards and annual crop production on drylands is limited by stored and seasonal precipitation.[17] Irrigation is practiced on about 2 percent of the farmland acres.

Average rainfall in Kimball County has been about 17 inches per year from 1890 to 1957.[18] Rainfall ranged from a low of about 8 inches in 1893 to a high of nearly 25 inches in 1905. Most of the precipitation occurs during the summer months with the peak in late May or early June. Average length of growing season is 137 days. The average abandonment rate for wheat from all causes is 24 percent and hail alone accounts for about half of this.[19]

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[17] For a more complete description of the soils and management problems see *Soil Survey of Kimball County Nebraska,* U. S. Dept. of Agr., Soil Conservation Service in Cooperation with University of Nebraska, Series 1957, No. 14. U. S. Govt. Printing Office, Washington 25, D. C.

[18] This information is from U. S. Weather Bureau records. Ibid. page 68.

[19] Ibid. According to Weather Bureau records Kimball County has the highest hail incidence of any county in the United States.

Table 2. Cropland use in Kimball County for selected years.[a]

Crop	Planted acres 1935	1950	1959
Winter Wheat	130,090	171,460	159,700
Summer Fallow	. . .[c]	147,942	165,800
Corn	27,790[b]	1,980	3,580
Oats	6,940[b]	9,100	4,230
Barley	14,600[b]	17,210	12,750
Rye	1,420[b]	1,960	6,620
Grain Sorghum, Forage Sorghum	5,420[b]	2,750[b]	1,280[b]
Safflower	. . .[c]	. . .[c]	6,380[d]
Beans, Potatoes, Sugar Beets	11,030[b]	2,830	2,220
All Hay	11,540[b]	7,970[b]	15,660

[a] These data are from *Nebraska Agricultural Statistics,* State Federal Division of Agricultural Statistics, U.S.D.A. Reporting Service, Lincoln, Nebr.
[b] Acres harvested.
[c] Figure not available for this year.
[d] U. S. Dept. of Commerce, Bureau of the Census, *Census of Agriculture, Nebraska,* 1960. Washington, D. C.

Winter wheat is the principal crop in Kimball County. In 1959 this crop, including equal acres for summer fallow, accounted for about 319.4 thousand acres of the approximately 610 thousand acres of land in farms (Table 2). There are about 417 thousand acres of cropland in the county. Thus, wheat and associated fallow acres occupy about 52 percent of the total land in farms and make up some 77 percent of the crop acreage. Hay is the second most important cropland use in terms of acres and accounts for about 16 thousand acres. Other miscellaneous crops are barley, grain sorghum, oats, corn, safflower, and rye. Acreages of some of these crops have declined in recent years relative to wheat acreage (Table 2).

The recent land inventory by the Soil Conservation Service is a valuable source of information on land use as related to physical capa-

Table 3. Land uses by land capability classes Kimball County, Nebraska.[a]

Capability class[b]	Land use: Cropland	Range	Forest woodland	Other	Total
	(Acres)	(Acres)	(Acres)	(Acres)	(Acres)
Dryland					
II-IV	339,420	83,327	274	2,722	425,743
VI-VII	65,527	90,328	. . .	1,722	157,578
Total	404,948	173,655	274	4,444	583,321
Irrigated					
I-III	10,971				
IV	1,029				
Total	12,000				12,000
Total all classes					595,321

[a] Data in this table are from the Conservation Needs Inventory completed in Nebraska in 1960 by the Soil Conservation Service, U. S. Department of Agriculture. Data shown here have been adjusted by the local Kimball County Conservation Needs Inventory Committee.
[b] Land capability classification of the Soil Conservation Service. Classes I to IV are considered physically suitable for crop use under certain conditions. There are no dryland soils in Kimball County classified as Class I or V.

bility of the land in Kimball County (Table 3). About 174 thousand acres, or 29 percent of all land, is in range use (Table 3). In 1959, 80 percent of the drylands in Classes II to IV were in cropland, 19 percent in range, and 1 percent in other miscellaneous uses. About 16 percent of the land used for crops is classed as VI and VII, that is, generally physically unsuited to cropping.[20] The magnitude of the land-use problem, however, cannot be determined from these data alone since the sizes and locations of these "unsuitable" tracts of cropland are unknown. If the cropland acres in Classes VI and VII are scattered in relatively small tracts among lands of relatively high productivity the more economical use may be cropland. If, on the other hand, these unproductive soils occur in relatively large tracts perhaps they could profitably be returned to range use.

In addition, the cropland classes—II, III, and IV—are considered suitable for cropping only under certain conditions. For example, Class IV requires specific conservation treatments and additional management inputs when used for cropping.

Yields of Wheat and Beef

It was possible, by use of the Conservation Needs Inventory data and predicted yields, to relate land use to soil productivity in Kimball County (Table 4). Wheat yield predictions under dryland farming were available for 43 soils from the county soil survey report. These soils were used in the subsequent analysis. Classified by yield of wheat, the percent of land in cropland declines gradually from 90 percent for the highest yielding group of soils to 75 percent for the lowest yielding

Table 4. Land use by general wheat yield classes, Kimball County resource areas D13c1 and D13c2, 1959.[a]

	20.8-16.8 (Bu.)	16.7-12.8 (Bu.)	12.7-9.6 (Bu.)	9.5-6.4 (Bu.)	Total
Wted av. yield[b]	18.04 Bu.	15.90 Bu.	10.30 Bu.	7.40 Bu.	13.00 Bu.
No. of soil types	11	10	13	9	43
Acres by Use:					
Cropland	111,387	50,880	116,811	54,689	333,767
Rangeland	11,973	10,372	30,300	17,391	70,036
Other	700	588	239	905	2,432
Total	124,060	61,840	147,350	72,985	406,235
Percent cropland	90	82	79	75	82
Percent of land	31	15	36	18	100

[a] Acre estimates by soils obtained by use of yield predictions for Kimball County and Conservation Needs Inventory data. Yield predictions made by soil scientists of the Soil Conservation Service and Nebraska Agricultural Experiment Station. Dryland soils in land capability classes II to IV only.

[b] Yield per planted acre.

[20] See "The Use of Soil Maps" by A. M. Hedge and A. A. Klingebiel in *Soil,* op. cit. pages 400-410, for a description of the soil classification used by the Soil Conservation Service, U. S. Department of Agriculture.

group. As the yield declines, the wheat-grass margin is approached. Other things equal, at the wheat-grass margin the soil could be expected to be half in cropland and half in rangeland.

Farmers apparently drew the line between cropland and rangeland at about 5.8 bushels per seeded acre (Figure 4). The percent of cropland for 16 groups of soils with different yields was related to wheat yields for these soils.[21] Using 50 percent cropland as the criterion, a wheat yield of about 5.8 bushels was the breaking point between wheat and grass use. The lowest crop yield for soils for which yields of wheat have been predicted was 6.3 bushels.

Kimball County "cropland" soils may also be described by their physical productivity as related to physical characteristics. Given climate, perhaps the most important physical attributes of soils are slope, texture, and depth of topsoil. These three characteristics are inter-

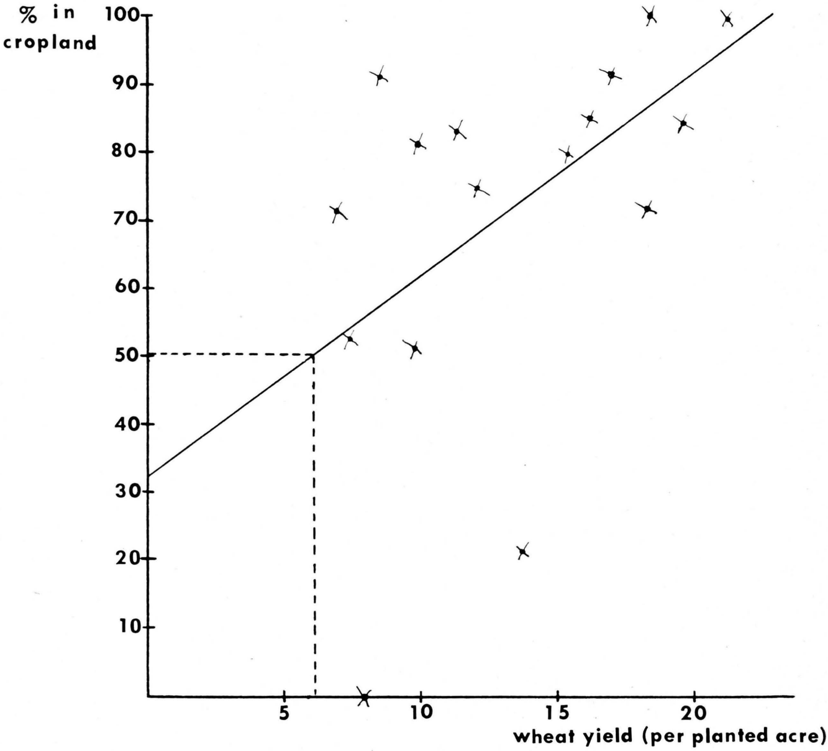

Figure 4. Land use of 16 groups of Kimball County soils in 1959 related to wheat yield.

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[21] A *t* value of 1.36 was obtained. The equation was $X_1 = 33.6496 + 2.8409X_2$ where X_1 is percent of acres of soils in cropland and X_2 is wheat yield per planted acre.

related, but each affects yields in itself. The slope is likely to influence the depth and texture of the topsoil because of water erosion; the depth and texture of topsoil are likely to be related because of wind and water borne movements of surface soils. Taken independently, the steeper the slope the more precipitation will run off and the lower will be the wheat yield.[22] The more shallow the topsoil, in general, the less will be the levels of organic matter and available nutrient elements in the soil. The texture of topsoil affects yields because fewer nutrients are held by a soil with coarse particles than a soil with fine ones.

The 43 Kimball County soils for which dryland wheat yields have been predicted were described in the 1962 soil survey report by percent of slope, deep and moderately deep topsoil, and sandy and silty soil surface. "Predicted yields," together with Kimball County soils which fit the descriptions, are shown in Table 5. Yields given in this table are used in the subsequent analyses.

Beef yields are not differentiated by soil type in the Kimball County report. Nor do the range specialists of the Soil Conservation Service

Table 5. Relationship between soil characteristics and wheat yields, Kimball County, soils in Land Capability Classes II through IV.

Soil depth and texture	Slope	Average predicted[a] yield	Kimball County soils[b]
	(Percent)		
Deep			
Silty			
	0–1	19.1	Aa, Go, He, Ke, Rb, Ta
	1–3	16.1	AfAW, AaAw, BhA, GoA KeAW, RbAW, TrA, TaAw
	3–5	13.7	AaBW, BhB, KeBW, RbBW TrBW, TaBW
	5–9	10.5	AaCW, RbCW, TaCW
Sandy			
	0–1	13.6	Gd, Pn, Tr
	1–3	11.2	PnBW, VrAW
	3–5	7.6	VrBW, BfBW[c]
	5–9	9.8	PnCW
Moderately Deep			
Silty			
	0–1	9.4	Cy, 3RbW
	1–3	10.5	3AAW, CyA, 3RAW
	3–5	8.4	3ABW, 3RBW
	5–9	7.0	3ACW, 3RCW
Sandy			
	0–1	7.0	3Pn, ChAW
	1–3	6.3	3PnB

[a] "Average predicted yield" estimated by soil scientists of the Soil Conservation Service, U. S. Department of Agriculture, and Nebraska Agricultural Experiment Station. Kimball Co. Soil Survey report, adjusted to a planted acre basis.
[b] See soil survey report for descriptions and harvested yields of individual soils.
[c] Slope of 1-5 percent.

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[22] The effects of soil and water conservation practices, with the exception of strip cropping, are not considered. Yields are for average management.

estimate carrying capacity for ranges. Instead, animal range-stocking recommendations are made by range site and condition. The 43 soils used for comparisons were in two range sites: sandy and silty. Stocking recommendations were the same for both sites. Without a basis for differentiating beef yields between soil types, the rather unrealistic assumption was made that beef yields were the same for all 43 soils. This beef yield was estimated on the basis of recommended stocking rates and estimated weight gains. The method used in this report to compare returns to wheat and grass could be applied, however, if beef yields were varied between soil types. A cattle ranch was synthesized from data available. It was assumed that cattle were sold as yearlings.

Stocking recommendations for Kimball County for a mature cow with unweaned calf are 1.67, 2.22, 3.33 and 6.67 acres respectively, for both sandy and silty range sites in excellent, good, fair and poor conditions.[23] For estimating acreage requirements for a 100-cow beef breeding herd a requirement of 2.0 acres an animal unit was assumed. This corresponds to a good to fair condition. Acres required per animal were adjusted for the period of time on range and hay and for the age of the animal.

A 100-cow herd was considered a minimum size for a family operation. The following acreage requirements were estimated for a 100-cow breeding herd:[24]

pasture requirement:	3413	acres
hay requirement:	102.6	acres
total	3515.6	acres

The grazing season is 10 months and the animals are on hay for two months.

Beef sold per year is estimated to be 68,396 pounds including sales of yearlings, cull cows and cull bulls. This figure allows for holding back herd replacement heifers. When the total pounds of beef available for sale is divided among the estimated acres required, a yield of 19.5 pounds per acre is obtained.

Method of Computing Returns and Comparative Advantage

The first step in computing returns and comparative advantage was

[23] The source for these stocking rates is "Range Technicians Guide," Soil Conservation Service, January 1958. Office of E. J. Dyksterhuis. Lincoln, Nebr. For a discussion of range sites and condition classes see E. J. Dyksterhuis "Range Conservation as Based on Sites and Condition Classes," *Journal of Soil and Water Conservation*. Vol. 13, No. 4, July, 1958.

[24] See Appendix A for a breakdown of the acre requirements by type of animal and the assumptions of the method used in arriving at the yield estimate.

to calculate total returns. Price, reduced by storing and handling costs, was multiplied by yield. The second step was to deduct nonland costs per acre from total returns. The return to lands of various productivities was estimated in this manner.

The comparison of wheat and beef to determine the highest return use need be made only at, or near, the breaking-point to correctly classify all soils into one use or the other. All soils with wheat yields less than the breaking-point yield are "beef" soils. However, two additional refinements were made: (1) breaking-point wheat yields were estimated at two average cost levels for wheat and beef, and (2) ratios of returns to wheat and range were estimated for each soil to determine whether economic rent to wheat or beef use existed for a soil. Economic rents to wheat use would exist where land returns in that use exceed land returns in beef use (see Figure 2).

The following equation was used to estimate wheat yields at the wheat-range margin:

$$Y_W = \frac{(Y_B p_B - C_B) + C_W}{p_W}$$

Where Y_W and Y_B are yields of wheat and beef, p_W and p_B are prices at the farm for wheat and beef, and C_W and C_B are nonland costs per acre.

For any given soil, yields and prices were considered constant. Two levels of average nonland costs[25] were used to estimate returns for four cost situations. These cost situations were: (1) high wheat and beef cost level, (2) high wheat cost and low beef cost, (3) low wheat cost and high beef cost, and (4) low wheat cost and low beef cost.

Cost figures were obtained for typical wheat and cattle farms in Kimball County. It is assumed that either economies of scale are exhausted in both types of enterprises or the size is not any less efficient in one type than the other.

Estimated Production Costs

Farm size in Kimball County averaged 1,458 acres in 1959 according to the census estimate.[26] There were 439 farmers in the county in 1959; 17 percent of the operators were owners and 39 percent were tenants. Farm real estate value was $83,678 per farm or $54.16 per acre. Average age of all farm operators was 46.2 years.

Wheat—Cost estimates for wheat are based on farms in a 1,000 to 3,000-acre range. The estimated labor requirement is .72 hour per acre and labor and management are valued at $2.00 per hour. Nonland fixed costs for depreciation, repairs, lubricants, shelter, interest, insur-

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[25] The two cost levels used were an estimate of total nonland cost for an average farm operation, and 65 percent of "average" respectively.

[26] *Census of Agriculture*, 1959. Op. cit.

ance, and taxes on machinery are included. Nonland variable costs included are for power, preliminary preparation, labor, seed, seed cleaning, and crop spraying.

Average or typical wheat production practices in Kimball County were obtained from the Epp-Vlasin study.[27] Costs associated with these practices were then estimated for 1959. These average or typical costs were adjusted for crop yields greater and less than the average and for rates of abandonment. Information with which to adjust costs for differences in soil productivity is limited but M. L. Cotner found, in a study in Geary County, Kansas,[28] that harvesting cost affected differences in production costs between soils more than tillage costs, and that soil texture and slope also affected costs through tillage operations. Production costs increased with soil productivity but less rapidly. For another study, a group of farmers were asked to estimate the differences in practices and costs between soils of varying productivity in Harlan County, Nebraska.[29] They estimated that the number of subsurface tillage operations would vary from three to five for soils ranging in yield from 3.5 to 18 bushels of wheat per acre. The number of times over with a rod-weeder was from one to three and seed costs varied from 1.67 to 0.67 of the average.

The procedure followed in this study to arrive at average total cost for a soil of given productivity was somewhat arbitrary; the number of rod-weeding operations, the seeding rates, harvesting costs, and hauling and storing costs were varied by soil productivity. The findings of both studies mentioned above were considered in arriving at the final estimates of average costs of production for soils of various productivities.

Another consideration in dealing with production costs is the range in average nonland costs because of various situations encountered in the use of land of any given productivity. For example, speed of operation is affected by size and shape of field. In recognition of these cost differences, not necessarily associated with soil productivity, 65 percent of nonland costs for the average operation in the county was also used. Estimated costs are shown in Table 6 for four generalized classes of soils. In the remainder of this section wheat yields are expressed in terms of a crop acre, and costs are nonland costs per crop acre. A crop-acre basis for yields was used because wheat is grown under an alternate year summer fallow system and 2 acres of cropland are required for each acre of wheat production. Costs of wheat production were estimated for the four general yield classes; costs of hauling and storing were estimated to be $.05 per bushel.

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[27] Op. cit.

[28] Cotner, M. L., Effects of Variation in Inputs and Price Relationships on Value of Cropland in Geary County, Kansas. Unpub. M.S. thesis, Kansas State College. 1959.

[29] Lindsey, Q. W., Op. cit.

Table 6. **Nonland costs of wheat production, per acre, for generalized yield classes, Kimball County, Nebraska, 1959.**[a]

Item	Unit	Nonland cost by yield class[b]			
		10.4–8.4 bu.	8.3–6.4 bu.	6.3–4.8 bu.	4.7–3.2 bu.
Av. Yield	Bu.	9.3	7.3	5.3	3.7
No. Soils	No.	11	10	13	9
One-way disk	Dol.	0.70	0.70	0.70	0.70
Subtiller	Dol.	0.80	0.80	0.80	0.80
Rod-weeder	Dol.	1.12	0.84	0.56	0.28
Drill	Dol.	0.64	0.64	0.64	0.64
Combine[c]	Dol.	1.65	1.65	1.54	1.49
Seed[d]	Dol.	1.04	0.83	0.83	0.55
Haul and Store[e]	Dol.	0.46	0.36	0.26	0.18
Av. nonland cost:					
per acre	Dol.	6.41	5.82	5.33	4.64
per unit	Dol.	.69	.80	1.01	1.25
Lower level of nonland cost:[f]					
per acre	Dol.	4.17	3.78	3.46	3.02
per unit	Dol.	.45	.52	.65	.82

[a] See appendix B for basic costs and sources used in estimating the costs in this table.
[b] Yield per crop acre. Alternate year summer-fallow and 20-30 percent abandonment assumed. Source of yields: County soil survey report for Kimball County, 1962, and private communication with Robert Eikleberry, Soil Conservation Service, Lincoln, Nebr.
[c] Cost of combining estimated to vary from $1.65 to $1.44 due to varying rates of abandonment. Value given is weighted average for soils within generalized class. Abandonment rate 20 to 30 percent.
[d] Seed cost increased by 25 percent for yields greater than 8.0 bushels and decreased by 25 percent for yields less than 4.8 bushels.
[e] Weighted average yield used.
[f] Sixty-five percent of "average nonland cost."

Beef—Costs of the cow-calf-yearling enterprise are based on a 100-cow herd and an estimated land requirement of 3,516 acres. A yield of 19.5 pounds per acre was estimated from range recommendations on stocking rates and animal weights. It is assumed that this yield does not vary by soil type.[30] The labor requirement is 18.8 hours per cow unit and labor and management are valued at $2.00 per hour. Total nonland cost per cow unit is $96.19. Total nonland cost per acre is $2.74 with an estimated lower level of $1.78. Nonland fixed costs include the investment costs of livestock, machinery, and equipment; maintenance and depreciation on wells and fences; taxes and insurance; and depreciation and repairs on machinery and equipment. The cost of capital was assumed to be 6 percent. Variable costs include power costs, proteins, salt, minerals, veterinary expenses, miscellaneous costs and labor.

Fewer data are available on production costs for beef than wheat in the western Nebraska region. Data from several sources were used to synthesize a 3,516-acre ranch with a 100-cow, cow-calf-yearling, beef

[30] Range stocking rates are based on discussions with personnel of the Soil Conservation Service, U. S. Department of Agriculture and Extension Service, Univ. of Nebraska, Lincoln, Nebr.

Table 7. Nonland cost of producing yearling beef animals on a 3,516-acre ranch in western Nebraska.[a]

Investment cost			
Livestock investment	$26,755		
Machinery and equipment investment	7,100		
Total	$33,855		
Annual investment cost at 6%		$2,031	
Other capital costs		3,828	
Labor costs[b]		3,760	
Total nonland cost		$9,619	
Nonland cost per cow unit[c]			96.19
Nonland cost per hundredweight sold			14.06
Nonland cost per acre			2.74
Estimated lower level of nonland cost per acre[d]			1.78

[a] See Appendix B for complete outline of costs, and sources of cost estimates.
[b] A labor requirement of 18.8 hours per cow unit is assumed.
[c] A cow unit includes replacements and young stock, and bulls.
[d] Sixty-five percent of "average nonland cost per acre." This is assumed to be the range in average cost due to interfirm differences in scale and farm resource situations.

herd. After synthesizing this ranch, nonland costs of production were estimated (Table 7).

Returns and Comparative Advantage of Wheat and Beef

The assumptions underlying the comparison of wheat and grass as land-use alternatives are that:

1. The costs and returns to beef cattle raising are the same for all soils on which wheat can be produced under typical farm conditions.

2. Climatic conditions are those which prevailed over the past 50 years.

3. There is perfect competition between wheat and grass in the use of land.

4. The yields of wheat and beef are not limited by the availability of labor and capital.

5. Costs of shifting from range to wheat are zero and costs of shifting from wheat to grass can be included in the production costs of cattle raising on an annual basis for an appropriate length of planning period.[31] Returns to land if used for wheat or if used for grass and beef raising are compared, assuming that the land will be used for one or the other of these. Because land taxes and any land maintenance costs are assumed to be equal regardless of use, these costs are not included in estimating returns. All soils in Land Capability Classes II to IV in Kimball County are considered. To illustrate returns and comparative advantage soils were divided into four general classes, on the basis of wheat yield (Table 6).

Returns concerned with are the residual returns to land after the deduction of nonland production costs. Rent to a use is the excess of

[31] The costs of shifting from wheat to grass, however, are considered separately later in the report.

land returns over land returns in another use and is determined by the ratio of wheat returns to range returns. Comparative advantage of a use arises if rent exists when the soil is in the use.

Estimated returns and comparative advantage (ratio of returns) are shown in Table 8 for the four generalized yield classes of soils. Returns to the two uses for each soil are illustrated in Figure 5. For 1955-59 average prices and 1959 costs, the average soil in each class has some amount of economic rent for use in wheat for any combination of returns in the two uses. The comparative advantage of wheat becomes relatively less as yield declines, as indicated by the smaller returns ratios. Six individual soils are submarginal for wheat if high wheat costs and low beef costs are used[32] (Figure 5).

One additional comparison of comparative returns will be made—how much would wheat prices have to decline for the average soil in

Table 8. Estimated returns and comparative advantage of wheat and beef by general yield classes, Kimball County, Nebraska.

Item	Unit	Wheat yield classes[a]			
		10.4–8.4 bushels	8.3–6.4 bushels	6.3–4.8 bushels	4.7–3.2 bushels
No. of soils	No.	11	10	13	9
Wheat					
Av. yield[a]	Bu.	9.3	7.3	5.3	3.7
Av. gross income (farm price)[b]	Dol.	16.19	12.81	9.33	6.51
Costs (nonland)[c]					
Average	Dol.	5.95	5.46	5.08	4.54
Lower Level	Dol.	3.87	3.55	3.21	2.96
Returns to land					
Average cost	Dol.	10.24	7.35	4.25	1.97
Low level of cost	Dol.	12.32	9.26	6.02	3.55
Beef[d]					
Yield (lbs.)	Lbs.	19.5	19.5	19.5	19.5
Gross income[b]	Dol.	3.60	3.60	3.60	3.60
Costs					
Average	Dol.	2.74	2.74	2.74	2.74
Low level	Dol.	1.78	1.78	1.78	1.78
Returns to land					
Average cost	Dol.	0.86	0.86	0.86	0.86
Low level of cost	Dol.	1.82	1.82	1.82	1.82
Average Return Ratios[e]					
W_H/B_H		11.9	8.6	4.9	2.3
W_H/B_L		5.6	4.0	2.3	1.1
W_L/B_H		14.4	10.8	7.0	4.1
W_L/B_L		6.8	5.1	3.3	2.0

[a] Yields per crop acre. Average is weighted for number of soils in each group.
[b] 1955-59 average price at farm. $1.76 for wheat and $0.1846 for beef.
[c] (See Table 7) Costs of storing and hauling have been deducted from price in this table.
[d] Cow-calf-yearling enterprise.
[e] These are the ratios of wheat to beef returns. Subscript H refers to high cost and L to low cost of production.

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[32] The soils estimated to be submarginal under these cost criteria are the last five moderately deep soils and VrBW in Table 5.

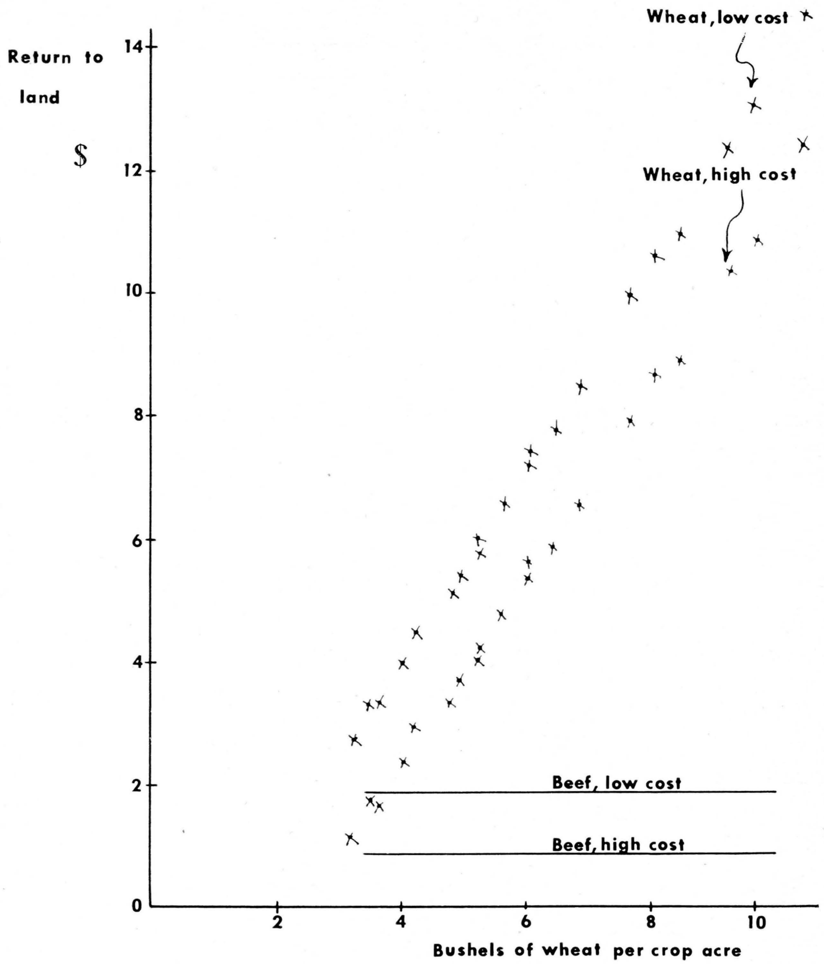

Figure 5. Estimated returns to soils in wheat and range, Kimball County, Nebraska.

a class to be classified on the wheat-range margin? This estimate is made for each yield class by setting the ratio of returns to the two uses equal to unity and solving for the price of wheat. The steps are:

$$\frac{Y_w (p_w - c_w)}{Y_B (p_B - c_B)} = 1 \text{ at the wheat-range margin,}$$

therefore

$$Pw = \frac{Y_B (p_B - c_B)}{Y_w} + cw$$

where Y_w and Y_B are yields of wheat and beef, p_w and p_B are prices at the farm, and c_w and c_B are nonland costs per unit of product.

Table 9. Break-even prices of wheat by wheat yield class, Kimball County, Nebraska.

	Price of wheat			
	Wheat yield class (Bu.)			
	10.4–8.4 bushels	8.4–6.4 bushels	6.3–4.8 bushels	4.7–3.2 bushels
	Dol.	Dol.	Dol.	Dol.
Net price of wheat if soil is at margin[a]				
Low beef cost[b]	.196	.249	.343	.492
High beef cost	.092	.118	.162	.232
Farm price of wheat if soil is at margin[c]				
Low beef cost				
Low wheat cost	0.65	0.77	0.99	1.31
High wheat cost	0.89	1.05	1.35	1.74
High beef cost				
Low wheat cost	0.54	0.64	0.81	1.05
High wheat cost	0.78	0.92	1.17	1.48

[a] Calculated by dividing returns to land in beef by wheat yield per crop acre.
[b] Cow-calf-yearling enterprise, prices of beef 1955-59 average of $18.46 per hundredweight. Returns to beef are $1.82 for low cost and $0.86 for high cost.
[c] Average price of wheat at farm in Kimball County for period 1955-59 was approximately $1.76 per bushel. These figures are net prices of wheat at margin plus nonland costs of production per bushel.

Farm wheat prices would have to fall from $1.76 (the 1955-59 average) to $0.54-$0.89 for the average soil in the highest wheat yield class to become marginal. At prices of $1.05 to $1.74, the average soil in the lowest yield class would become marginal with respect to wheat use (Table 9). A price of $1.72, or 75 percent of parity, was the 1960 support price in Kimball County. A price of $1.12, or 52 percent of parity was estimated 1960 feed grain value of wheat at the farm for Kimball County.[33]

The effect of wheat price reductions (assuming no restrictions to land use shifts) on production from soils in Classes II to IV, is illus-

Table 10. Estimated wheat production on soils in classes II through IV, Kimball County, under various wheat prices.

Farm price[a]	Average production[b]
(Dol.)	(1,000 Bu.)
1.48–1.76	2,218.1
1.32 (1.17 to 1.47)	2,010.8
1.04 (.92 to 1.16)	1,409.2
.84 (.78 to .91)	1,004.7

[a] Midpoint prices and range of prices required to shift soils.
[b] The production estimates in this table are for the 43 soils previously defined. In addition to the approximately 334,000 acres represented by these soils there are some 66,000 acres of dry cropland in land Classes VI and VII.

[33] These prices obtained from J. L. Stallings, Agricultural Economist, U. S. Department of Agriculture. Prices estimated for use in Regional Research Project W-54, Adjustments to Alternative Wheat Programs.

trated in Table 10. In this table, high wheat and beef costs and average predicted wheat yields are assumed.

In addition to relative prices and costs for wheat and beef the present use of land is another factor which may have a strong impact on the decision on best use. This is particularly true in the case of shifting from cultivated crops to range.

EFFECTS OF REGRASSING COSTS ON LAND USE DECISIONS

Changes in agricultural land use from intensive to extensive types of enterprises are accompanied by physical, institutional, and economic changes. For example, as a result of plowing rangeland a soil surface stable and relatively high in organic matter may be removed by erosive agents exposing a clay or rocky subsoil. The physical possibilities of regrassing are thereby seriously limited.

At the same time, over a period of years, changes in social and economic institutions normally occur as land use is intensified. These institutions must be altered or dispensed with if agricultural resources are withdrawn. For instance, farm sizes and tenure patterns well adapted to grain production are likely to be poorly adapted to range livestock production.

To regrass cropland in the Plains, a wait of three years or more is required with the possibility that the seeding may have to be repeated one or more times. Additional economic factors to be considered are that farmers must pay the costs of seeding and must obtain fences, buildings, water and equipment to care for the livestock. Much of the capital equipment used on a grain farm is of little or no use in a range livestock operation.

In contrast, although intensification is accompanied by equally drastic economic, physical and institutional changes, it may be accomplished in a relatively short period of time. A wheat crop may be obtained the first year after plowing. As a result of the relatively low cost of intensification and high cost of extensification, land on or near the break-even margin for wheat and beef is likely to be broken out and, once broken, to remain in cropland. This section deals with the effect of regrassing costs on land use decisions and the economic criteria which must be met for regrassing to "pay." Only the land treatment costs of regrassing, including the waiting period, are considered, but fencing, building, and other costs could be included without changing the procedure used.

Effect of Regrassing Costs on Land Use in Kimball County

There are alternative ways of approaching the problem of how costs of regrassing affect the decision of whether to grow crops on the land, utilize it for range cattle production, or abandon it. The analysis used here is based on the logic of the annuity. The question, in terms of the land use problem at or near the wheat-grass margin, is how large an annual return in beef production is required to meet opportunity costs of returns in wheat production and costs of regrassing?[34]

The procedure is to estimate the annual return required to meet the present value of regrassing costs for various lengths of planning periods, then deduct this value from estimated annual returns in beef production. The decision for wheat or beef is then based on a comparison of annual returns in wheat and adjusted annual returns in beef. In this way supermarginal, marginal and submarginal soils, now in cropland can be identified. For some soils, of course, the land will not yield a positive return in wheat or in beef. The smallest (absolute) negative return then specifies the use which will result in the least loss if the land is to be used for agriculture.

Annual returns required to pay a present regrassing cost will decline as the number of years included in the planning period increases.[35] For instance, the annual return for ten years required to pay a regrassing cost with present value of $20 is about $2.72; the annual return for 20 years is $1.74. After 20 years the required annual return drops only slowly (Figure 6).

In addition to meeting regrassing costs the beef enterprise must meet the opportunity of returns foregone in alternative land uses, in this case wheat. This may require a planning horizon longer than that

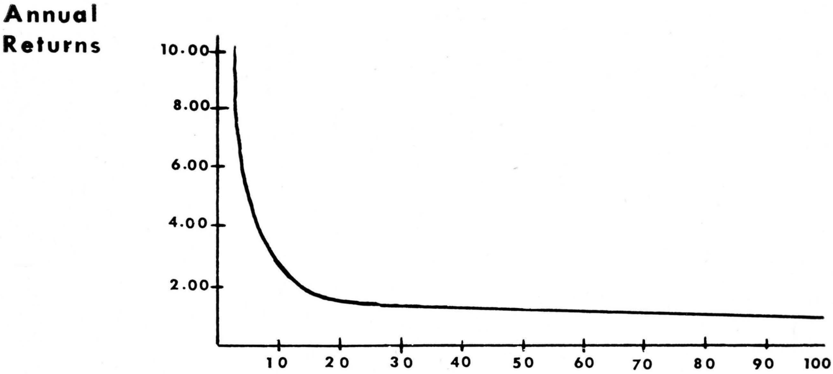

Figure 6. Annual returns required to pay $20 in the first year. In contsructing this schedule an interest rate of 6 percent was assumed.

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[34] An alternative approach to this problem, equally applicable, would be to estimate the rate of discount which when applied to given annual returns for a given planning period would just pay the present regrassing cost. In this approach it would be assumed that the operator bases the decision on regrassing on the rate of return in regrassing as compared to the rate of return in alternative investments. Both methods are forward-looking and future costs, prices, and technology must be assumed.

[35] Average yields and prices are assumed to prevail. Yield uncertainty is not dealt with here.

needed to just pay regrassing costs (positive returns to wheat) or this period may be shortened (negative returns to wheat).

The assumptions for this analysis are, as before, that beef returns are constant for each year and are equal to returns under the specified average weather conditions. It is assumed that 1955-59 prices and 1959 costs are relevant. Returns to land for the cow-calf-yearling enterprise are estimated at $0.86 and $1.82 per acre per year for high and low nonland costs, respectively. The present value of regrassing costs in Kimball County is estimated to be $30.08.

An annual beef return of $2.62 is required to pay regrassing costs over a planning period of 20 years if the operator pays all costs, an interest rate of 6 percent is assumed and returns in wheat are zero (Table 11). If land returns for a soil used for wheat were only $0.27 per year without regrassing, about 25 years would be required with beef returns of $2.62, to pay costs of regrassing and allow for opportunity returns in wheat use (2.62 – 0.27 = $2.35). For soils where returns to land used for wheat were negative the required planning period would be reduced. For example, if annual returns in beef were $2.62 per year, as before, but wheat returns were $–0.36 per year the planning period would be reduced to about 16 years [$2.62– (–0.36) = $2.98].

It is estimated that, at a "low" nonland cost of production, a cow-calf-yearling enterprise in Kimball County would require about 80 years to pay regrassing costs. Something in excess of 100 years would be required, assuming a high average nonland beef production cost in estimating returns. The effect of reducing the total and annual cost of regrassing by one-half is shown in columns 4, 7 and 8 of Table 11. In this case the high beef returns (low average costs) pay for regrassing in 10 to 12 years, low returns (high average production cost) pay off in about 100 years.

The foregoing estimates indicate the great difficulty of regrassing cropland. Even though only part of the cost of reseeding the land is considered (costs of fencing, providing water and other costs for livestock facilities are omitted) regrassing does not pay unless one or more of the following conditions prevail:[36] (1) the farmer has a planning horizon of 20 years or more, (2) returns to wheat production are negative, (3) the farmer can obtain substantial economies in beef production, or (4) the cost of regrassing is reduced, for example, because only part of the cost of regrassing is borne by the farmer.

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[36] In addition to the conditions listed, of course, in this static treatment we are assuming that price levels do not change, nor the alternative costs of production. In other words, it is assumed that annual rates of return are averages expected over the given planning periods and the 6 percent rate of return is as large or larger than opportunity rates on use of the capital for alternative investments. At opportunity rates greater than 6 percent the annual return to regrassing would have to be larger for a given length of planning period or for a given annual return the length of planning period would have to be longer.

Table 11. Annual returns required to pay regrassing costs for various time periods and returns to wheat at the wheat-grass margin, Kimball County, Nebraska.

Length of planning period (years)	Present value of annuity of $1 for n years[a]	Annual return needed to pay regrassing cost[b] (or annual cost)		Annual deficit or excess[c]			
				Return to beef (CCY)			
		Total	One-half	Total $0.86	Total $1.82	One-half $0.86	One-half $1.82
	($)	($)	($)	($)	($)	($)	($)
2	1.8334	16.41	8.20	–15.55	–14.59	–7.34	–6.38
4	3.4651	8.68	4.34	– 7.82	– 6.86	–3.48	–2.52
6	4.9173	6.12	3.06	– 5.26	– 4.30	–2.20	–1.24
8	6.2098	4.84	2.42	– 3.98	– 3.02	–1.56	–0.60
10	7.3601	4.09	2.04	– 3.23	– 2.27	–1.18	–0.22
12	8.3838	3.59	1.79	– 2.73	– 1.77	–0.93	0.03
14	9.2950	3.24	1.62	– 2.38	– 1.42	–0.76	0.20
16	10.1059	*2.98*	1.49	– 2.12	– 1.16	–0.63	0.33
18	10.8276	2.78	1.39	– 1.92	– 0.96	–0.52	0.43
20	11.4699	*2.62*	1.31	– 1.76	– 0.80	–0.45	0.51
25	12.7834	*2.35*	1.18	– 1.49	– 0.53	–0.32	0.64
30	13.7648	2.19	1.09	– 1.33	– 0.37	–0.23	0.73
40	15.0463	2.00	1.00	– 1.14	– 0.18	–0.14	0.82
50	15.7619	1.91	0.96	– 1.05	– 0.09	–0.10	0.86
60	16.1610	1.86	0.93	– 1.00	– 0.04	–0.07	0.89
80	16.5090	1.82	0.91	– 0.96	0.00	–0.05	0.91
100	16.6180	1.81	0.90	– 0.95	0.01	–0.04	0.92

[a] The annuity formula used is $[1-(1+r)^{-n}]/r$, where r is rate of interest and n is number of years. A rate of 6% is assumed. Source: C.R.C. Standard Mathematical Tables, Chemical Rubber Pub. Co., tenth Ed., Cleveland, Ohio, 1956.

[b] Assumed present total value of regrassing cost is $30.08. See Appendix C.

[c] Return to wheat must be equal to or less than these values for regrassing to pay for the time period considered; in terms of reducing loss or increasing returns.

EVALUATION, APPLICATION, AND IMPLEMENTATION OF THE ECONOMIC LAND CLASSIFICATION

Given the myriad economic, physical, and institutional conditions which affect land-use decisions, there is no single set of conditions which will meet all criteria in specifying "best" land use. If an attempt were made to include all possible sets of conditions such a classification would be so complex as to be severely limited in its usefulness. The method used in the classification proposed in this report has the following characteristics: The unit of classification is soil type or some collection of soil types based on physical productivity; size, shape, and location of tracts are recognized indirectly as limitations in specifying any best use; the relative return to land is used as the major criterion in determining best use; the method includes consideration of highest land returns under two sets of costs, and in some cases costs of changing to a different use determine "best" use.

The theoretical framework outlined and applied to 43 dryland soils in Kimball County is based on traditional economic principles of production and distribution. The framework is based on profit as the prime motive for production. The returns to land are separated from the returns to other resources. Limiting economic assumptions are made from consideration of the characteristics of Great Plains farming and the particular choice proposition of wheat or beef. Production functions for both uses, and therefore product substitutions, are assumed to be linear. Reliance is placed on the price mechanism as the means for determining the proper division of product between resource factors given the yields of soils. Cost-affecting institutions are recognized as variables affecting returns, and thus affecting the allocation of land between uses. Nonland costs of production are varied downward to 65 percent of estimated average cost for one comparison to allow for these cost-affecting factors. Labor and capital intensity is also varied somewhat for differences in the productivities of soils in the case of wheat.

Many of the results rest upon the correctness of the assumed product and factor relationships and the estimated yields (production functions) for wheat and beef. The rates of substitution between products, the costs, and the product prices all rely to some extent on the correctness of the yields. The assumption that the yields reflect levels of intensity achieved by farmers by attaining the highest level of efficiency is probably hazardous. The effect of location is neutral because of the small area analyzed. For larger areas this factor would have a strong impact on best land use.

The results of the regrassing analysis also depend on the correct estimation of the production response of land to the re-grassing treatment. This analysis is essentially static in that time is treated only in the discounting process—yields, prices, and costs are not varied with time.

Returns to land in range use are assumed constant over time and between land of varying productivities.

Only one criterion has been used to specify best land use in this report—the highest level of returns to land resources maintained over time. Efficiency at the firm level is assumed in the analysis. Efficiency of resource use in the aggregate sense, which would involve the values of products to society and the valuation of labor and capital in highest alternative uses, has not been dealt with. Neither has the stability of incomes, an additional criterion, been considered. Insofar as stability of income substitutes for absolute levels and the stability of income from wheat use differs from the stability of income from range use, this is a gap in the analysis. Another criterion of land use, that of conservation of land resources in the sense of a fund, is not considered here. However, conservation goals with respect to land as a fund resource are often so arbitrary or conflicting as to defy valuation. Given future values and a time preference for returns, this criterion could also be set up in the production-distribution framework and the value of the use of the fund over time introduced as a condition.

Perhaps the most serious data gap lies in the lack of information on the spread in nonland costs of production by enterprises. Part of this gap could be closed by knowledge of the scale relationships in Great Plains farming; that is, what is the most efficient size of farm and what happens to the level of average cost as farm size increases?[37] Another part of this gap is due to the problem of valuing underemployed labor and capital resources in farming when opportunity costs in other pursuits are not realistic in the short run.

When acres of soil types in the county are summed, the treatment of total acreages as if they occurred in continuous tracts is limiting as a means of specifying most economic use. Location of land, with respect to other kinds of land and with respect to other uses, is a variable in determining most economic use. Location of land with respect to the institution of property rights is also a variable in determining most economic use. This limitation in specifying most economic uses of land exists in the use of aggregate acres of soils even if the area is all in one use or if uses vary and the soil is of equal productivity.

In the economic analysis of regrassing, data are needed on the response of lands of varying productivities to regrassing. In addition

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[37] Some recent work in Great Plains states has been aimed at closing this knowledge gap. Two such studies are: Esmay, J. L., *Efficient Resource Combinations on Dryland Farms in Southeastern Idaho,* Idaho Agricultural Experiment Station Bul. No. 355. April, 1961, and Karl, W. G., *Cattle Ranching in the Northern Plains Area of Wyoming: A Preliminary Report.* Mimeo Circular No. 155, Wyoming Agricultural Experiment Station, Univ. of Wyo., Laramie. June, 1961. The former study concludes limited economies of scale exist in the range of size from 1,000 to 3,000-acre wheat farms. The later study concludes (page 19) "It is apparent that no particular size (120 to 873 breeding cows and yearling heifers) or type of operation (cow-calf or cow-calf-yearling) is outstanding in productivity or efficiency over other types."

to these physical data needs, we need to know more about the economic horizons of individual farmers and their time preference for income. Forecasting future prices and costs is an additional hazard not unique to this problem. The value of the classification used in this study for determining best land use in the long-run is limited by lack of knowledge of future relative changes in prices of products, in prices of factors and in technology. The use of rapid data processing would not solve this problem, but would allow reclassification of land as physical and economic factors change.

Role of Rapid Data Processing Methods

By the use of rapid data processing techniques,[38] the land could be reclassified in a relatively short time in response to changes in yields, prices, and costs. This technique would add flexibility to the classification and help overcome a serious disadvantage of previous proposals to classify land economically. The objection has been that economic land classifications were useful only for a short period of time, for example, until there was a rather sharp change in demand or supply conditions affecting the factors or products. The basic input data in a rapid data processing system would be identification of the area, the soil type and the yields of alternative crops adapted to the soil. The yields of the crops could be considered more or less permanent depending upon the rate at which the yield is increasing (or perhaps decreasing in limited cases) over time.

The two values estimated for the classification of land in this report are the land returns to a given land use, and the ratio of the land returns in the given use to the land returns in an alternate use. The essential variables needed to calculate the land returns and returns ratios are: (1) the yields of products for each land use to be considered, (2) the price assumptions for each product, and (3) the assumed costs of production (nonland) for each land use to be compared.

There may be considerable cost advantages in making these calculations by methods of rapid data processing. The rapid data processing procedure may also be advantageous when considering alternative prices of products, costs of production or yields of products. In addition, annual costs of shifting use (e.g. regrassing cropland) may be introduced as an adjustment of cost or returns of a use to estimate the advantage if present land use is considered as a variable.

The cost of calculating returns and returns ratios by means of a high speed computer for the small number of soils in this study was undoubtedly higher than hand methods. However, it was desired to set up a system for making the calculations by high speed methods for

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[38] See Appendix D for a description of a computer program which could be used to classify land economically.

possible use with larger numbers of soils and additional areas. Once a program is developed the cost per soil declines as the number of soils compared increases. With repeated use, the cost of the rapid data method with use of high speed computers is substantially less than the hand method of calculation.

Application and Implementation of an Economic Land Classification

Individuals and local, state, and national decision-making units are concerned with best use of land and nonland resources. Some of the uses of a classification of land resources on the basis of economic criteria are discussed below.

1. For public policies related to allocation of nonland resources between kinds of land. Under present conditions of over-abundant agricultural products, and with indications of deterioration of land resources from too intensive uses, public policies may be required to direct the movement of nonland resources between kinds of land and between areas. This purpose requires both an inventory of the production potential of land and knowledge of the process of decision-making in land use by individuals.

2. For policies related to allocation of nonland resources between agriculture and the rest of the economy. Returns to land under alternative uses could be compared to assess the land for its best use and its capacity to absorb nonland resources. The direction of shift would be determined by the relative contribution of these resources in agricultural and non-agricultural sectors.

3. For assessing the feasibility of policies to alter existing institutional arrangements in different areas of the Plains. Many land uses are influenced by ownership or other institutional arrangements. Economic potential of lands (to society) does not follow property lines nor depend on tenure arrangements between individuals. Therefore, a knowledge of the process and factors conditioning land uses and their quantitative effects is needed to influence the direction of land-use changes.

4. For real estate lending policies. Setting these policies requires a knowledge of the economic potential of land of given physical characteristics in alternative uses and the most economic use which can be made of the land.

5. For equalization of tax assessment. This is an almost universal problem. It is especially critical in areas where shifts in land use are occurring rapidly. A procedure for determining the economic potential of land in terms of its tax-paying ability would be useful here.

6. For resource development programs. The economic potential of land is useful in estimating the costs and returns, as well as the best types and sizes of farm units, for the development area.

7. For estimating sale or rental values of land for public land purchase or lease programs. There was need for an estimate of land returns and values during the land purchase program of the 1930's. There was a similar need under the Conservation Reserve program begun in 1956. States and the Federal Government also lease and sell land to private parties.

8. For planning organization and distribution of local government services. Knowledge of the economic potential of land would be valuable in estimating the probable man/land ratio and the needs for certain types and amounts of services.

In the discussion of means of implementation, land-use decisions may be classified by two levels: (1) the farm firm level and (2) levels beyond the farm firm: local, state, and national. Conflicts between the individual farmer and higher levels of decision-making may arise because of limited planning horizons; tenure arrangements and the locations of property lines; and the knowledge, management abilities and preferences of the farm operator. The result is that many socially desirable land use patterns are uneconomical for the individual. These possible areas of conflict should be recognized in attempts to implement classifications of land for levels beyond the farm firm. Without changes in institutions, including the shifting of some of the risks involved in land-use changes, there will continue to be rather large differences between the feasibility of patterns of land use at the firm level and at higher levels of decision-making.

The theory and method of classifying land economically, as outlined in this report, goes only part way in specifying desirable land-use patterns. An attempt has been made to allow for firm differences by use of a rather arbitrary range of costs for enterprises, since land-use decisions are most often made within the framework of the farm firm. More research is needed on the actual production cost differences between grades of land and between firms being operated under different conditions. Social objectives in land use need to be identified and made explicit.

An alternative approach, assuming that farmers attempt to maximize their returns subject to the restraints imposed by institutions, is to observe actual uses made of given land by a majority of the farmers and apply these "best" uses to an area. This measure can be made by use of the discriminant or probability analysis technique.[39] In general, land is classified (or the land-use margins are specified) by the present uses. An advantage of this method is that institutional restraints are made a part of the land-use decision. An obvious disadvantage is that institutional restraints on land use cannot be separated from uneco-

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[39] This technique has been used to classify farms into wheat and range classes. See D. M. Blood, *Delineating Firms Sensitive to Shifts between Wheat and Range Forage in the Northern Great Plains,* Mont. St. College, Bozeman, Mt. Mimeo Cir. No. 84, Sept. 1954.

nomic land use and if many land users have gone beyond the margin in a use (for example, a large number of farmers are cropping submarginal cropland) or land use is based on past conditions which are no longer relevant the land-use margin will be biased in terms of the land returns criterion.

One way of applying the probability analysis used in this report is to relate statistically the percent of cropland to yields of wheat for different soils. The coefficient of the wheat yield variable approximates the percentage change in land use from range to crop use as yield changes. The wheat-range margin is estimated by identifying soils with a predicted cropland use index of 50 percent. For soils with a value greater than 50 percent, presumably the marginal rate of substitution between the two is less than the inverse price ratio net of nonland costs and these soils are on the wheat use side of the margin. The opposite would be true for soils with a value less than 50 percent—they would be on the range-use side of the margin. This type of analysis, of course, requires yield estimates for soils and alternative uses, which are not now available for many areas of the Plains. Research on production functions for Great Plains soils is needed to determine the relationships between yields and soil characteristics and nonland inputs.

APPENDIX A -- WHEAT AND BEEF YIELDS

Wheat

Wheat yields in this study are expressed, with few exceptions, in bushels per crop acre. Yields on a crop acre basis were estimated by adjusting harvested-acre yields from the Kimball County Soil Survey Report for summer-fallow and rates of crop abandonment (Table 1).

Management level A, assumed in these yield estimates, is described as a "management system that provides turning under crop stubble, alternating crops and fallow and strip cropping."[1]

Rates of wheat crop abandonment averaged about 25 percent for the period 1930 to 1957.[2] Rates of from 20 to 30 percent were used for the soils in this study.[3]

Among additional causes of abandonment are slope, depth, and position of soil. Yields of individual soils were discounted an additional 10 to 20 percent for differences in these characteristics.[4] Harvested yields of the steeper, shallower soils were discounted by 30 percent because of: (1) loss of water through runoff, (2) less water hold-

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[1] *Kimball County Soil Survey Report.* Op. cit., page 27.

[2] Ibid., page 69.

[3] Eikleberry, Robert, Soil Conservation Service, Lincoln, Nebraska, Private communication, 1960.

[4] Ibid.

Table 1. Wheat yields for soils considered to be suitable for range and wheat use in Kimball County.[a]

Soil	Slope	Depth[d]	Dryland capability[e] unit	Range site	Estimated wheat yields		
					Per harvested acre[a]	Per seeded acre[b]	Per crop acre[c]
Altvan							
Af AW	1–3	D	III e–3	Silty	13	10.4	5.2
Aa	0–1	D	III c–1	Silty	24	19.2	9.6
Aa Aw	1–3	D	III e–1	Silty	21	16.8	8.4
Aa BW	3–5	D	III e–1	Silty	19	15.2	7.6
Aa CW	5–9	D	IV e–1	Silty	14	11.2	5.6
*3 AAW	1–3	M	III e–1	Silty	17	11.9	6.0
*3 ABW	3–5	M	IV e–1	Silty	12	8.4	4.2
*3 ACW	5–9	M	IV e–1	Silty	10	7.0	3.5
Bayard							
Bf BW	1–5	D	III e–3	Sandy	10	8.0	4.0
Bridgeport							
BhA	1–3	D	III e–1	Silty	20	16.0	8.0
BhB	3–5	D	III e–1	Silty	17	13.6	6.8
Chappell							
*Ch AW	1–3	M	III e–3	Sandy	10	7.0	3.5
Cheyenne							
*Cy	0–1	M	III c–1	Silty	15	10.5	5.2

Table 1 (continued)

Soil	Slope	Depth[d]	Dryland capability[e] unit	Range site	Estimated wheat yields		
					Per harvested acre[a]	Per seeded acre[b]	Per crop acre[c]
*Cy A	1–3	M	III e–1	Silty	14	9.8	4.9
Glendive							
Gd	0–1	D	III e–3	Sandy	13	10.4	5.2
Goshen							
Go	0–1	D	II c–1	Silty	26	20.8	10.4
Go A	1–3	D	III e–1	Silty	24	19.2	9.6
Haver							
He	0–1	D	II c–1	Silty	24	19.2	9.6
Keith							
Ke	0–1	D	III c–1	Silty	24	19.2	9.6
Ke AW	1–3	D	III e–1	Silty	23	18.4	9.2
KE BW	3–5	D	III e–1	Silty	20	16.0	8.0
Parshall							
Pn	0–1	D	III e–3	Sandy	17	13.6	6.8
Pn BW	1–5	D	III e–3	Sandy	16	12.8	6.4
*Pn CW	5–9	D	IV e–1	Sandy	14	9.8	4.9
*3 Pn	0–1	M	IV e–3	Sandy	10	7.0	3.5
*3 PnB	1–5	M	IV e–3	Sandy	9	6.3	3.2
Rosebud							
Rb	0–1	D	III e-1	Silty	21	16.8	8.4

Rb AW	1–3	D	III e–1	Silty	20	16.0	8.0
*Rb BW	3–5	D	III e–1	Silty	17	11.9	6.0
*Rb CW	5–9	D	IV e–1	Silty	14	9.8	4.9
3 RbW	0–1	M	III c–1	Silty	17	13.6	6.8
*3 R AW	1–3	M	III e–1	Silty	14	9.8	4.9
*3 R BW	3–5	M	IV e–1	Silty	12	8.4	4.2
*3 R CW	5–9	M	IV e–1	Silty	10	7.0	3.5
Tripp							
Tr	0–1	D	III e–3	Sandy	21	16.8	8.4
Tr A	1–3	D	III e–3	Silty	19	15.2	7.6
Tr BW	3–5	D	III e–3	Silty	15	12.0	6.0
Ta	0–1	D	II c–1	Silty	24	19.2	9.6
Ta Aw	1–3	D	III e–1	Silty	21	16.8	8.4
Ta BW	3–5	D	III e–1	Silty	17	13.6	6.8
Ta CW	5–9	D	IV e–1	Silty	13	10.4	5.2
Vebars							
Vr AW	0–3	D	III e–3	Sandy	12	9.6	4.8
Vr BW	3–5	D	IV e–3	Sandy	9	7.2	3.6

[a] Yield predictions from *Soil Survey for Kimball County, Nebraska.* Management level A, Cooperative S.C.S., U.S.D.A. and Univ. of Nebraska, March 1962, pages 28-29. Yields will be slightly higher for soils occurring in the Keith-Rosebud Association in northwestern Kimball County.

[b] Harvested yields per acre are discounted by abandonment rates of 20-30 percent. Soils with (*) are discounted 30 percent for slope and/or depth of soil. The remainder are discounted 20 percent. Historical abandonment rates (1932-56) were 25 percent. Twenty to thirty percent range in abandonment recommended by Robert Eikleberry, Soil Survey, S.C.S., Lincoln, Nebraska.

[c] Yields per seeded acre divided by 2 since a system of alternate year summer fallow and wheat is practiced.

[d] All soils are either deep or moderately deep. D denotes deep and M, moderately deep.

[e] These capability units are for soils outside of the Keith-Rosebud Soil Association.

ing capacity, and (3) loss of nutrients through runoff and erosion.[5] Yields per crop acre may be converted to a harvested yield by multiplying by 2.86 for 30 percent abandonment and 2.5 for a 20 percent rate of abandonment.

Beef

Beef yields were estimated for a cow-calf-yearling operation in which yearling animals are sold at 720 pounds in late September or early October. Yields of beef per acre were estimated by assuming normal yields and using acreages recommended by the Soil Conservation Service and the Nebraska Experiment Station. Annual operations of the herd are shown in Table 2. Acreage requirements and annual yields are illustrated in Table 3.

Beef yields and/or carrying capacity are not available by soil type. Recommendations are made only by range site. For the soils in this study recommendations do not vary for the range sites, sandy and silty, represented.[6]

APPENDIX B - - COSTS, PRACTICES AND PRICES

Wheat Costs and Practices

Average total nonland costs for wheat production in Kimball County are shown in Table 4. Size of farm assumed for these costs is 1,000 to 3,000 total acres. Approximately 2,600 acres would make the wheat farm comparable to the cattle ranch in terms of a total annual labor requirement of 1,870 hours, and labor income of $3,740.

Practices and labor requirements are summarized in Table 5. Nonland costs by yield classes are summarized in Table 6.

Beef Costs and Practices

Costs of beef production are based first on the assumptions in Appendix A. It is further assumed that changes in inventory values from year to year average zero and that breeding cows are raised on the ranch. Costs are classified into investment, other capital costs, and labor costs (Table 7).

Returns for two levels of costs are summarized in Table 8. The farm price, weighted for livestock weights and classes, is $18.46 per hundredweight.

Marketing costs and sources of data are summarized in Table 9. Labor requirements are given in Table 10.

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[5] Ibid.

[6] Dyksterhuis, E. J., Private communication and materials from Range Technicians' Guide. 1960.

Table 2. Cow-calf yearling livestock operations, Kimball County, Nebraska.[a]

Kinds and classes of livestock	Number	AU factor	Jan. Feb. Mar. Apr. May June July Aug. Sep. Oct. Nov. Dec.
Cows (with calves)	100	1.0	← winter feed — → ← — — — — — — — — — — Grazing — — — — — — — → (Weaning)
Calves, weaner	90	.4	← winter feed — → ← — Grazing — →
Yearlings	90	.7	← — — — — — — — — — Grazing – →
Long yearlings (rep. heif.)	14	.7	← — Grazing — →
Coming 2 Yr. Olds	14	.9	← winter feed — → ← — — — — — — — Grazing — — →
Bulls	4	1.3	← winter feed — → ← — — — — — — — — — Grazing — — — — — — — — →

[a] This table is based on recommendations of the Soil Conservation Service, U. S. Dept. of Agriculture, and the Nebraska Agricultural Experiment Station, Lincoln, Nebraska, 1960.

Table 3. Acreage requirements and beef gains for beef breeding herds in Kimball County, Nebraska.[a]

	No. of months	Acres required		
		Per AUM	Per AU	Total
Pasture requirement:				
Cows (100)	10	2.0	20	2,000
Weaner calves (90)	3	.8	2.4	216
Yearlings (90)	7	1.4	9.8	882
Yearlings (repl. heif.) (14)	3	1.4	4.2	59
2 Yr. olds (14)	6	1.8	10.8	152
Bulls (4)	10	2.6	26	104
Total pasture acres				3,413
Hay requirement:				
Cows (100)	2	.334	.667[b]	66.7
Coming 2 Yr. olds (Heif. repl.) (14)	2	.300	.600[c]	8.4
Weaner calves (90)	2	.134	.267[d]	24.0
Bulls (4)	2	.438	.875[e]	3.5
Total hay acres				102.6
Total pasture and hay requirement				3,515.6
Beef gains, with yearlings sold at 720 pounds:				
Total pounds				
Yearlings (89.55 at 720#)[f]			64,476 lbs.	
Less repl. heifers (14 at 720#)			10,080	
Plus cull cows (13 at 1,000#)[g]			13,000	
Plus cull bulls (2/3 at 1,500#)			1,000	
Total pounds sold per year			68,396 lbs.	
Pounds per acre				
68,396 lbs. ÷ 3,515.6 acres			19.5 lbs.	

[a] The following assumptions are made: (1) Pasture is native range in the good condition class on silty upland soils as classified by S.C.S. range conservation standards. Average weather is assumed. (2) Bulls are purchased as mature animals and replaced every six years. Four bulls are kept for 100 cows. (3) Cows are culled by September 1. Cows are replaced every seven years on the average. (4) Cows are bred to calve in March and April. A 90 percent calf crop is weaned in September-October. (5) Cows, calves, and yearlings are wintered on a maintenance ration only. (6) The pasture season is 10 months in length with 2 months of roughage feeding. (7) Calves and yearlings are sold around October 1.

[b] Assumes requirement of 200 AUM, 1 ton of hay for 3 AUM, and yield of 1 ton an acre.

[c] Assumes .9 of cow requirement per animal.

[d] .4 of cow requirement.

[e] 1.3 of cow requirement.

[f] A death loss of .5% is assumed for yearlings.

[g] A death loss of 1% is assumed for cows.

Table 4. Summer-fallow wheat—average nonland costs per seeded and per crop acre, 1959.[a]

	Cost per acre				Total cost (seeded A.)	Cost (crop A.)
	Use of machine[b]	Power[c]	Prelim. prep.[d]	Labor[e]		
	(Dol.)	(Dol.)	(Dol.)	(Dol.)	(Dol.)	(Dol.)
One way disk 10′	.23	.44	.17	.57	1.41	.70
Duck-foot subtiller 10′	.28	.45	.20	.67	1.60	.80
(3) Rod weeder 24′	.27	.52	.20	.68	1.67	.84
Drill 14′	.44	.27	.16	.40	1.27	.64
Combine 12′ S. P.	3.06	. . .	.51	.56	4.13	2.06
Total	4.28	1.68	1.24	2.88	10.08	5.04
Seed					1.11	.56
Seed treat and clean					.08	.04
Spraying					.47	.23
Total (except hauling and storing)					11.76	5.87

[a] Changes in costs since 1947 from *The Farm Cost Situation,* AMS, USDA, Washington, D. C., May 1959, p. 2. 1947 costs from *Cost of Operating Machinery on Nebraska Farms,* F. Miller, Q. W. Lindsey, and A. G. George, December 1948. Nebr. Agr. Exp. Sta. Bul. 391, Lincoln, Nebr. Machine operations from *A Comparison of Alternative Systems of Farming in S. Kimball County, Nebraska,* by R. D. Vlasin. Unpub. M.A. thesis, 1956, Lincoln, Nebr., Univ. of Nebr. Lib.

[b] Includes depreciation, repairs and lubricants, shelter, interest, insurance, and taxes. Annual use assumed in acres is one way disk 780, duck-foot subtiller 312, rod weeder 1,880, drill 496, and combine 421 (acres). Nebr. Agr. Exp. Sta. Bul. 391, pp. 22-24.

[c] Power costs were $1.36 per hour for the duck-foot and drill, assuming 21-25 drawbar horsepower, and $1.55 per hour for the one way and rod weeder, assuming 26-30 drawbar horsepower.

[d] Preliminary preparation charged approximately 14 percent of other costs.

[e] Labor charged at $2.00 per hour.

Table 5. Wheat summer fallow practices[a] and hourly requirements[b] per acre.

Machine	Months	Hours/acre time required
One way 10′	April	.29
Duck-foot sub-tiller 10′	May	.33
(3) Rod weeder 24′	June, July, August	.34
Drill 14′	September	.20
Combine 12′ s.p.	July	.28
Total hours		1.44
Hours per year		.72

[a] R. D. Vlasin, op. cit.

[b] Miller, et. al. op. cit.

Table 6. **Wheat summer fallow practices and costs by yield classes, Kimball County, 1960.**[a]

Practice	Yield per crop acre	Times over	Adjusted cost per crop acre
			(Dol.)
One way disk	all	1	0.70
Subtiller	all	1	0.80
Rod weeder:			
1.	10.4–8.4 Bu.	4	1.12
2.	8.0–6.4	3	0.84
3.	6.0–4.8	2	0.56
4.	4.2–3.2	1	0.28
Drill	all	1	0.64
Combine	. . .	.7–.8	1.44–1.65
Seed:			
1.	10.4–8.4	1	1.04
2.	8.0–6.4	1	0.83
3.	6.0–4.8	1	0.83
4.	4.2–3.2	1	0.55
Hauling and storing	all	. . .	$0.05 per bushel

[a] See Table 6 page 20 for summary of costs by yield classes and assumptions.

Table 7. Annual nonland costs of cow-calf-yearling operation in Kimball County, Nebraska, 3,516-acre ranch and 100-cow herd.

Investment:

1. Livestock

Kind	Weight	Value/cwt.[a]	Number	Months[b]	Investment
Cows	1,000	$12.51	100	12	$12,510
Calves	400–450	25.12	90	5	4,004
Yearlings[c]	450–750	20.60	90	7	6,489
Heifer yearlings	750–800	18.58	14	3	504
2-yr. old heifers	900	12.48	14	8	1,048
Bulls			4	12	2,200
Total livestock investment					$26,755
2. Machinery and equipment[d]					7,100
Total all nonland investment					$33,855
Annual nonland investment cost at 6%					2,031

Other capital costs:[e]

Item and quantity	Cost/cow unit	Cost/100 cows
	(Dol.)	(Dol.)
Power costs for hay—1.03 T at $2.75/T	2.83	283
Protein, salt and minerals	11.25	1,125
Veterinary and drugs	5.00	500
Bull—⅔ at $550	3.67	367
Maintenance and depreciation on wells and fence	2.00	200
Taxes and insurance, 1.5% of investment	5.08	508
Depreciation and repairs on machinery and equipment—9%	6.39	639
Miscellaneous expense 1.5% of gross	2.06	206
Total other capital costs	38.28	3,828

Labor costs:

18.8 Hrs./cow unit[f] X 100 cows at $2.00/Hr.[g] = 3,760

Summary of nonland capital and labor costs:

Item	Cost/cow unit	Cost/100 cows	Cost/acre
	(Dol.)	(Dol.)	(Dol.)
Investment	20.31	2,031	0.58
Other capital	38.28	3,828	1.09
Labor	37.60	3,760	1.07
Totals	96.19	9,619	2.74

[a] This is farm value and was estimated by deducting transportation and other marketing costs from Omaha market prices. Livestock prices for Omaha (1955-59) were obtained from *Livestock Market News,* AMS, USDA.

[b] Investment in livestock was weighted by the number of months the animal is owned by the farm operator or the number of months the animal is in a specified class.

[c] The yearlings' sexes are divided: 59% steers and 41% heifers. This division is reflected in the value/cwt. assigned to this class.

[d] The value of machinery and equipment is based on unpublished data from Nebraska Sandhills' ranches of approximately the same size. Unpublished data, Dept. of Agr. Econ., Univ. of Nebraska, 1959.

[e] Based on budgetary data given in *Greater Returns from your Farm,* by Arlen Lutz. Nebr. Ext. Cir. 58-810, Lincoln, Nebraska, pp. 17-18. The hay cost was estimated for power costs only.

[f] Labor requirement from unpublished data, Dept. of Agr. Economics, Univ. of Nebraska, Lincoln, Nebraska.

[g] Assumed current marginal value product of labor is $2.00 per hour.

Table 8. Returns to cow-calf-yearling operation, Kimball County, Nebraska 3,516 acres.

Animal	No.	Lbs. sold	Omaha price	Marketing cost	Gross return
Yearlings[a]	75.55	54,396	$22.20	$887.30	$11,188.61
Cull cows	13	13,000	11.71	189.00	1,333.30
Bulls	⅔	1,000	16.18	13.70	148.10
Total gross return					$12,670.01
Gross return per acre					$ 3.60
Return to land per acre[b] (Average nonland cost)					$ 0.86
Return to land per acre[c] (Low average cost)					$ 1.82

[a] Divided 59% steers and 41% heifers after deduction for replacement heifers.
[b] The return to land is exclusive of taxes on land. A cost of $2.74 per acre for nonland resource inputs is based on inputs and factor costs specified in the foregoing table.
[c] Low cost is 65 percent of high cost to allow for, among other things, scale differences between ranches.

Table 9. Cost of marketing livestock from Kimball, Nebraska, farm to Omaha.

	Cost
Farm to city of Kimball (truck)[a] per cwt.	$0.20
Kimball to South Omaha (rail)[b] per cwt.	0.99
Expenses at Omaha Terminal per head[c]	2.68
Cost per 100# for 1,000# cow	1.46
Cost per 100# for 750# yearling	1.55
Cost per 100# for 400# calf	1.86

[a] G. E. Klipple, Range Conservationist, Crops Research, A.R.S., U. S. Department of Agr., Fort Collins, Colo. Private communication, March 2, 1960.
[b] U. P. ticket office Private communication, July 15, 1960. Carload rate 22,000-24,000/carload.
[c] Information provided by Dr. Matsushima, Anim. Husb. Dept. University of Nebraska, Lincoln, Nebraska Private communication, July 15, 1960. Includes commission $1.08, yardage $1.05, feed $0.33, transit ins. $0.20, and meat board $0.02.
Based on 1959 sale of 72 head and 45,740 total pounds. Total costs:

Commission	$ 78.00
Yardage	75.60
Feed	23.68
Transit ins. (truck)	14.40
Meat board	1.40
Total	$193.08

Table 10. Labor requirements for cow-calf-yearling operation, Kimball County, Nebraska.

Hours for yearling wintering and grazing	6.75 Hr.[a]
Hours for cow-calf	10.00 Hr.[a]
	16.75 Hr.
Labor requirement for hay	2.06 Hr.[b]
Total	18.81 Hr.

[a] Source: Unpublished data, Dept. of Agr. Economics, University of Nebraska, Lincoln, Nebraska.
[b] Labor requirements for mowing, raking, sweeping, and stacking hay from A. W. Epp, *Cost of Operating Machinery on Nebraska Farms,* Nebr. Agr. Exp. Sta. Bul. 413, September 1952, Lincoln, Nebraska.

Product Prices

Wheat and beef prices used in this study are given in Tables 11 and 12.

Table 11. Wheat prices[a] for northwest Nebraska crop reporting district.

Year	Price/bushel
	(Dol.)
1955	2.00
1956	1.95
1957	1.85
1958	1.65
1959	1.61
Average	1.81

[a] Prices from Nebraska Agr. Stat. Annual Reports, 1955-58. State Federal Division of Nebr. Agr. Statistics, Lincoln, Nebraska.

Table 12. Omaha livestock prices.[a]

	Average price per cwt.
	(Dol.)
Slaughter:	
Cows—canner and cutter, Oct. 1955-59	11.71
Bulls—Util. and com. Oct. 1955-59	16.18
Stocker and feeder:	
Bulls—herd replacement price, local Oct. 1955-59	550.00[b]
Steers, 500-800# gd.-choice:	
Oct. 1955-59	23.62
Mar.-Sept. 1955-59	23.72
Heifers, 500-750# gd.-choice:	
Oct. 1955-59	20.20
Mar.-Sept. 1955-59	20.77
Cows, Util. slaughter grade:	
Av. yearly, 1955-59	13.97
Steer calves, 300-500# gd.-choice:	
Oct. 1955-59	27.42
Oct.-Feb. 1955-59	26.94
Heifer calves, 300-500# gd.-choice:	
Oct. 1955-59	23.87
Oct.-Feb. 1955-59	23.54

[a] *Livestock Market News,* Livestock Division, AMS, USDA, Washington 25, D. C.
[b] Based on private communication with Paul Guyer, Dept. of Anim. Husb., Nebr. Agr. Exp. Sta., Lincoln, Nebraska.

APPENDIX C -- REGRASSING COSTS

Regrassing costs are shown in Table 13. The time distribution of these costs is: $7.88 the first year, $19.59 the second year, and $4.18 the third year. Present value, at 6 percent, is $30.08.

Table 13. Regrassing costs,[a] Kimball County, Nebraska, 1959-60.

Operation	Times or amt.	Mo. or year	Cost/a.
			(Dol.)
Seedbed preparation and seeding:			
One way disk	2	Aug., May	0.83
Treader	1	June	0.18
Drill (sorghum)	1	July	0.34
Drill (grass)	1	April	2.40
Treader	1	April, May	0.18
Mow weeds	2	2d year	1.15
Mow weeds	1	3d year	0.58
Total machine cost			5.66
Labor cost	2.5 Hrs.		5.00
Total			10.66
Seed costs:			
Sorghum[b]	30# at 7.5¢		2.25
W. wheatgrass[c]	5# at 78¢		3.90
Blue grama[c]	3# at 50¢		1.50
Sideoats grama[c]	3# at 90¢		2.70
Little bluestem[c]	4# at 68¢		2.72
Total seed cost			13.07
Total operation and seed cost			23.73
Adjustment for failure—4/3 of total cost (1 failure out of 4)[d]			7.91
Total cost			$31.64

[a] These costs are exclusive of fencing and water costs. In addition, cost is not adjusted for net returns to use of sorghum for grazing or other use. Machine costs based on Vlasin-Epp data op. cit. and increase in index of machine costs of .5982 from 1954 to 1959.

[b] Source: Lancaster Crop Improvement Association, Norghum. 1960.

[c] Source: Eldon Erickson, private communication, Nebraska A.S.C., Lincoln, Nebraska, November, 1960.

[d] Average failure rates for native grass seedings in Kimball County are not known because of limited experience. In light of private discussion with persons with experience in other states it is believed that this failure rate is not too high.

APPENDIX D -- A RAPID DATA PROCESSING PROCEDURE

The following procedure was developed and tested on the Burroughs 205 computer at the University of Nebraska. The procedure outlined is one of many possible procedures which could be used to compare returns to land in alternative uses assuming both a.) no cost of shifting and b.) a cost of shifting use.

The various steps involved in performing the classification of soils by means of the rapid data technique may be summarized as:

1. Obtain estimates of per acre yields, production and use-shifting costs by soils, and make price assumptions.
2. Determine identification codes for study area, soils and any other items desired on the cards.

3. Plan the layout of the data on the punchcards. At this point consideration must be given to the number of uses which will be compared, as well as the number of price and cost assumptions, in order to determine whether one or more cards are needed per soil and the number of items which will be common to each "soil" card. In addition, spaces must be allowed for answers if they will be punched on the same card as the data.

4. Punch the data on cards.

5. Develop the computer program. This step may have to be done concurrently with the punchcard layout planning without some knowledge of the operations of the computer. This step involved setting up the commands which the computer will perform to arrive at the desired answers—where the data is located, what operations to perform and what to do with the answer.

6. Make the computations and punch the answers. In this step the program is read into the computer, the input (data) cards are placed in the reading stage, the output (answer) cards are placed in the output stage and the program steps are performed for each card.

7. Print results. The answers are printed from the punched cards along with desired identification codes.

The following layout could be used. It is assumed that the data are punched on one card and the answers are calculated by the computer and punched on another card for each soil. Identification punches (for example columns 1-12 and 79-80) would be pre-punched on the answer cards.

The data card layout:

	No. Cols.	Col. No.
1. Study area	(2)	1– 2
2. Soil identification, coded	(3)	3– 5
3. Range site, coded	(2)	6– 7
4. Land capability class, coded	(2)	8– 9
5. Wheat yield	(3)	10–12
6. Wheat prices at farm		
a. 1955-59 average	(3)	13–15
b. Other price	(3)	16–18
c. Other price	(3)	19–21
7. Wheat costs—1959		
a. Low average, nonland	(3)	22–24
b. High average, nonland	(3)	25–27
Open	(6)	28–33
8. Annual cost of regrassing	(3)	34–36
9. Costs of shifting to other use	(3)	37–39
10. Beef yields (1 decimal)	(3)	40–42
11. Other use yield	(3)	43–45
12. Beef prices at farm		
a. 1955-59 average	(3)	46–48
b. Other price	(3)	49–51
c. Other price	(3)	52–54

Card Layout (continued)

	No. Cols.	Col. No.
13. Other use prices		
a. 1955-59 average	(3)	55–57
b. Other price	(3)	58–60
14. Beef-costs per acre (price a)		
a. Low average, nonland	(3)	61–63
b. High average, nonland	(3)	64–66
15. Beef costs per acre (price b)		
a. Low average, nonland	(3)	67–69
b. High average, nonland	(3)	70–72
16. Other use costs per acre		
a. Low nonland	(3)	73–75
b. High nonland	(3)	76–78
17. Card identification	(2)	79–80

In this data card layout it may be noticed that the soils can be classified under alternative price, cost and land use assumptions. For instance, assuming a 1955-59 price for wheat and low average cost of wheat production, the return to land would be computed by columns 10-12 times columns 13-15 minus columns 22-24. With the data on the card 36 returns ratios between wheat and beef could be calculated for combinations of costs and prices. Alternate price and cost levels could be used by repunching the appropriate columns on the data card.

If a regrassing cost was included, the annual cost of regrassing (including the opportunity cost of wheat returns) would be deducted from beef returns (or added to beef production costs) by making this instruction a part of the computer program. A different program, or program modification, could be devised for each desired set of assumptions.