The economics of pasture integration on irrigated farms
by Clarence William Jensen

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics at Montana State College
Montana State University

Abstract:
Over the past several years there has been quite a large amount of written material, both popular and professional, on the subject of the relative profitability of seeded pastures. This study is an attempt to determine the economic position of the pasture enterprise in the irrigated farm unit.

In Part I a review of the literature in the field of forage production is followed by a discussion of the methods of determining the proportions of crops and forages to be established in the farm organization.

Part II deals with methods of apportioning enterprises and attempts to establish a favorable relationship between the budget method of organizing the farming system and the theory of enterprise selection and combination* A budget of the "typical" farm organization for the area of study is developed in Part III Alternative budgets are developed, with some emphasis given to the effects upon the various organizations from variations in farm product prices.

The conclusions in Part IV are "based upon interpretations of the position the pasture enterprise may hold in the irrigated farm unit.

THE ECONOMICS OF PASTURE INTEGRATION ON IRRIGATED FARMS

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ABSTRACT

Over the past several years there has been quite a large amount of written material, both popular and professional, on the subject of the relative profitability of seeded pastures. This study is an attempt to determine the economic position of the pasture enterprise in the irrigated farm unit.

In Part I a review of the literature in the field of forage production is followed by a discussion of the methods of determining the proportions of crops and forages to be established in the farm organization.

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PART I. INTRODUCTION

Review of the Literature

Throughout the nation a greater emphasis is being placed upon the position of the pasture enterprise in the management and operation of the farm business. Of particular interest to this study is the apparent trend toward increased pasture acreages in the irrigated areas of the West. This is "apparent" in the sense that the importance and frequency of occurrence of pastures on farms is now recognized. However, there is too little information available as to the number of acres or the number of pastures in use in years past with which to make a valid comparison.

Popular Literature--In recognition of the desire by farmers for information regarding the costs and returns of seeded pastures, the most productive mixtures of seed, management practices required in establishment and maintenance, and the production capabilities of these pastures, publishers of farm and other magazines have responded with numerous articles. Of these, one has been selected as representative and especially applicable to this particular area. 1/

The author (Mr. O'Brien) makes no attempt at an economic study other than by the implication of increased profits resulting from decreased labor and operating costs. The article was written primarily for farm readers but in such a manner that interest might be stimulated

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1/ O'Brien, Harry R., "New Pasture Profits for the West," Country Gentleman, Philadelphia 5, Pa., Vol. CXXII, No. 3, March, 1952, p. 27.

in other readers as well. This is accomplished by choosing a few strikingly successful operators who have established pastures on their farms and using them as examples upon which to build a "story."

The title itself, "New Pasture Profits for the West," is indicative of a popular belief that pastures on irrigated land are something new, and, in some respects, this may be true. Irrigated pastures have probably reached a high point in usage, and, as such, they would constitute something "new" to the West. Mr. O'Brien claims this to be a wide-spread change in land use on tens of thousands of western farms and ranches, dwarfing the million-acre Central Columbia basin as to size and importance. The statement is made that cultivated crop acreages are being reduced to "make room" for pastures in irrigation districts that are now established. As an actual occurrence within a farm plan, this may be true, but hardly as a complete substitute for other crops. The author does make mention of the inclusion of pastures in a rotation of crop land but does not attempt to analyze the reason for, or the benefits resulting from, this practice. Pasture profits alone are not the only consideration in determining pasture usage. If this were so, pastures of a more permanent type would probably be called for.

Testimony of the carrying capacity of irrigated pastures was collected for various regions in the West. One operator in Whitman County, Washington reported a sixty-acre pasture carrying 200 cows and calves "in midsummer," but no mention was made of the length of the

grazing season. In western Oregon, yields the equivalent of six to ten tons of alfalfa per acre were attributed to irrigated land after 500 to 1000 pounds of ammoniated sulfate were applied. This equivalent yield was not clarified, leaving the reader to conclude for himself that this must have been an equivalent in grazing, probably based upon feed requirements for various kinds of livestock.

Regardless of the interest which the article may be capable of promoting, it will fall short of giving a farmer the information he would need to evaluate the economic position of pastures on his farm. No apparent effort was made to determine the costs involved in establishing a pasture, the recommended establishment and maintenance practices, or the risks involved in getting a pasture started.

Professional Literature--The need for more adequate information has also been recognized by Experiment Stations of the West. Many experiments have been carried on with pasture grasses and legumes, both of an agronomic and an economic nature. One of the earliest experiments was conducted at the Huntley Experimental Farm, beginning in 1913. 2/ This began as a preliminary test of the relative productivity of various grasses and legumes, both separately and in mixtures. Three different

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2/ Hansen, Dan, Irrigated Pastures, University of Montana Agricultural Experiment Station Bulletin No. 166, Bozeman, Montana, September, 1924, p. 6.

mixtures were used (labeled Mixture No's 1, 2, and 3) 3/, with each mixture seeded by four different methods. These four methods were (a) spring seeded with a nurse crop of wheat cut for grain; (b) spring seeded with a nurse crop cut for hay; (c) spring seeded without a nurse crop; and (d) late summer seeding without a nurse crop. Method (c) out-yielded methods (a) and (b) by 1.5 tons of hay, and method (d) by 2.5 tons in the first two years. Also, mixture No. 1 exceeded all others in yield. After the second year, there was less yield difference in the various methods of seeding, with the No. 1 mixture maintaining the highest yields. Even though the non-nurse crop method produced the highest yields of hay the first two years, this was still not the most profitable method. Under method (a) a wheat crop yield of 35 bushels per acre was obtained, giving, in total, a higher net income than the other methods.

The experiments were later expanded to include a determination of the most successful grazing rates and various other management practices which might serve to increase the carrying capacities of these pastures. Tests were also conducted to ascertain the amount of additional

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3/ Mixture Contents

	Rates of Seeding (pounds per acre)		
	Mixture No.1	Mixture No.2	Mixture No.3
Awnless bromegrass	2	2	0
Orchard grass	5	5	5
Tall fescue	3	3	3
Perennial rye-grass	3	3	0
Kentucky bluegrass	4	4	4
White clover	2	0	2
Alsike clover	2	0	2
TOTALS	21	17	16

production obtainable from top-dressing pastures with barnyard manure.4/ All the experimental plots, totaling six acres, were divided into two equal pastures, A and B. Pasture A was given a top-dressing of manure in the fall of 1920 and again in the fall of 1921 at the rate of 12 tons per acre. All other maintenance practices for the two pastures were similar. The results after three test years indicated a beneficial effect of the manuring. 5/ The pastures were grazed by dairy cows and milk production was credited to the pastures as yield, with average prices for 1918 to 1923 inclusive used for calculating returns. Net returns are net only of supplemental feed. An increase in net returns per acre of $6.01 (gross of manure value and costs of applying) was obtained on pasture A for the three-year average (1921, 1922, and 1923). However, the increase in 1923 alone was $21.66 per acre, or about 20 percent over pasture B. An exception to this increase was that in 1921, the year of the second application of manure, pasture A yielded $2.74 less per acre than pasture B. This might indicate an imbalance between the amounts of nitrogen and phosphorus available to the plants, probably with nitrogen present in excessive amounts. The effect of too high a ratio of nitrogen upon different species of grasses is indeterminate, as all the test plots appear to have been lumped together without regard to seed mixture or method of seeding.

4/ Hansen, Dan, op. cit., pp. 17-20.

5/ Ibid., Table IV, p. 21.

In 1916, a one-acre pasture seeded with the No. 1 mixture was established to determine its maximum carrying capacity under heavy applications of manure. Each year, from 1917 to 1923 inclusive, the pasture received a top-dressing at the rate of about 15 tons per acre. The five-year average net return (using the 1918-23 price average and gross of manure value) was $121.71 per acre, with an average carrying capacity of 2.13 cows per acre. 6/ Here, too, the returns are net only of supplemental feed. The highest rate of grazing was reached in the fifth year, being 2.47 cows per acre during a 136-day season, but the highest net return of $134.22 per acre was obtained in the third year. The returns for the next two years declined to $115.26 the fifth year.

The records of these particular experiments end in 1923, and it is not known whether the moderately fertilized pasture (pasture A) would continue to show increases in returns in following years and whether the heavily manured pasture would continue to decline as it did in the fourth and fifth years of the tests.

A pasture established in 1928 by the Oregon Agricultural Experiment Station was a forerunner of other pasture experiments to follow in that state. Established with ladino clover on land previously abandoned as worthless for ordinary cropping purposes, its success led to thousands of other such irrigated pastures in western Oregon. 7/

6/ Ibid., pp. 20-25, and Table V, p. 24.

7/ Oregon Agricultural Experiment Station, The First Fifty Years of the Oregon Agricultural Experiment Station, 1887-1937, Station Circular 125, Oregon State College, Corvallis, Oregon, August, 1937.

Studies more recently undertaken show a considerable variation in the carrying capacities in the western states (Table I). This may partially be accounted for by wide differences in altitude along with varying lengths of the growing season, the intensity with which management is applied to the pasture enterprise, and in the higher productivity of some soils.

Table I. Irrigated Pasture Production (per acre) in Selected States. (a)

State	AUM's (b)	TDN Equivalents (c)
Montana (d)	7	3415
Oregon (e)	8	2952
California (f)	10	4849
New Mexico (g)	22	10667

(a) Source for AUM's: Baker, C. B., "The Economics of Irrigated Pastures," to be published in the forthcoming Proceedings of the Sixth International Grasslands Congress, Pennsylvania State College, State College, Pennsylvania, August 17-23, 1952.
(b) An "Animal Unit Month" is the grazing of one mature cow for one month or the equivalent of other animals. See Appendix A for AUM conversion table.
(c) This is the equivalent of the Total Digestible Nutrients required by the various classes, ages, and weights of livestock.
(d) Montana Agricultural Experiment Station, unpublished data taken from the Lower Flathead Valley of northwestern Montana in 1949-51.
(e) Oregon Agricultural Experiment Station Bulletin 391; data taken from eastern Oregon, 1935-36.
(f) California Agricultural Extension Service Circular 125; data taken from northern California, 1944-47.
(g) New Mexico Agricultural Experiment Station Bulletin 362; area and period of study not specified.

The length of the growing season in New Mexico along with high land values would likely cause management to be applied much more intensively than in other states, since pastures there must compete

for land use with highly intensive vegetable crops.

Management practices recommended by the New Mexico Experiment Station (which are quite similar to recommendations by other stations) to increase production include rotation grazing by dividing pastures into small plots and moving the livestock frequently, 8/ clipping to control weed growth, numerous light irrigations, fertilization with commercial fertilizers and barnyard manures, and occasional harrowings to spread animal droppings. 9/

A study was conducted to determine the effect of frequency of irrigations and fertilization upon the carrying capacity of irrigated pastures at the Caldwell Experiment Station in southwestern Idaho. It was found that by increasing the irrigations from five to seven during the growing season, the carrying capacity increased 15 percent. When 12.5 loads of manure were applied along with the more frequent irrigations, the increase was 58.7 percent above that of the less frequent irrigations without manure. 10/

These are all examples of positive results from technological investigations of pasture establishment and management. The Idaho study

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8/ Wherever the practice is possible, the recommendation is to lay out plots of a size which will carry the livestock for one day, only.

9/ Staten, Glen, et al, Irrigated Pastures in New Mexico, Agricultural Experiment Station Bulletin 362, New Mexico A & M, July, 1951, pp. 5-17, 28.

10/ United States Department of Agriculture, "Good Pastures," Farmers' Bulletin No. 1942, Washington 25, D. C., May, 1943, pp. 7-8.

is a good beginning in the determination of input-output relationships for irrigation and fertilization. A continuation of this study to determine these relationships at other rates of application should give a more accurate knowledge of productivity at various input levels. With increased knowledge of productivity, a more exacting pasture management program could be expected to yield higher returns to the farmer. In order that the farmer may use his management ability most fruitfully, he needs to know not only that ten tons of manure will increase his yields to fifteen animal unit months per acre; he must also know how much greater the yield will be than if eight tons of manure are applied. The same is true for the relative productivity of different frequencies of irrigation.

Summary--There is nothing new in pasture grazing, as such. Mankind has, throughout history, made use of forages to maintain dairy and meat-producing herds of livestock. However, the use of irrigated land for the production of forages to be grazed by livestock is comparatively new. In this country, development of land and water resources for irrigation has taken place within the last 100 years. 11/ Farmers in these development areas have been constantly exercising their best judgment as to which crops to produce, attempting to find the "best" combination

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11/ Northern Great Plains Council, Toward Stability in the Great Plains Economy, The Agricultural Experiment Station Bulletin 399, University of Nebraska, College of Agriculture, Lincoln, Nebraska, July, 1950, p. 51.

of enterprises. Their experiences have been taken up in popular literature and would convey the impression that, in some instances, pastures are so productive as to be able to replace all other farm crops and still yield a higher income. 12/

It is not a question of determining whether or not the whole irrigated farm ought to be seeded to pasture. Rather, the problem is one of deciding what proportion of the farm in pasture will yield the greatest income to the farm as a unit, integrating seeded pasture as a land use competitor into the plan of operation. Benefits accrue to the land and the income of succeeding crops indirectly, which makes the choice of crops to produce and the plan of rotation depend upon factors other than net income from any one crop in any one year.

The Problem

The purpose of this study is to determine the most profitable proportion of pastures and cash crops in an irrigated farm organization. This is to be accomplished through an empirical study of the costs and returns of seeded pastures as experienced by farm operators in the survey area. A complete budget will be drawn up, based upon a farm organization synthesized as being typical for the area of study, with alternative budgets set up to determine relative profitabilities of the various farm organizations made up of varying proportions of crop, pasture, and livestock enterprises.

12/ O'Brien, op. cit., p. 86.

Enterprise Selection and Combination

The economic problems of deciding upon crop enterprises, crop rotations, and the livestock enterprise, are not of such a nature that the farmer can make his choice of enterprises and set them individually. More often they must be decided upon together in the problem of increasing net farm income. The relationships of one crop to another, the pasture enterprise to these crops, and the livestock enterprise to the pasture and crop enterprises have a direct bearing upon the organization system that will be developed. How these enterprises are selected and combined will directly affect the farm income.

Competitive Enterprises—According to the theory of enterprise selection and combination, choice of enterprises must rest upon the relationships existing between enterprises as well as their individual profitabilities. Some crop enterprises are in direct competition with one another for land, the farmer's labor, use of machinery, and other productive resources. These are called "competitive" enterprises. Wheat and barley, for instance, are competing enterprises in that they cannot usually be grown on the same land at the same time. The growing of one will probably not exhibit a beneficial effect upon the yield of the other. They also require similar resources and at about the same time of the year. If, with a given acreage barley is to be expanded, it must be done at the expense of a corresponding reduction in wheat acreage. 13/ When this relationship exists between two or more crops,

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13/ Hopkins, John A., Elements of Farm Management, Prentice-Hall, Inc., New York, 1947, p. 45.

the choice should be the enterprise with the promise of yielding the greatest net income to the farm as a whole. 14/

This is not an all-or-nothing choice for a permanent basic crop, but a short-term plan, only. (A farmer could hardly expect his management problems to become static over time while operating within a dynamic economy.) The farm business can usually be most profitable, in the long run, if the organization is kept flexible enough to take advantage of changes in the relative prices of competitive crops when the prices of these crops are subject to wide fluctuations. Similarly, when the relative prices of the resources used in production fluctuate, net farm income may benefit if the operation is in position to take advantage of favorable price changes. There must be added the restriction that the farmer's price expectations must be accurate enough for him to choose the crop which turns out to be the more profitable to grow.

There are, however, conditions which may tend to cause specialization in either one or another enterprise. Single enterprise specialization may result in economies of production not obtainable in a more flexible organization. If relative prices (factor and product) are quite stable, a higher net income may be obtained from this type of organization. When the degree of specialization is reduced, the opportunity to get a relatively high net income in any one production period is also reduced. Changes in techniques may tend to render a specialized operation less

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14/ Ibid., p. 46.

profitable if it is incapable of adopting new techniques because of rigidity in the type of organization. Some machinery is adaptable to many different uses. Where single enterprises require highly specialized machinery, time- or use-depreciation is not the only effective cost. Obsolescence may also make a particular type of specialized machinery useless long before it would normally depreciate through usage.

Enterprises which are competitive may substitute for one another in either of two general ways, (1) at a constant marginal rate of (product) substitution, 15/ or (2) at a diminishing marginal rate. 16/ 17/ When the conditions for (1) hold, successive increases in quantity of production of one crop require a constant (corresponding) decrease in the output of another crop. This type of substitution occurs when there is no contribution made by one crop toward the production of another and when both require the same resources during the same period.

Complementary Enterprises--Another type of relationship may be found to exist between enterprises when there is some beneficial

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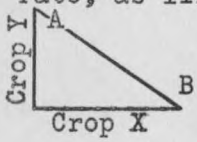
15/ If the crops X and Y substitute for each other at a constant marginal rate, as illustrated by the substitution line AB, it is possible for their price ratio to fall on the same line, indicating an indeterminate situation in which the farmer would not know what to produce; yet, farmers are able to determine which crop to produce.



16/ Heady, E., and Jensen, H., The Economics of Crop Rotations and Land Use, Agricultural Experiment Station Research Bulletin 383, Iowa State College, Ames, Iowa, August, 1951, pp. 431-2.

17/ The Marginal Rate of Substitution is the change in crop Y with respect to a change in crop X (MRS = $\triangle$ Y/ $\triangle$ X).

contribution made by one enterprise toward the added productivity of another. This is referred to as a "complementary" relationship. 18/ Complementary crops may compete for resources within any one crop season, but, by rotating their production, the complementarity becomes effective and an increase in the output of both crops can be expected from a given amount of land and other resources. When two crops are complementary, a greater production of one or both crops may be obtained than if they had been grown independently. 19/ The time span is of some importance regarding yields of crops. This period of time must be long enough for the full effects to be felt in highest yields obtainable from a given rotation. At least one complete rotation of all the crops would be the minimum length of the period of time required for reflection of the full complementary effects.

As a complement to various types of tilled crops, pastures contribute in several ways toward increased crop production. By adding nitrogen to the soil (one of the elements frequently lacking), fertility and productivity can be maintained or increased. Soil tilth and structure are improved through deeper and more abundant root growth of the grasses and legumes. The organic content is also built up when the pasture is plowed under. Other contributions are in the form of weed, pest, disease, and erosion control to the extent that a larger product

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18/ Heady and Jensen, op. cit., pp. 430-1

19/ Ibid., p. 431.

can be obtained from a smaller acreage. 20/

Supplementary Enterprises—Additional enterprises may be added to a farm operation due to a "supplementary" relationship which may exist between certain enterprises. These particular enterprises may utilize labor, land, or equipment when there is little or no demand for them by other enterprises. Most crops have periods of peak demand for resources during a few months of the year, leaving these resources idle the remainder of the time. Idle resources can often be profitably used by a supplemental enterprise. Many crops also require different amounts of the various elements, making it possible to choose crops which do not compete for plant nutrients.

The supplementary relationship of an enterprise can be considered to exist as long as the resources used in its production have an opportunity cost of zero, 21/ with respect to other major enterprises on a given farm. When that restriction in classification is met, only idle unproductive resources will be used for supplementary enterprise production. These enterprises are of less importance than are complementary enterprises in determining the farm organization and rotation of crops, but their contribution to net income may be significant.

Theory of Enterprise Selection and Combination—The largest

20/ Forster, G. W., Farm Organization and Management, Prentice-Hall, Inc., New York, revised edition, 1946, p. 58.

21/ The opportunity cost for any resource used in production is the net return that resource would get in the best alternative use.

possible net income for the farm business can be assumed as the goal which most operators will attempt to attain. With this objective in mind, the problem becomes one of determining a proportion of enterprises which will yield a net income greater than other combinations.

Guiding principles for the selection and combination of enterprises depend upon their respective competitive, complementary, or supplementary relationships as discussed above. Three general rules will best set up the basis of enterprise choice as follows: (1) From among competing enterprises, select the crop or livestock enterprise which promises to yield the largest net income for the use of resources; (2) Combine with the main enterprise those complementary enterprises which will contribute to an increase in the net returns of the farm business; (3) Add supplementary enterprises, making use of idle resources, provided the addition of these enterprises will increase net farm income. 22/

The Competitive-Complementary Continuum--A theoretical model for the selection of the enterprises (grain crops and pasture) within a rotation may serve to show the range of relationships between these enterprises and to give some indication of the proportion of each crop to maintain in the cropping program. There is an empirical problem of obtaining data which will reflect the conditions that would be anticipated from the diagram. The data would have to show responses in yield of grain crops to a number of given changes in the proportions of crops

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22/ Hopkins, John A., op. cit., p. 49.