Economic aspects of water spreader developments on southeastern Montana ranches
by Merle E Quenemoen

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

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The methodology of the investigation is presented in Part II. Also a budget is developed for a typical Northern Great Plains family-operated sheep ranch and alternative budgets are presented for the same ranch after the installation of a water spreader. The increment to net ranch income' resulting from the water spreader is discounted to arrive at the net capital value of the investment.

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ECONOMIC ASPECTS OF WATER SPREADER DEVELOPMENTS ON SOUTHEASTERN MONTANA RANCHES

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MERLE E. QUENEMOEN

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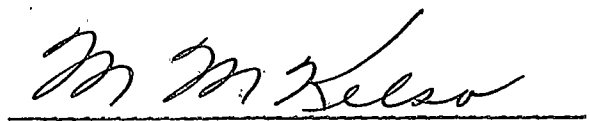
Approved:



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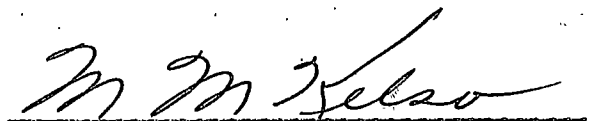

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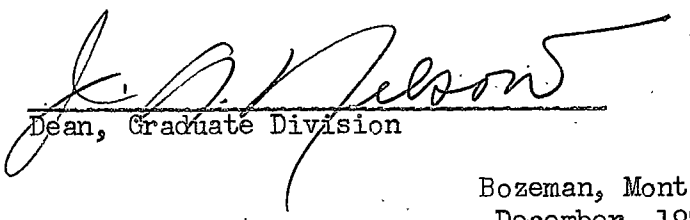

Dean, Graduate Division

Bozeman, Montana
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ABSTRACT

The purpose of this study is to develop a method which may be used in a practical way for evaluating a capital investment, particularly an investment in land development in the form of a water spreader.

Part I develops the various aspects of the problem and provides a setting or foundation for the study. The budget method is described and discussed in relation to its place within the framework of the theory of the firm. The literature concerning the physical properties of water spreaders is reviewed and considered in an economic setting.

The methodology of the investigation is presented in Part II. Also a budget is developed for a typical Northern Great Plains family-operated sheep ranch and alternative budgets are presented for the same ranch after the installation of a water spreader. The increment to net ranch income resulting from the water spreader is discounted to arrive at the net capital value of the investment.

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PART I. INTRODUCTION

The Problem

"Although large scale pioneering and homesteading in new areas is over, new land development is by no means of the past. It goes on continuously, the rate of development fluctuating with economic conditions." 1/

This study represents an inquiry into one phase of the above phenomenon. Since the passage of the Taylor Grazing Act in 1934 the boundaries of the individual ranches of the west have become clearly defined. Now, more than ever, ranchers are faced with a fixed land resource.

There are two common problems confronting ranchers in the Northern Great Plains area. Clawson states that one of the major problems of the range livestock industry is to achieve units large enough to provide the ranch family with sufficient employment and income. 2/ The other problem is to obtain a balance of feed resources that will maximize net profits to a given ranch.

In resolving these problems the rancher has two alternatives. He may purchase or lease more land, or make a capital improvement on his present land or a combination of both. He must determine which alter-

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1/ H. H. Wooten and M. R. Purcell, Farm Land Development, Present and Future, U.S.D.A. Cir. 825, October, 1949, p. 1.

2/ Marion Clawson, The Western Range Livestock Industry, New York, McGraw-Hill Book Company, Incorporated, 1950, p. 199.

native or combination of alternatives will yield him the greatest net return.

It is the objective of this study to develop, step by step, a methodology for evaluating land improvement in a ranch economy. To give the study as great a degree of realism as possible, the specific case of land development by the use of a water spreader device will be used.

Physical Aspects of Water Spreading

Water spreading, often used synonomously with flood irrigation, is defined as the practice of diverting flows from ephemeral streams and distributing the water over permeable soils of valley floors. 3/

Although flood irrigation is relatively new in some localities of the United States it has a long history. Flood water farming was one of the important sources of livelihood of the prehistoric sedentary Indians of the Southwest. 4/ Evidence of these old structures can still be found.

Properly constructed water spreaders, on adaptable sites, have found great favor with ranchers and farmers. They provide a practical method of controlling gully erosion on range land as well as increasing forage production. In many cases water spreaders have saved a valuable ranch resource by checking gullies from "cutting back" into productive

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3/ D. S. Hubbell and J. L. Gardner, Effects of Diverting Sediment-Laden Runoff From Arroyos to Range and Crop Lands, U.S.D.A., Tech. Bul. No. 1012, Aug., 1950, p. 1.

4/ K. Bryan, "Flood Water Farming," Geographical Review, XIX (July, 1929), pp. 444-456.

rangeland. 5/

There are many types of water spreaders. Dikes, dams, ditches, weeps, headgates, and other devices may be used in getting effective flood irrigation. Water spreaders are not built to pattern but are built to fit the land. It is apparent then, that these devices will vary considerably depending on prevailing conditions.

The objective in any water spreader system should be to utilize, as completely as possible, the water available in such a way that the stock resources of the soil are not uneconomically depleted. 6/ The available land for development is, of course, a limiting factor here.

There are various schools of thought among engineers on methods of attaining this objective. For instance, dikes may be built large enough to handle the total amount of runoff water that flows in the creek or smaller dikes may be built and a control system installed at the diversion point. Since it is not the scope of this thesis to analyze various engineering methods of water spreading it will not be discussed further.

The economic analysis will be based on the water spreader as given. It must be kept in mind, however, that a change in engineering policy will effect the economic aspects of the problem.

5/ Wayne H. Miles, "Water Spreading", Soil Conservation, X (1944), pp. 73-76, 87.

6/ See S. V. Ciriacy-Rantrup, "Private Enterprise and Conservation", Journal of Farm Economics, XXIV (February, 1942) pp. 75-96. A stock resource is defined as a resource of which the present rate of use necessarily reduces the future use.

Soils and Topography - An important consideration in any water spreading system is soil type and topography, both on the spreader site and on the watershed from which the flood water is obtained. Again this is chiefly an engineering aspect and only brief reference will be made to it here.

The most satisfactory type of soil is loam, 5 or 6 feet deep, with a clay subsoil. The loam provides a mellow, porous surface which absorbs water rapidly and the relatively impervious clay subsoil prevents the escape of water through leaching.

Where clay soils are flood irrigated it is desirable to arrange the dikes so that the water may be ponded. Clay soils have the capacity to hold large amounts of water but they do not absorb water readily and much of the effect of the flood water is lost unless it is held back by the dikes. 7/ Permeability tests can be made prior to construction in order that the system may be designed to pond the water for the optimum length of time.

The soil type on the watershed is significant for several reasons. Clay soils generally yield a considerable amount of runoff water but it may be heavily laden with sediment. Hubbell and Gardner report some important soil and vegetational changes due to spreading sediment laden

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7/ See G. H. Bingham and O. W. Monson, Flood Irrigation, Montana Agricultural Extension Service Cir. 84, June, 1937.

water in New Mexico. 8/ It has been observed, by the author, that generally the only sediment problem which occurs on spreaders in Southeastern Montana is the silting of storage dams. By proper watershed management this problem can to some extent be resolved.

Watersheds of lighter textured soils and luxuriant vegetation yield less runoff water but it carries little sediment. With this type of watershed, spring runoff is usually quite dependable. It is obvious that light spring and summer rains are less likely to provide irrigation water for a dependent spreader from this type of watershed.

Topography is an extremely important consideration in determining the feasibility of a spreader site. In general it is not feasible to build a spreader on land with more than two percent slope. It should be understood, however, that water spreaders are not built to pattern - they are built to fit the land. In fitting a spreader to land that is rough or steeply sloping a complex system must be used which usually requires a large capital outlay. In general, the rougher and steeper the land, the greater the capital outlay required and the less likely the system will be economically feasible.

Vegetational changes - When flood water is diverted to range land there is a decided change in type, quality, and quantity of vegetation.

8/ Hubbell and Gardner, op. cit., pp. 30-50.

Investigators in New Mexico found that western wheatgrass (Agropyron smithii) was one of the most tolerant grass species in places of sedimentation. They found that the additional water benefited all types of vegetation but the sediment it carried had adverse effects on all grasses except western wheatgrass. Total vegetational responses varied with the amount of rainfall and the amount of sediment deposited. Increases in yield up to nine hundred percent have been noted. 9/

Maintenance operations - There has been a wide variation in reports on maintenance for water spreaders. Some ranchers have reported no annual maintenance but this seems to be the exception rather than the rule. It is impossible to set up a rule of thumb guide for maintenance requirements on any spreader project. It is apparent that maintenance costs will depend upon the initial planning and care with which the project is constructed, physical features of the land and soil, and vegetation.

There are, however, unforeseeable events which necessitate including some maintenance in the operating plans for the water spreader regardless of how well it is constructed. Such items as holes caused by rodents, wash outs caused by flash floods, snow plugged ditches, and other conditions will require maintenance, the extent of which can only be estimated by careful consideration and good judgement.

9/ See Hubbell and Gardner, op. cit., pp. 3, 51-62.

Useful life span of a water spreader - An important question which inevitably arises when contemplating any kind of capital improvement is how long will it last? This again is a problem of individual cases and does not lend itself to any generalization.

When storage reservoirs are used in the water spreading system there is definitely a time limitation upon which storage capacity depends. This is variable depending upon the amount of silt which is deposited annually. This must be included in the evaluation analysis of the spreader as we shall see later.

The usual response to the question on the expected life of water spreaders by ranchers in Southeastern Montana was that it would last indefinitely with normal maintenance. Only in the case of storage dams is there believed to be a major item of depreciation affecting the value of the investment.

Economic Aspects of Water Spreading

A common "rule of thumb" method for determining the economic feasibility of a ranch water spreader is simply this: 'If the water spreader will double forage production, an investment equal to the value of the land prior to development is justified.' Implicit assumptions upon which this proposal rests are, (1) there are no costs of producing and marketing the additional product, (2) returns to scale are constant, and (3) there is a perfect market supply and demand for inputs and outputs, respectively. Upon critical inspection of these assumptions it becomes apparent that the "rule of thumb" is on tenuous ground and at best is merely a rough guide.

Other "rules of thumb" may be set up for use on such problems of evaluation but it appears that upon close analysis they break down, either in a general way as exemplified above or in a specific way when applied to special cases. The theory of the firm offers an alternative which is not characterized by these weaknesses of breadth and depth.

The theory of the firm defined - In a purely abstract sense the theory of the firm is a general set of principles relating factors of production into an economic unit capable of producing economic goods. The theory is a product of the enterprise system and is especially adapted to the capitalistic economy.

The content of the theory of the firm - As a framework for an economic analysis of an enterprise or business, the theory of the firm is invaluable. It serves as a tool with which the firm may be reduced to its component parts. In effect this breakdown simplifies the previously highly complex concept, the firm, and puts it in a form that is comprehendible to the human mind.

One assumption, basic to the theory of the firm, is that the entrepreneur is striving for maximum profits. It will be apparent later that certain conditions may lead the entreprenuer toward ends inconsistent with maximizing profits but for the present the assumption shall be accepted. The theory is as widely accepted in the attempt to maximize pro-

fits as the law of supply and demand in determining price. 10/

The equilibrium condition of the firm depends upon the shape of the market supply curve and the market demand curve and the price for inputs and outputs. Enterprise combination, size of the firm, and other determinants of equilibrium are all directly dependent on the combination of these factors.

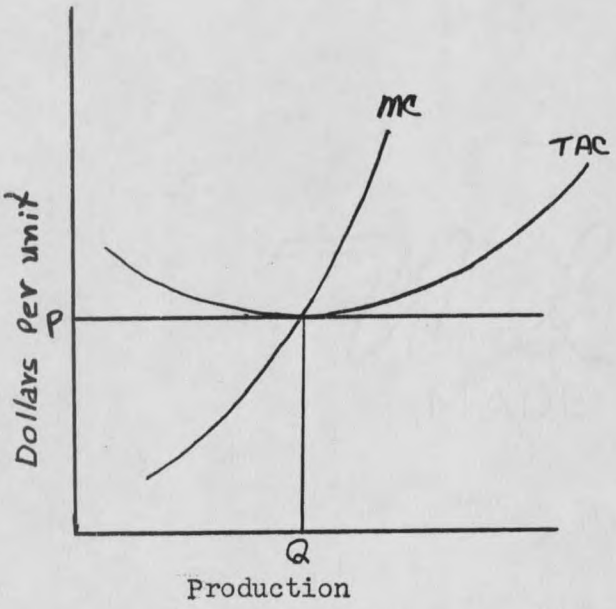

Figure 1. Unit cost equilibrium of a firm with a perfectly elastic market for output.

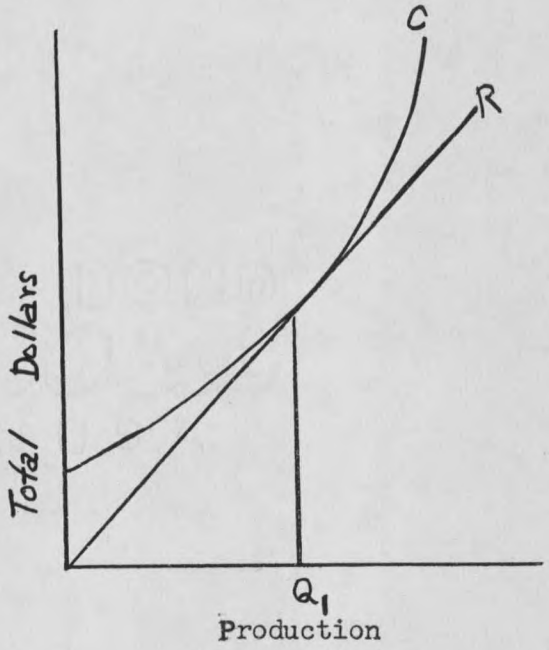

Figure 2. Total cost equilibrium for a firm with a perfectly elastic market for output.

10/ Earl O. Heady, "Economic Models in Farm Production Economics Research," Journal of Farm Economics, XXX (May, 1948) p. 202.

Since a stock ranch, characteristically, is in a purely competitive position with regards to other agricultural firms for inputs and outputs, the discussion may be limited to a firm of pure competition. Costs, per unit of factor, and revenue, per unit of product, can be exemplified by a line horizontal to the "x" axis. Such a firm will maximize profit by equating the marginal cost per unit of output and the price per unit of product. As an illustration Figure 1 represents a firm producing at Q, the level of output that equates the price of the product, P, and the marginal cost, MC.

Stated another way, maximum profit will be reached at that production level when the difference between total cost and total revenue is the greatest (At the production level Q_1 the difference between total cost and total revenue is zero. At all other production levels this difference is negative.) The former method, Figure 1, deals with unit costs while the latter, Figure 2, deals with total costs. Both methods, drawn to scale for a given set of conditions, will result in the same production level at maximum profit.

It is common to subdivide the decisions made by the firm into two categories: (1) comine inputs, both technologically and price wise, so as to have the most economical cost curve possible, and (2) consider demand conditions for the product of the firm.

Relationships between inputs and outputs are complex. For any desired output both kind and quantity of input is important. Boulding holds the entreprenuer analagous to a cook in that he uses a recipe of in-

puts, kind and quantity, to give him a desired output. In the case of agricultural firms he points out that they are like a cook using an extremely poor oven. Even though the proper combination and quality of inputs are used the farmer is faced with uncontrollable inputs that make the output indefinite. 11/

Both qualitative and quantitative relationships between inputs and outputs will be guided by technology since any output requires certain techniques of production. Assuming the use of modern technology, a firm producing a single product will have a cost curve dependent on the level of output for its shape. The shape of the cost curve for a firm producing more than one product will also depend on the enterprise combination within the firm.

Since the demand for output, with respect to the single agricultural firm, is perfectly elastic, the second phase of the decision presents no problem. In other words product prices will not vary with changes in the production level within the firm. Product prices are given and only price expectations for the future influence the action of the firm from the demand side.

This study is primarily concerned with the production cost curve stage of applying the theory. The theory of the firm is basic to an explanation of input or resource allocation. Certain unique conditions

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11/ See Kenneth E. Boulding, Economic Analysis, New York, Harper & Brothers Pub., Revised Edition 1948, pp. 498-520.

effect agricultural firms, however, that may more or less obscure the significance of the theory.

A critique of the theory of the firm - Among economists, opinions differ regarding the application of the theory of the firm to farm and ranch management. Professor Schultz states:

> In the real world of production, processes of the firm are being altered continuously. Routine procedure will not suffice. Change born out of dynamic circumstances is ever present. Adjustments are called for. It is the entreprenuer who decides what shall be done. Decisions are carried out within the framework of the firm. 12/

Now a somewhat modified stand is taken by Cochrane and Butz as they conclude:

> ...the aggregate output of a multiple enterprise farm firm does not expand and contract as the presumed marginal cost curves of the individual enterprises might lead one to expect; expansions in the aggregate output of the firm would seem to be more closely related to the farm technological advances than to the principle of variable proportions. Thus the theory of the firm in agriculture has become circumspect. 13/

It seems that the difference in these two views is more apparent than real. The crux of the problem is that "presumed marginal cost curves" are basic premises which are in themselves often erroneous. Because of this, the theory of the firm does not seem to shape the decisions of some agricultural firms.

12/ T. W. Schultz, "Firm and Farm Management Research," Journal of Farm Economics, XXI (August, 1939), p. 574.

13/ Willard W. Cochrane and William T. Butz, "Output Responses of Farm Firms", Journal of Farm Economics, XXXIII (November, 1951) p. 445.

For instance, it is often stated that agriculture is not responsive to price declines. If one considers the marginal cost curve without the important aspect of fixed costs, the theory of the firm will seem to be inadequate as an explanation of the action of the firm.

There are some important factors peculiar to the agricultural firm which one must be cognizant of to fully appreciate the theoretical aspects of decisions made. First, it is generally conceded that resources used in agriculture do not pass freely between agricultural and non-agricultural uses in response to relative price changes. As a general rule, agricultural land is of no use except for agriculture. Labor is relatively immobile, i.e. there is a definite lag between changes in price levels and the shift of labor in response to that change. It appears that capital does not pass freely between agricultural and non-agricultural endeavor. Although present agricultural credit facilities make this last point less apparent than formerly, it is still somewhat evident.

Secondly, expectations play a more important part in the decisions made by agricultural firms than by industrial firms. Price expectations influence industry. Agriculture has an additional expectation to consider in the form of production fluctuations due to climatic variations. Because expectations of price and production are so important in agriculture it is often difficult to look back and recognize that the actions of farms and ranches were in any sense, logically based on the principles laid down by the theory of the firm.

For instance it is entirely possible that some ranches in the North-

ern Great Plains were not meeting variable costs during some years in the 1930's. Logically, according to the theory of the firm, these ranches should have gone out of business. Due to expectations for the future, immobility of resources, and family ties they did not go out of business.

The third consideration is that people are bound to custom and do not make changes readily. Social and economic obligations, together with family ties may also come into this category. This third aspect is often quite helpful in explaining irrational action on the part of agricultural firms.

Fourth, and of utmost importance, is the fact that an extremely high portion of agricultural inputs are fixed. 14/ Although this would not ordinarily obscure the principles of the theory as used by agriculture, it aggrevates the three preceeding factors and causes a magnification of their influence on the action of the firm. As an example, an entreprenuer may be able to stay in operation longer by liquidating or mortgaging his fixed assets to meet variable costs even though the logical thing to do, according to the theory would be to go out of business. (It is assumed here that high fixed costs are correlated by high fixed assets.)

The foregoing discussion has attempted to point out some of the pitfalls to be avoided in explaining the action of certain agricultural firms by use of the principles set forth by the theory of the firm. The func-

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14/ See Ibid., p. 448.

tions relating the variables used may often have extreme and uncommon shapes. This does not detract from the validity or soundness of the theory but makes it cumbersome and if you will, "circumspect".

The Budget Method

To many the word "budget" means a plan for expenditures. A "farm budget" is more than that. It must be a plan not only for monetary expenditures but for the use of all physical resources as well. It is not necessary that a dollar and cents value be put on all items unless they represent purchases, sales, or inventories. The farm operation is carried on in physical terms and only the results need be measured in terms of money. 15/

The budget method of analysis as developed by G. A. Pond of Minnesota and J. W. Tapp, formerly of the Bureau of Agricultural Economics, Washington, and published in 1923 has been widely used. It has been useful in agriculture as a method for determining ways of increasing farm income. 16/

The budget method defined - The budget method is a device for determining the highest profit combinations for a firm. It is comprised of

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15/ John A. Hopkins, Elements of Farm Management, New York, Prentice-Hall, Inc., 1947, p. 112.

16/ See Andrew Boss and George A. Pond, Modern Farm Management Principles and Practice, St. Paul, Minne., The Webb Publishing Company, 1947, pp. 20, 198-222. See also George A. Pond and J. W. Tapp, Bulletin 205, Minnesota Agricultural Experiment Station, 1923.

two parts. First the budgets must be synthesized, i.e. the component parts of the firm, as indicated by the theory of the firm, are drawn together in the form of a budget. This is done with all the proposed combinations of inputs. The second stage is to evaluate the results of the budget comparisons and thus determine which one is likely to yield the entreprenuer the greatest profit.

The use of the budget method - In practice the budget method may be used for comparing, (1) alternative plans for a new farm business, (2) alternative plans for a going farm business, (3) returns from alternative farm enterprises, (4) alternative methods of production, or (5) alternative investment opportunities. There are several variations of the budget method which may be used depending on the nature of the problem to be analyzed. The comparison of complete budgets is the method upon which the other variations are based.

The method of substitution is generally used in the process of enterprise selection. It consists of completely or partially substituting for the existing enterprises a different combination of enterprises and of checking the effect of the changes on the total net income of the farm. 17/ In this method only costs directly attributed to the new enterprise are considered thus saving considerable time over the complete budget method.

17/ G. W. Forster, Farm Organization and Management, New York, Prentice-Hall, Inc., 1949, p. 81.

Another variation, the method of direct comparison, is based on a comparison between the operator's farm and the average for other farms of a similar type. In the use of this method it is assumed that changes based upon the experiences of successful farmers are more apt to meet with success than trial and error changes of the substitution method. This method is obviously limited to changes in the direction of established agricultural patterns. 18/

A third variation is that of the standard combination method. For this method, standard enterprise combinations are developed for specific farm conditions and given resources. Farmers are shown how they fit together, what the probable financial results will be, and how to achieve the specified combination. 19/ It has the same limitation as the above variation.

Divisions of the farm budget - The farm budget is normally broken down into three main divisions, viz., the crop plan, the livestock plan, and the power and labor plan. 20/ These divisions, are not always arranged in such a way that they are distinct and separate but regardless of how they are put together the basic information must be included for each division.

18/ Ibid., pp. 97-113.

19/ Ibid., pp. 114-150.

20/ Hopkins, op. cit., pp. 113-14.

The crop plan, including pasture land, is the logical starting place since it determines the amount of livestock that can be included in the farm organization as well as the labor and power needs. The cropping and grazing system should be integrated with the other divisions of the budget so as to maximize net income in the long run. To attain this objective, due consideration must be given to erosion control and soil maintenance.

The livestock plan must be based on feed, labor, and power requirements. The decision between having livestock and not having livestock is not difficult in the range country since livestock usually present the only means of harvesting the range resource. There is, however, an important phase of planning relative to the class and kind of livestock used to do the "harvesting". For instance, some ranges are more efficiently harvested by sheep than by cattle and to go a step further they may be better adapted to raising fat lambs than feeder lambs.

Now the problem is not solved merely by getting the crop and livestock enterprises in balance. Each class of livestock, as well as each kind, may have different labor and power requirements which must be taken into consideration. The budget should be designed to give full employment to the available labor. The efficiency of the labor will in turn be dependent upon the use of power and equipment. If labor is relatively scarce it will pay to add power and equipment and vice versa.

Thus far the emphasis has been placed upon the physical balance needed to get maximum net farm income. Different combinations of capital, with regard to liquidity, will result in firms with various shades of

flexibility. The budgets are useful in studying the problem of flexibility, which is particularly important in the Northern Great Plains. This offers one case where the basic assumption of the theory of the firm, that the entreprenuer is striving for maximum profits, is not entirely applicable. The entreprenuer may be willing to relinquish some of his profits for more stability.

Data needed for budget - Obviously a budget is no better than the data used in it's construction. The data used in a budget may be divided into two broad categories, viz., production data and price data.

Production data must include information on physical inputs and outputs of the ranch firm. Production is notoriously affected by physical factors such as climate, insects, and disease. Therefore production data are subject to fluctuations, sometimes extreme, and must be used with discretion.

Price data must include prices of both inputs and outputs. It is generally true that in agriculture the price for input factors fluctuate less, in the short run, than do product prices. This makes the job of budgeting farm expenses easy relative to that of budgeting farm income. It is important that the relationship between the two sets of prices be consistent, however, and that comparisons of budgets be based on consistent expectations of prices and production.

In passing we may note that in making a farm budget one must have complete knowledge of the available resources for the farm, i.e., one must know the limits of the land, labor, capital, and management which

are used in the construction of a comprehensive budget.

Price and production estimates must be selected for the particular budgeting job for which they are to be used. For instance lowest possible prices and yields may be used to bring out problems that will have to be dealt with in "poor" years. Average prices and yields will give the entrepreneur an estimate as to probable long run net farm income. Present prices and average yields will be useful in year to year budgeting. 21/

Relationship between the budget method and the theory of the firm - The chief value of the budget method, as previously stated, is to compare net farm incomes under various conditions of resource allocations and enterprise combinations for the purpose of finding an organization that will yield the entreprenuer a higher net income. This is compatible with the basic assumption of the theory of the firm, i.e., the entreprenuer is striving for maximum profits.

The theory of the firm is difficult to use empirically. However, it serves to segregate the variables which make up the component parts of the firm. This analysis enables the human mind to more easily recognize the functions of the firm.

Now with the boundaries of the components of the firm defined by the theory, it is possible to "synthesize" them, in order to arrive at a

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21/ See A. E. Anderson, "The Farm Budget", Journal of Farm Economics, XIII (January, 1931) pp. 65-70.

numerical value, by using the budget method. The theory, then, serves as an abstract guide for building the budgets.

Some difficulty arises in shifting between the abstract theory and the concrete budget. This is caused by certain weaknesses in the theory and lack of complete data. For instance the theory assumes that inputs can be added in infinitesimal units. This is not true. For example, a water spreader would change a firm's position on a given cost curve a considerable amount and it would not lend itself to small unit changes.

In spite of this difficulty the theory is invaluable as an aid to be used in synthesizing budgets. With this in mind the next step shall be to develop a methodology for evaluating a ranch water spreader.

PART II. EMPIRICAL FINDINGS

Description of The Methodology

As stated previously the purpose of this study is to develop a methodology for evaluating water spreaders. It is not the object of the study to be able to say whether or not water spreaders in general are desirable and are economically feasible. It has been pointed out that conditions vary so much in each individual case that it is impossible to make valid generalizations about water spreaders. Each potential spreader must be evaluated as an individual case.

The universe - This study has specifically analyzed ranches with water spreaders in Southeastern Montana. The location of ranches involved in this study are shown on the accompanying map, Fig. 3. The study was limited to this area for three reasons; (1) the topography and soil conditions are favorable and there is considerable interest in water spreaders in this area, (2) It was felt that by limiting the size of the universe to said area a more uniform sample could be drawn in the limited time available, and (3) the Bureau of Agricultural Economics made a ranch study in this area in 1951-52 and the data they gathered were available as a source of supplemental information.

The sample - It was decided that since the emphasis would be placed on the method in this study rather than on a statistical investigation, it would be unnecessary to use a large sample. The purpose of the sample was to get a general idea of the use being made of water spreaders within the universe and to find out how the ranchers reacted to them.