Delineating firms sensitive to shifts between wheat and range forage in the northern Great Plains
by Dwight M Blood

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:
The purpose of this study as stated in Part II is to investigate a methodology for delineating firms which are sensitive to shifts between wheat and range forage production.

Part I lays the groundwork for the study by presenting a general picture of the shifting situation in the Northern Plains as it has existed in the past, and the general situation which operators of units sensitive to shifts are faced with today. Some of the implications of shifting situations are noted.

Part II defines the specific research problem and establishes the economic criteria for determining optimum wheat-range forage production patterns in dry land areas. The factors relevant to achieving an estimate of the economic model are then described. From this framework, the hypothesis of the study is derived.

Part III carries the empirical tests of this hypothesis. Use is made of linear discriminant analysis and multiple regression techniques in an attempt to carry out the purpose of the study and form a basis for inferences concerning the analysis.

Part IV summarizes the positive accomplishments and sets forth suggestions for further research. Success in the development of the discriminant function suggests still further applications of this technique. Moreover, it may have succeeded in isolating a set of conditions permitting an increase in research productivity.

DELINEATING FIRMS SENSITIVE TO SHIFTS BETWEEN WHEAT AND RANGE FORAGE IN THE NORTHERN GREAT PLAINS

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ABSTRACT

The purpose of this study as stated in Part II is to investigate a methodology for delineating firms which are sensitive to shifts between wheat and range forage production.

Part I lays the groundwork for the study by presenting a general picture of the shifting situation in the Northern Plains as it has existed in the past, and the general situation which operators of units sensitive to shifts are faced with today. Some of the implications of shifting situations are noted.

Part II defines the specific research problem and establishes the economic criteria for determining optimum wheat-range forage production patterns in dry land areas. The factors relevant to achieving an estimate of the economic model are then described. From this framework, the hypothesis of the study is derived.

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PART I.

INTRODUCTION

If it were necessary to make a choice of one word which would best describe the Northern Plains, that one word would undoubtedly be "uncertain". Endowed with an unstable and widely varying weather foundation upon which the agricultural economy of the region must be established, the already existing problems related to price variations are magnified by extreme variations in production. The intricate facets of uncertainty are great obstacles in analyzing potential shifts. Encompassing a physical area of approximately 300,000 square miles, the Northern Plains contains roughly a tenth of the total land area of the United States. 1/ It is bounded on the east by the 98th meridian, and on the west by the Rocky Mountains. The Canadian border marks the upper boundary on the north, while the southern extremity is represented roughly by the 43rd parallel. Included within these boundaries is ". . . the western three-fourths of North Dakota, South Dakota, and Nebraska, the eastern two-thirds of Montana, the eastern one-third of Wyoming, and the northeastern one-tenth of Colorado . . ." 2/

The region is one of extremes, making the use of "averages" deceptive. The climate of the Plains ranges from conditions approximating those of the humid Midwest at the 98th meridian to semiaridity over most of the region.

1/ George A. Rogler and Leon C. Hurtt, "Where Elbowroom is Ample", Grass, U.S. Dept. of Agriculture Yearbook, 1948, p. 477.

2/ Loc. cit.

The 98th meridian serves as the dividing line since its annual precipitation averages approximately 20 inches, which is the minimum for successful production of most humid area crops. This is reduced to approximately 10 inches toward the western extremes.

The significant aspect of the moisture supply in the Plains lies not in its total variation, but in the fact that it hovers so closely around the critical margin for plant survival, where a small adverse variation can spell disaster.

The topography of the Plains ranges from a gently rolling surface over most of the eastern portions to the rough and broken areas of the west.

The changing aspects of climate and natural factors are reflected by continually changing patterns of land use. The one extreme is represented by areas in which wheat production strongly predominates; the other by an almost complete range forage and livestock producing economy. In a rather indistinct area somewhere between these two extremes can be noted areas in which wheat and livestock ranches are coexistent, or where wheat and livestock are both produced on the same ranch.

Generally speaking, these two extremes represent the two principal generalized types of farming in the region. "Islands" of irrigated farming complete the picture. These enhance the stability of the region and complement the dry land areas in important ways.

The Wheat and Small Grains Area

The 98th meridian is the scene of transition between the humid Midwest and the semiarid wheat producing area of the Northern Plains. This

is the margin of transference of wheat to a more intensive type of agriculture. The transition is first evident in rainfall and other climatological changes, which is in turn reflected by the changing physical characteristics of the land itself.

The transition is finally reflected by changing agricultural production patterns. Crop production predominates in this area, with a tendency toward specialization in the production of wheat.

The Range Livestock Area

To the south and west of the major wheat producing areas, as rainfall diminishes and as the terrain becomes steeper and rockier, the relative advantages for wheat production diminish. At the same time the relative advantages for cattle production increase. At the area of transition between these two major types of agricultural production lies the margin of transference from wheat to a less intensive type of agriculture. This is the margin to which this study is relevant. It is in this margin of transference that most of the shifting of resources between wheat and cattle production occurs as the variables affecting shifts change in their relative importance.

There are, of course, many localized areas within the two extreme areas of production that are susceptible to shifting. A complete delineation of all geographic areas that are susceptible to shifts is beyond the scope of this study. The discussion and analysis does apply in general, however, to most of the areas sensitive to shifts between wheat and livestock, and especially to areas where shifts may be determined on the basis of physical criteria alone.

The Background: Historical Aspects

Historically, many shifting problems have occurred in the Northern Plains each year since the production of wheat and cattle began in the region during the late 1800's. Only two periods in history, however, have witnessed major shifts of sufficient proportions to create national policy problems with respect to the dire circumstances created by their aftermath. The first exodus from the Northern Plains occurred in the years intervening between the two world wars. This was the aftereffect of the expansion in wheat acreage which occurred during World War I. In response to phenomenal price increases accompanied by good weather conditions, farmers expanded their wheat acreage from 56 million in 1914 to 74 million in 1919 (harvested basis). Following a moderate cutback after the war, seeded acreage remained above the 60 million mark throughout the 1920's. 3/

As foreign shipments fell off, domestic production continued to remain above pre-war levels as advances in mechanization made it possible to reduce the real cost of producing wheat and for the more successful operators to expand the size of the wheat producing unit. The great drought and depression of the 1930's combined forces to bring a second major disaster to the Plains. 4/ A high proportion of fixed costs incurred by firms in the area necessitated continued attempts to produce at maximum capacity levels, especially since production alternatives were practically nil in many

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3/ Warren R. Bailey and Charles W. Nauheim, "Prospective Adjustments in Wheat Farming", U.S. Dept. of Agri., Bur. of Agri. Econ. (mimeo report prepared for distribution at 31st Annual Agricultural Outlook Conference, Washington, D.C., October 28, 1953), p. 1.

4/ Loc. cit.

instances. This situation was extremely hard on small operators without reserves as well as those operators with high indebtedness brought on through over-optimism and high land investments during the temporarily favorable conditions existing during the war and the years immediately following.

Those who weathered the lean years of the 1930's received their due reward as history repeated itself in the 1940's. In response to an optimum combination of stimuli in the form of an unprecedented series of favorable weather years and price conditions, the sod-busting race was on again as managers and speculators again pushed back the margin of wheat production. Greater certainty with respect to price due to government non-recourse loans made profits relatively certain as long as the good weather would hold out. In addition, as impending government acreage restrictions approached reality, operators were quick to expand their acreage of wheat in order to establish as large a base as possible upon which future acreage allotments would be based, realizing that potential acreage allotments might possibly be capitalized into the value of the land should the acreage allotment program remain in effect for long. These factors tended to serve as impediments in holding back the margin of wheat production in sensitive areas until drought and surpluses brought trouble.

Bailey and Nauheim have aptly summed up the rest of the historical situation:

> Early in War II, farmers were urged to plant feed and oil-seed crops and to hold down wheat acreage. Under a feed-price subsidy, the surplus wheat was fed to livestock. In the 4 years, 1942-45, an average of 300 million bushels were fed annually--200 million more than usual. The bins were cleaned. Beginning in 1945, large quantities of wheat were needed for export to both allied and occupied countries in Europe. Prices rose and farmers increased

> plantings from 53 million acres in 1942 to an all-time peak of 84 million in 1949. Improved yields together with large plantings have resulted in crops of more than a billion bushels each year since 1944, except in 1951 when yields were exceptionally low.
>
> By 1949 exports had tapered off and large wheat stocks again threatened. Acreage restrictions were invoked for 1950 but the Korean Incident abruptly changed the picture. Demand and price increased, restrictions were quickly removed and plantings again increased to about 78 million acres.
>
> Greatly reduced export demand in 1952 has resulted in large wheat stocks--about 560 million bushels. An acreage allotment of 62 million has been announced for 1954 and marketing quotas have been voted. This represents a 21 percent reduction from the 1953 acreage . . . 5/

Implications

Some of the underlying causes and criteria for determining shifts may be revealed by an analysis of past shifts, and may serve as a basis for a foundation for present research. It would be a mistake, however, in planning for the immediate future in analyzing potential shifts to formulate too many analogies or direct comparisons among conditions existing then and now. Certainly, the basic underlying causes would still remain the same, but changes in their relative effects prevent direct comparisons among conditions existing then and now. A rise in the general price level, technnological and social changes, and changes in world outlook are among the factors that have served to alter the general situation existing today as compared to twenty or thirty years ago.

5/ Bailey and Nauheim, op. cit., pp. 1, 4.

Technological advancements in both the wheat and cattle industries have served in effect to substantially enlarge the transition area between the two; i.e., they have made it possible to produce wheat and cattle in areas where their production prior to these advancements was virtually impossible. Development of new disease and drought resistant, stronger stemmed, higher producing varieties has had an important effect upon wheat production. The livestock industry has been affected by new and faster means of revegetation, water diversion and usage, and disease combating methods. Thus, the factors which determine the margin at which land use is shifted from livestock to crop production and vice versa have not only changed in value, but the rates at which such shifts can be made have also changed. For example, it has been assumed before that it is relatively impossible to reseed and re-establish range vegetation in any reasonable length of time once the land has been committed to wheat production. Technology has already begun to shorten this necessary transition period, as well as to increase the forage production potential once the shift has been accomplished.

So although historical incidents may be used as guideposts to the current situation, they must be tempered with relative changes in the relevant variables involved before they will be of value in analyzing current shift potentials.

Barring further outbreaks of hostilities within the next few years, further reductions in wheat acreage seem likely. Now, the question arises: how much of the pressure can be relieved by shifts to livestock production, and when and where should such shifts occur? Moreover, are there cattle producing ranches that should be in wheat, and to what degree would

countershifts, if they could be made, affect the shifts out of wheat? In light of the recent flood of both popular and experiment station literature urging managers to produce more grass and livestock, these are extremely important considerations. The crusaders were anxious to forestall future dustbowls and economic catastrophes when the impending decline in postwar international demand for wheat and grain exports simmered back down to normal levels.

Livestock production, in the overall picture, is not the panacea that popular opinion has created as the alternative to wheat in the Northern Plains. R. I. Throckmorton sheds some light on the estimated role of livestock and grass in the diverted acreage problem. He estimates that the use of the area diverted from wheat in 1950 ran something like this: grasses, 12 percent; legumes, 14; fallow, 30; other crops, 41. 6/

There are some very practical reasons why the percent diverted to grasses and livestock production is not greater, and will not likely become too much greater in the future. Some of the more obvious of these, of course, deal with government policies, lack of stock water, capital limitations, etc. Of great importance as limiting factors are the institutional problems, especially those related to land tenure; as well as social problems. All will be dealt with further in a later section which analyzes the factors affecting shifting in more detail.

6/ R. I. Throckmorton, "Report of Conditions in the Great Plains as of April 1, 1950", cited by O. L. Mimms, "Diverted Acres in the West", Proceedings of the Western Farm Economics Association, June, 1950, p. 32.

Even with its limited importance in the overall picture, the margin between wheat and cattle is still extremely important in the marginal areas sensitive to shifts. Possibilities of shifting to other alternatives throughout the entire wheat area are currently being investigated in other studies.

PART II.

DEFINITION OF THE PROBLEM

Concerning shifting problems in general, Sherman E. Johnson has written:

> Too little attention has been given to the problems involved in the shifting margins of both major and minor uses of land. Frequently the response to the changing outlook for farm products is too slow to keep up with a new source of demand. And then once the shift is started it may go too far. This leads to maladjustments in the use of land because after major changes have been made the process is not readily reversible. 7/

The purpose of this study is to investigate a methodology for delineating firms sensitive to shifts between wheat and range forage production. With this relatively modest goal, it is hoped that the problem of estimating the effects of strategic shift variables in dryland areas of the Northern Great Plains might be made more tractable. Rules of thumb and general criteria can be treacherous if not tempered to take into effect the unique conditions confronting each firm. But they do serve as direction indicators in the planning process and, as such, their potential usefulness is very great.

A. The Theoretical Framework

Shift problems within the firm are problems of selecting enterprises and allocating resources among them in such a way as to yield an optimum

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7/ Sherman E. Johnson, "Principles of Land Utilization", John F. Timmons and William G. Murray, editors, Land Problems and Policies, (Ames: Iowa State College Press, 1950), Ch. 5, p. 67.

in terms of net farm income over time. An enterprise has been defined as "... a line of production necessitating individual and distinct production treatment". 8/

Enterprise Relationships

The individual firm within an area sensitive to shifts has three alternatives when considering its wheat-range forage production pattern: it may produce all wheat, all cattle, or some combination of both. The final organization of the firm is dependent upon the relationships between the two enterprises in light of the complete sum of environmental characteristics peculiar to the unit being considered.

When both wheat and cattle compete for essentially the same stock of resources, they are known as competitive enterprises. Under these conditions, and with a given supply of resources with which the firm must be run, an increase in the total physical product of wheat (cattle) due to an extension of additional resources to this enterprise, necessitates a decrease in the total physical product of cattle (wheat). For example, if the amount of wheat land is increased, a reduction in the cattle herd will be necessitated.

Two other types of relationships may exist between wheat and livestock enterprises. A complementary relationship exists when, on a given unit and with a given stock of resources, an increase in the total physical product of one enterprise is associated with an increase in the total physical

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8/ Lawrence A. Bradford and Glenn L. Johnson, Farm Management Analysis, (New York: John Wiley & Sons, Inc., 1953), p. 153.

product of the other. This is true even when resources are diverted to one by reducing input thereof in the other, as when livestock production is increased at the expense of actual crop acreage.

Situations of complementarity between wheat and livestock are quite rare in dryland shifting areas, if they exist at all. In many cases, it is possible for a wheat and livestock enterprise to exist side by side within the same firm, and yet present no outward indication of complementarity whatsoever. Topography, soils, and other conditions within the firm may divide the two enterprises, making them independent of each other with respect to most resources, especially land. This situation is especially evident on many ranches having a level expanse of land for wheat production, and a rough, broken area of native range. The enterprises may still compete, however, for certain resources; e.g., the purchase of a new registered bull may limit weed spraying activities and thus decrease wheat yields.

It is possible, of course, that "latent complementarities" may exist within certain units; investigations should be conducted to determine such possibilities. If such conditions are found to exist, the firm would profit by their subsequent development.

If, within a given firm, there are resources which have a zero opportunity cost 9/, an enterprise may be added which will be of a supplementary nature. Supplementary enterprises do not compete for resources with other enterprises; neither do they complement others; they merely make use of

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9/ I.e., they have no other alternative use and hence, no other means of yielding a potential net return.

resources that would otherwise remain dormant. If supplementary enterprises are added to wheat or livestock units, they are likely to be in the form of poultry, dairy, sheep or garden enterprises and not as a supplementary been project on a wheat farm or vice versa. This, of course, will vary over time as general conditions vary, and especially as the supply of available family labor with no opportunity cost varies.

The major type of enterprise relationship which is evident in sensitive shifting areas, then, is a competitive relationship between range forage-livestock production and wheat production.

The Theoretical Model

In general, net farm income will be increased, for a given time span, by shifting resources from wheat (cattle) to cattle (wheat) production, if, as a result of the resource shift the increment to net income from the additional wheat (cattle) exceeds the decrement in net farm income from reductions in the production of cattle (wheat).

The model relevant to the problem concerns the product-product relationship existing between wheat and cattle. The basic assumption of a product-product relationship is that prices can be varied while a significant portion of the resources used in common between the two enterprises can be held constant in type and in quantity. The basic theory for determining optimum enterprise combinations has been outlined by Heady. 10/

10/ Earl O. Heady, Economics of Agricultural Production and Resource Use, (New York: Prentice-Hall, Inc., 1952), pp. 201-275.

With wheat and cattle competing for a given sum of resources within a given unit, the physical relationship between the two enterprises, or the manner in which they substitute for each other, must be determined as a first step in developing an estimate of the model.

There are three general directions in which wheat and cattle may substitute for each other: they may substitute at increasing, decreasing, or constant rates.

1. Increasing rates of substitution exist, if, as cattle is substituted for wheat, successively greater sacrifices in wheat output must be incurred in order to achieve a unit increase in cattle output, and vice versa. This results in the concave opportunity curve pictured in Figure 1. OW and OC represent total output in physical units if resources are shifted all to wheat or all to cattle, respectively. Curve CW represents a continuum of various combinations of wheat and cattle that can be produced with the same (equal) resource outlay, hence, it is termed an "iso-product" or "equal-opportunity" contour. The slope of the line indicates the marginal rate of product substitution between wheat and cattle.

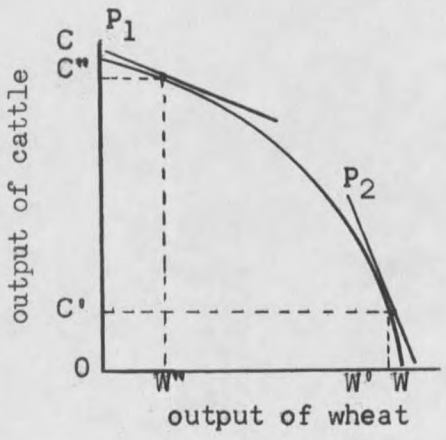

Fig. 1. Increasing rates of product substitution between wheat and cattle.

For example, assume that resources are being shifted from wheat to cattle, or that cattle output is being substituted for wheat output. If

increasing rates of substitution are valid in explaining the physical relationship between wheat and cattle, then the first unit by which wheat output is diminished would result in a rather large increase in cattle output. However, as successive constant decrements in wheat output occur, the corresponding increments to cattle output diminish, until a decrease of one unit of wheat output would result in virtually no change in cattle output. The marginal rate of product substitution of cattle for wheat is thus found to increase. The same situation is true in reverse in shifting from cattle to wheat.

2. Decreasing rates of product substitution exist between wheat and cattle if successively smaller sacrifices in wheat output would be required in order to achieve a unit increase in cattle output, and vice versa. This results in an opportunity curve convex to the origin, as shown in Figure 2.

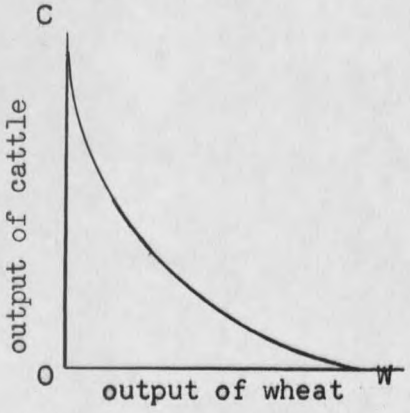

Fig. 2. Decreasing rates of product substitution between wheat and cattle.

If this situation is found, profits will increase continually until all of the resources are diverted to the production of one of the commodities. Decreasing rates of substitution are not likely to exist throughout the relevant range. 11/

3. Constant rates of product substitution indicate constant sacrifices in the output of one enterprise as resources are

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11/ See Heady, op. cit., pp. 217-219.