A method of analysis of range possibilities for submarginal crop land in Montana
by Layton S Thompson

A THESIS Submitted to the Graduate Committee In Partial Fulfillment of the Requirements For the Degree of Master of Science In Agricultural Economics
Montana State University

Abstract:
The object of this study is to develop a method of analysis for use in determining the economic feasibility of artificial revegetation on submarginal crop land in different areas in Montana. The procedure includes a study of certain economic aspects of submarginal crop land, an analysis of the costs of grass seeding and the value of pasture so established, and a demonstration by use of a model case of the steps which should be used in determining the feasibility of a seeding project. It is hoped in this way to establish a basis on which to bring together the work of the technician and the economist in order to solve some land use problems in a practical way. In brief, the method of analysis which is advocated involves the computation of the expected yearly per acre return from the proposed project and the yearly per ac cost of the investment in establishing the pasture plus per acre cost of utilising the pasture. By subtracting these costs from the value computed, the land charge which the project will carry may be computed.

Such an approach nay point the way to necessary adjustments in land tenure or in land charges (taxes and interest on investment.) The study indicates that further work needs to be done on the correlation between yield of crested wheatgrass and climate and soil type and condition. There is also a wide field open for investigation concerning the value of social incomes from grass cover, and another concerning the pecuniary value of created wheatgrass which is due to the special role it plays in the ranch management plan.

A METHOD OF ANALYSIS OF RANGE POSSIBILITIES FOR SUBMARGINAL CROP LAND IN MONTANA

by

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Submitted to the Graduate Committee

in

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at

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Approved:

G. A. Craig
In Charge of Major Work

R R Renne
Chairman, Examining Committee

V. B. Potter
Chairman, Graduate Committee

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ABSTRACT

The object of this study is to develop a method of analysis for use in determining the economic feasibility of artificial revegetation on submarginal crop land in different areas in Montana. The procedure includes a study of certain economic aspects of submarginal crop land, an analysis of the costs of grass seeding and the value of pasture so established, and a demonstration by use of a model case of the steps which should be used in determining the feasibility of a seeding project. It is hoped in this way to establish a basis on which to bring together the work of the technician and the economist in order to solve some land use problems in a practical way. In brief, the method of analysis which is advocated involves the computation of the expected yearly per acre return from the proposed project and the yearly per acre cost of the investment in establishing the pasture plus per acre cost of utilizing the pasture. By subtracting these costs from the value computed, the land charge which the project will carry may be computed. Such an approach may point the way to necessary adjustments in land tenure or in land charges (taxes and interest on investment.) The study indicates that further work needs to be done on the correlation between yield of crested wheatgrass and climate and soil type and condition. There is also a wide field open for investigation concerning the value of social incomes from grass cover, and another concerning the pecuniary value of crested wheatgrass which is due to the special role it plays in the ranch management plan.

"Grass is the forgiveness of Nature - her constant benediction. Fields trampled with battle, saturated with blood, torn with the ruts of cannon, grow green again with grass, and carnage is forgotten. Streets abandoned by traffic become grass-grown like rural lanes, and are obliterated. Forests decay, harvests perish, flowers vanish, but grass is immortal.... Its tenacious fibers hold the earth in its place, and prevent its soluble components from washing into the wasting sea. It invades the solitude of deserts, climbs the inaccessible slopes and forbidding pinnacles of mountains, modifies climates, and determines the history, character, and destiny of nations. Unobtrusive and patient, it has immortal vigor and aggression. Banished from the thoroughfare and the field, it abides its time to return, and when vigilance is relaxed, or the dynasty has perished, it silently resumes the throne from which it has been expelled, but which it never abdicates. It bears no blazonry of bloom to charm the senses with fragrance or splendor, but its homely hue is more enchanting than the lily or the rose. It yields no fruit in earth or air, and yet should its harvest fail for a single year, famine would depopulate the world."*

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*Ingalls, John James, "Blue Grass".

INTRODUCTION

The Problems of Submarginal Crop Land in Montana

One of the problems with which we are confronted in relation to Montana's resources is to find that means of utilizing submarginal crop land which is at the same time most feasible and most beneficial. During the period from 1909 to 1919, when the majority of the dry land farming areas in Montana was being settled,[1] a large acreage of Montana land was brought under the plow. Exceptional yields due to the fertility of the newly plowed sod-land and better than average rainfall, good prices due to the World War, and an increased use of power machinery resulted in the plowing of several million acres of range land which later proved unsuitable for farming. Much of this land has been abandoned and presents not only a problem of unused resources but also one of social and economic maladjustment. The role of land planning is to make the best use[2] of the land and to minimize the effects of the maladjustment.

In order to indicate something of the scope of the submarginal land problem in Montana, an outline of past changes and probable changes in land use is herewith presented. According to the census of agriculture, there was a net decrease in crop land[3] in 38 counties during the period 1929 to

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1. Johnson, Neil W., and Saunderson, M. H., Types of Farming in Montana, Bul. 328, Montana Agricultural Experiment Station, October, 1936.
2. Best use in the economic sense. It will be seen as the discussion progresses that "best use" may mean no use, or that from the standpoint of society it may mean a use which will pay to the individual entrepreneur less than the cost.
3. Including crops harvested, crops failure, and idle or fallow land.

1934 of 934,185 acres. This figure does not account for any new land which was broken during this time which would offset other acres of abandoned land. There was probably land abandoned in the 18 counties which show a net increase in crop land from 1929 to 1934. (See fig. 1) The state office of the Agricultural Adjustment Administration estimates the total crop land in 1938 to be approximately the same as the 1935 census figure.[4] In addition to land abandoned from 1929 to 1934, there were 485,734.6 acres in Montana in 1938 designated as restoration land by the Agricultural Adjustment Administration. Montana's quota for the A. A. A. restoration program, which will be reached over a period of years, is 875,000 acres. In 1938 there were also 1,748,818.5 acres of idle crop land (not including fallow) within the area covered by A. A. A. contracts. The area under A. A. A. contracts represents approximately 90 per cent of Montana's crop land. Although some of the land designated as idle crop land is only temporarily idle, it is probably safe to say that a large portion of it is submarginal for some reason or other. Using these data as a basis for estimate, it seems probable that well over 2 million acres of land have gone out of production in the 10 years from 1929 to 1939, which means that it has made little progress toward natural revegetation.[5]

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4. Interview with Harold Abel, State Statistician, Agricultural Adjustment Administration, Bozeman, Montana, December 28, 1939.
5. Only for Petroleum County has there been a western range survey (1937) covering the entire county and showing detailed land use. It was found that 113,716 acres of this county has been plowed. About 25,000 acres of this land was in crop or fallow in 1938. About 22,000 acres was designated as idle crop land. This means that about 60,000 acres in this county have been abandoned, exclusive of that designated as idle crop land.

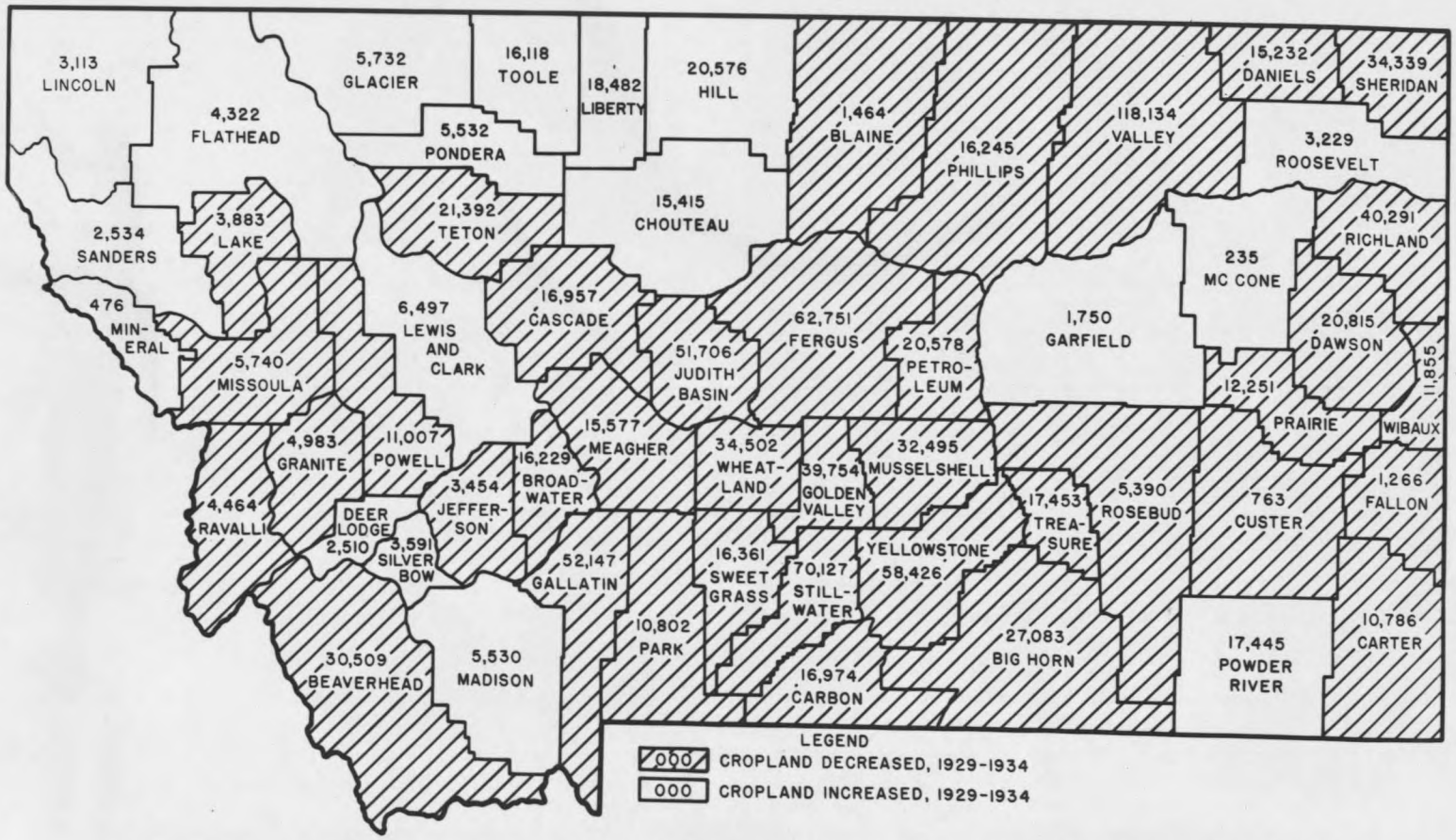

FIGURE 1.--NET CHANGE IN AMOUNT OF CROP LAND IN MONTANA COUNTIES FROM 1929 TO 1934

Includes Crops Harvested, Crops Failure, and Idle or Fallow Land*

*Source of Data: Census of Agriculture

In addition to the estimated two million or more acres of crop land abandoned since 1929, there is other submarginal land which is being kept in cultivation by subsidy of one kind or another, but which may eventually be abandoned, and also crop land which had been abandoned before 1929 and is in various stages of natural revegetation. According to various estimates, four to five million acres of land which has at some time been cropped in Montana has been abandoned up to the present time.[6] For our purpose, it is not necessary to get an exact figure for the amount of submarginal crop land. Even the lowest estimates are sufficient to indicate that the correct disposition of this land is one phase of the readjustment of Montana's agriculture.

Definition of Submarginal Crop Land

A plot of land may appear to be submarginal yet actually be marginal or supramarginal. Because of this and because of the common confusion in the popular use of the terms, it is necessary here to define and analyze them. From the standpoint of society as a whole, marginal land is land on which the return for its utilization is just enough to remunerate the outlay of labor, capital and entrepreneurship incident to its utilization. In a discussion of marginal land, interest on investment in land as a cost plays no part, nor does land tax above a minimum tax to defray expenses of establishing roads and other expenses directly incident to utilizing the land, for these are items which an individual entrepreneur pays for the

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6. Hansmeier, M. P., Possibilities of Crested Wheatgrass for Reseeding Montana's Range Land, B. S. Thesis, Montana State College, 1936, p. 5.

right to collect rent from land, and marginal land produces no rent. Rent is that part of income which is attributed to the use of land as a gift of nature, and we have defined marginal land as that which yields only cost of utilization.

The term "marginal land" is by definition a relative concept. There is a margin of extensive utilization and a margin of intensive utilization. The intensity of use is defined by the relative amount of capital, labor and entrepreneurship which is applied. There is land so unproductive as to be submarginal for any use. Pasture in the Great Plains is the least intensive of all agricultural uses, and land may be submarginal even for pasture for the simple reason that pasture can be so unproductive that an animal would use up more energy in grazing the scattered forage than could be gained from the forage. Even if the forage were better, the same result would occur if the cost of improvements necessary to utilize the forage, such as fences, water development, eradication of poisonous plants, or reseeding, were more than could be justified by the return. Still other land may justify the application of capital for grazing purposes, or, if physically suitable for cultivation, may yield a return sufficient to compensate the cost of utilizing it for cultivated crops. Only land of certain grades and in certain sites can be used for truck farming or other very intensive uses. Hence we may say that a particular plot of land is marginal for this, that, or the other use. That is, there is an extensive margin for each degree of intensive use, a point where it just pays to use land for each particular purpose.

Marginal crop land is, then, that land which returns just enough to pay for using it for crops, and submarginal crop land is land which produces

less than enough to pay for so utilizing it. There is a difference, however, between marginal land and land which is marginal for a particular use. Land which would be intensively used would almost certainly be supramarginal for some use. For example, any land which would be used for crops would probably yield some rent as pasture. Consequently, in order that it will be drawn into crop use it must yield not only the cost of producing the crop (labor, capital, and entrepreneurship) but also enough rent to entice it away from the other use, as illustrated by figure 2. That is, it must return when used for crops not only the production costs but at least as much more as the rent which the pasture would produce.

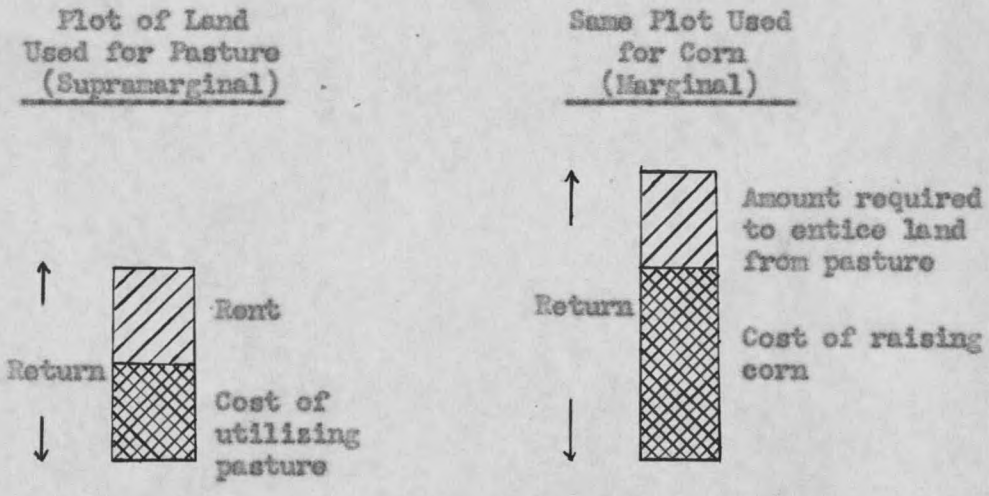

FIGURE 2.--RETURN REQUIRED TO ENTICE LAND FROM ONE USE TO ANOTHER

The margin for any particular use is determined not alone by position and productivity due to soil and climate, but shifts because of other factors, including price relationships (farm costs and income), types of farming

and farm organization, farming methods, and capacity of individual farmers. Obviously, an increased demand for a product will cause a rise in price and extend simultaneously the extensive margin and intensive margin of cultivation in regard to that particular product. It should be remembered, however, that land will not shift from its present use to one which will yield a greater return unless the increased return is at least large enough to compensate the transference of land to the new use.

Let us now consider land from the standpoint of the individual farmer. When land returns more than enough to remunerate the outlay for labor, capital and entrepreneurship, assuming fertility to remain unchanged, it is said to yield economic rent. It is this ability to yield rent which gives land value. The yearly income which is due to rent is capitalized by the entrepreneur who invests money in the right to collect rent from land. If land yielded $2 per acre above the cost of operation and the prevailing interest cost were five per cent, the value of the land would be approximately[7] $2 ÷ .05, or $40 per acre. To the individual farmer, the

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7. The conventional formula for determining farm value from realty income, based on the idea of present worth of future income, is $V = \frac{a}{r} + \frac{i}{r^2}$, where "V" is value of land, "a" is annual income, "r" is the rate of capitalization, and "i" is a straight line annual increase in income which will continue indefinitely, i.e., to infinity. This formula is of theoretical value but scarcely practical because it assumes that "a", "r" and "i" will remain constant. It is difficult to determine whether or not, or to what extent soil is being mined, or to forecast tax policies of governments, or to forecast future interest rates. The formula assumes that "i" is a straight line annual increase in income which will continue indefinitely, which assumption it might be difficult to substantiate. It is quite likely that a straight line decrease would more nearly fit the picture. For a short time valuation the formula, $V = \frac{a}{r}$, gives a fairly accurate valuation.

investment in land is a cost of operation. If he pays more than is profitable according to normal productivity of his land, he may increase his cost by overinvestment in land to the extent that the land will seem to him to be unsuitable for the use to which he has put it. This is what happens when production of abnormally good years is used as a basis for capitalization of land.

A tax on land amounts to a confiscation of land value. A tax of $1 per acre on the land which yielded $2 per acre above cost of production reduces the income by $1 per acre and the value by $20 per acre. Taxes, like investment in land, tend to be affected by abnormally good years and, unless they can be adjusted, may prohibit the use of land which is theoretically marginal or supramarginal.

This study concerns the disposition of Montana's submarginal crop land. In land use planning it will be necessary to examine the costs and returns carefully before classifying the land. For example, it has already been indicated that much of Montana's dry farm land was settled at a time when prices and yields were abnormally high, resulting in high capitalization of land. Since interest is a cost to farmers, if and when land capitalization can be brought into line with land productivity values, some land which is now apparently submarginal for crops will be recognized as marginal or supramarginal from the crop farming standpoint.

Or, again, the tax rate, itself affected by land utilization, becomes more or less fixed and in turn affects the feasibility of land utilization. Table I shows the amount of county owned land in Montana for the years 1925, 1930, 1934 and 1937. This land, a large part of which is

TABLE I.--COUNTY OWNED LAND IN MONTANA*

For the Years 1925, 1930, 1934, 1937

Year	Acres	Per Cent of Total Land Area
1925	55,965	.06
1930	1,212,579	1.30
1934	2,537,088	2.72
1937	3,348,191	3.59

*Source: Renne, R. R., Who Owns Montana's Land?, Mimeo. Cir. 15, Montana Agricultural Experiment Station, 1939, Table III, p. 18.

abandoned crop land, has become submarginal because of some combination of the factors listed above and has been taken over by the counties as settlement for delinquent taxes. In addition, there are over 4,000,000 acres five or more years delinquent and subject to tax deed.[8] Some of this delinquency probably has been caused by improper distribution of the tax load. Perhaps some of our apparently submarginal crop land can still be used for crops by a proper adjustment of the tax load. An increased demand for farm crops, causing higher farm prices, would cause submarginal land to become marginal or supramarginal, although the outlook is not good for any substantial increase in demand for Montana farm products.

Land may be marginal or supramarginal for crop use but not appear so because of the low ability of the man who farms it. In other words, the problem may be not submarginal land but a submarginal entrepreneur. Land which has gone out of crop production because of this reason may yet be cropped by a farmer of at least normal ability.

In addition to these maladjustments, the classification of land as to proper use is made complex by the difficulty of determining what is normal productivity of land or normal prices.

Although it is not within the scope of this study to attempt to set up criteria by which to determine whether or not crop land should continue to be used as crop land,[9] it might well be pointed out that from the

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8. Renne, R. R., and Lord, H. H., Montana Farm Taxes, Cir. 94, Montana Agricultural Experiment Station, Bozeman, Montana, June, 1938.
9. Studies of this type have been made, e.g., the following: "Land ranging from 12 to 15 bushels are in the doubtful area as far as wheat or other cereal production is concerned.... Land producing less than 12

standpoint of general land planning, whether it be by county governments, government planning agencies, or farmers, this decision should be made on the basis of normal costs and normal returns, considering possible adjustments.

Objectives of the Study

It is with crop land which, because of conditions of climate and soil, has been found by study or experience to be not productive enough under normal conditions to pay the costs of farming it, including labor income sufficient for a family living, that this study is concerned. This type of land will go back to non-crop pasture land status. An adjustment of land costs (interest and taxes) will probably be forced. For certain grades of this land and under certain cost conditions the best disposal of it is to seed it to perennial grasses. Under certain conditions, too, this may be done under private ownership. Under other conditions the returns from this type of land will not cover interest on any investment in land or any tax load, but from the standpoint of society it would be good policy for the government to reseed the land or subsidize its reseeding to conserve resources or avoid a dust hazard. Finally, there are probably areas where the better plan would be to let the land go through the slow process of natural revegetation (including soil building). A method of analysis by which to determine the feasibility of

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9. (Cont'd) bushels to the acre under a summer fallow system may be definitely regarded as uneconomical and shifted to some other level of use. Definite plans should be made to encourage the reseeding of this type of land to some species of grass which is adapted to conditions prevailing in the Great Plains." E. A. Starch in Land Use Planning in Montana, Mimeo. Cir., Montana Agricultural Experiment Station, February, 1934, pp. 5 and 6.

restoring submarginal crop land to range by artificial revegetation for different grades of land and under different cost conditions should be of value to counties having tax delinquent lands to dispose of, to government planning agencies, or to farmers. To develop such a method of analysis is the objective of this study.

Method

The study is designed to be research in technique or method rather than facts. The fact that a considerable variation exists in climate, soil, topography and economic conditions which affect the feasibility of artificial revegetation, makes each small area a separate problem. It was neither possible nor did it seem necessary to obtain detailed information for every individual plot in the state and classify it as to the economic feasibility of artificial revegetation. This project was designed, rather, to determine the steps through which each individual should go in analyzing his own situation, using data which apply to his own particular area.

The method used is as follows:

1. All data which were available were collected for the state as a whole to indicate the scope of the problem of submarginal crop land, variations which exist in factors affecting reseeding, and trends in the restoration program.
2. Valley County, which ranks highest in the state in acres of abandoned land and idle crop land, and second in number of acres designated as restoration land by the Agricultural Adjustment Administration, was chosen as a sample county for more intensive

study. Detailed data for this county were obtained and used to set up a model case for which to determine the value of artificially established pasture, cost of establishing this pasture, and the net income left for land charges.

3. There is general agreement that crested wheatgrass (Agropyron cristatum) is the grass which gives the best results for artificial revegetation in most parts of Montana. For this reason that grass was used in the study.

4. Certain assumptions, such as the value of an animal month of grazing capacity and the cost of drilling seed per acre, were drawn from other studies. If the judgment of the reader dictates that these assumptions are incorrect for his particular case, he can substitute his own figure for these as well as data applying to his particular land area.

Source of Data

The data used were obtained chiefly from six sources, which are as follows:

1. Data for comparing amount of crop land at different times for Montana counties were taken from the United States Agricultural Census.

2. Data concerning land use and farm practices including restoration land, idle land, and grass seeding were obtained from state Agricultural Adjustment Administration records.

3. The County Agents' supplementary crop reports were used to

determine the approximate amount of crested wheatgrass sown in 39 counties and the value of this grass for forage and seed.

4. Figures compiled from Western Range Survey field sheets were used to determine carrying capacity of different types of range in Valley County, and a type map, also a result of the Western Range Survey, has been used to illustrate the problem of abandoned crop land.

5. A questionnaire was mailed to 300 farmers (200 in Valley County, 48 in Fallon County, and 52 in Toole County) for the purpose of getting information concerning crested wheatgrass seeding under actual farm conditions. A return of about 33 per cent was obtained from this questionnaire, which was arranged in very simple form. Its chief function was to aid in determining the degree of success farmers have obtained from sowing crested wheatgrass by different methods of sowing, and time required to get the grass up.

6. Data concerning carrying capacity of crested wheatgrass pasture were obtained from the reports of the Judith Basin Branch of the Montana Agricultural Experiment Station.

ANALYSIS OF PASTURE VALUE

What Shall be Done with Submarginal Crop Land?

Perennial Grass the Natural Climax Vegetation.--The problem here under consideration is as follows: We are given a large acreage of crop land in Montana which is found to be unsuitable for farming. Some of it is obviously submarginal but is being kept in production by subsidy of one kind or another. Eventually it may drop out of production. Still other of this submarginal land has been abandoned to weeds and grasshoppers:- mute evidence that either someone made a faulty estimate of its normal productivity in relation to costs and prices, or else a short time viewpoint was held. What is to be done with this land?

The logical answer is that it should be and will be returned to grass, either through the slow process of natural revegetation (through the stages of plant succession) or through artificial revegetation. The natural climax vegetation over most of the dry land farming area is perennial grass, and if the land is left undisturbed for a period of years, grass "silently resumes the throne from which it has been expelled, but which it never abdicates."[1]

Natural Revegetation.--The process of natural revegetation of abandoned crop land is a slow one. It is estimated that it requires about 50 years under average conditions and with unrestricted grazing to replace

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1. Ingalls, John J. Quoted from his "Blue Grass" by Leo Edw. Melchers in Grasses in Kansas, Report of Kansas State Board of Agriculture, Topeka, Kansas, 1936, p. 8.

the weeds which appear first with a good stand of native forage grasses by this method. Table II shows the result of a study of plant succession on abandoned land made in Wheatland County by E. W. Nelson in 1935. Because of the slow return of the most valuable species blue grama, the land had after 16 years only about one-half the grazing capacity of native range. There is little incentive for private individuals to own this type of land, and unless the return for reseeding will justify the cost, this land will go to make up what is termed the "new public domain". The chief cost of natural revegetation is the time element, to be brought out in the Analysis of Costs.

Non Pecuniary Value of Grass.--There are reasons other than its value for pasture, for the desirability of getting abandoned crop land into grass, which, especially from the social point of view, have a bearing on the amount which can profitably be spent in order to get a good cover of grass as soon as possible. Experiments have shown very conclusively that grass has great value in controlling water run-off and soil erosion. On certain watersheds this may be very important from the standpoint of flood control or the prevention of silting of reservoirs. This characteristic is also important from the standpoint of soil conservation and prevention of the lowering of the water table. Where soil is subject to wind erosion, grass may be very valuable, not only in preventing soil loss but in preventing the discomfort caused by dust storms[2] and the loss to crops and

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2. "Much of the state's low yielding lands could be eliminated without materially affecting the state's total wheat production," writes E. A. Starch (Bul. 318, Montana Agricultural Experiment Station, Montana's Dry Land Agriculture, p. 10). It is alleged, however, that dust layers from plains dust storms settled in homes in Washington, D. C. during the spring of 1934.

TABLE II.--OCCURRENCE OF NATIVE SPECIES ON VARIOUS TYPES OF LAND IN WHEATLAND COUNTY, MONTANA, 1935*

Species	Native grass land	Abandoned plowed land			
		1 - 5 years	6 - 10 years	11 - 15 years	16 years and more
	Per cent	Per cent	Per cent	Per cent	Per cent
Blue grama	36.0	0	2.0	3.0	3.4
Bluestem	7.8	6.0	12.0	12.0	18.0
Needle and thread	12.5	1.0	13.5	20.0	16.0
June grass	4.0	0	1.0	2.0	**
Native bluegrass	**	0	**	**	**
Other grasses	3.0	0	4.0	4.0	8.0
Dryland sedges	13.0	**	1.0	2.0	2.3
Total grasses and grasslike plants	76.3	7.0	33.5	43.0	47.7
Perennial and biennial weeds	4.8	13.4	16.2	15.4	12.4
Annual weeds (mostly Russian thistle)	5.2	72.3	30.2	18.4	13.0
Browse	13.9	7.3	20.1	25.2	26.9
Total	100.0	100.0	100.0	100.0	100.0

* Source: The Western Range, Senate Document 199, Washington, D. C., 1936, Table 48, p. 244. (Study by E. W. Nelson, now Head of Department of Range and Pasture Management, Colorado State College, Fort Collins, Colorado)

** Less than 0.5 per cent.

grass in adjoining fields due to wind driven particles of sand. Although there is no suitable measure for it, there is even an aesthetic value in the appearance of a well-grassed area in comparison with one covered with weeds and drifting soil. These, as well as the stabilization of the agricultural industry, are considerations which must guide public agencies in determining the procedure for regrassing abandoned farm land which has become public property or in subsidizing reseeding operations of private individuals or groups.

It is the increasing importance, as our civilization becomes more complex and as its different aspects become more and more finely interrelated, of taking into account social cost and social income that justifies the increasing emphasis in land planning by public agencies. The purpose of planning activities, involving such phases as public purchase of submarginal land, changes in land tenure, exercise of police power by rural zoning, or creation of cooperative soil conservation and grazing districts, is not solely to protect the interests of the remote future, but may be to benefit people now living. A feature of the traditional American attitude, that every man should enjoy a right to the unrestricted ownership of a piece of earth, is being modified as it becomes increasingly possible for great numbers to suffer loss because of the way a private owner handles his land.

For example, a nonresident may have become the owner of an area of plains grassland for speculative purposes. As a private owner, it might

possibly be a wise course for him to plow the land and chance getting two or three good crops from the new land, even though it should turn out to be bad "blow land" in the years to follow. But from the standpoint of the neighbors who are in the path of the dust from the area - even in some years of people living as far as the eastern seaboard - this method of handling the land may involve a social cost far in excess of the return to the owner. Conversely, the return from restoring a piece of abandoned crop land to grass may not justify the entire expense from the standpoint of the individual entrepreneur, but if putting the land to grass prevents bad dust storms, helps to prevent floods, prevents silting of reservoirs or navigation channels, or, by adding to the aesthetic qualities of the landscape, helps attract tourists, the social income added to the private income might more than justify the expense.

All this is tied in with differences in social and individual time discount, involving such considerations as the continuity and security of the state, costliness in periodically liquidating and recreating communities, or the probability of developing substitutes or changing requirements. The evaluation of these broad social considerations has been termed a "frontier in land economics".[3] For the present, in reference to a range restoration program, we can only assume that these values are given concrete expression in subsidies to farmers or in seeding activities on publicly owned land.

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3. Gray, L. C., and Regan, Mark, "Needed Points of Development and Reorientation in Land Economic Theory," Journal of Farm Economics, Vol. XXII, February, 1940, p. 46.

Pasture for Livestock the Primary Consideration.--In determining the proper procedure for returning the submarginal crop land to its natural cover, however, allowances made for the protecting and healing values of grass will be only incidental to the primary consideration - its value as pasture for livestock. In regions of very limited rainfall the utilizer of land comes very early up to the margin of intensive cultivation. Obviously, land which may have no value as wheat land may have value as pasture because of the difference in costs (fixed and variable) of producing the two products. Since grass is a perennial crop, there is no outlay for seed or for seeding and tillage operations. The expense of harvesting of pasture is also cut down to whatever management practices are necessary to effect proper utilization of the feed by livestock. There is, of course, grass land which has no value for pasture. An extreme case would be an area on which the grass is so poor that an animal uses up all its energy in going about hunting enough food to keep alive. If the grass were better, but too far from water and not good enough to pay for the necessary investment in water development, we get the same result (no value). This line of reasoning holds for all the costs which might be related to utilization of pasture land, including such items as fences, water development, eradication of poisonous plants, and reseeding operations. Also, such items as excessive supplemental feed costs due to unbalanced ranch units must be considered.

How Value of Pasture Land is Determined.--The value of land for pasture, then, must be determined by examining the cost of producing and utilizing the feed in relation to the value of the feed in terms of animal

months of feed.[4] Since the objective of this study is to put the method of analysis on such a basis that by its use the feasibility of artificial revegetation may be examined from the standpoint of different types of ownership, the costs have been divided into two groups: (a) the cost of establishing and utilizing the pasture and (b) the costs arising directly from ownership of land, i.e., taxes and interest. In order to determine the feasibility of artificial revegetation, it is proposed to carry the analysis through the following three stages:

1. Determine the value of pasture so established.
2. Determine the cost of establishing and utilizing this pasture.
3. After determining the expected net income which is available for land charges, attempt to reach some conclusion as to the practicality of the project from the standpoint of private or public ownership.

Crested Wheatgrass

History of Use in Montana and Present Trend.--It has been indicated that because there is general agreement that crested wheatgrass is the most satisfactory grass for use in artificial revegetation in Montana, that grass will be used in this analysis. Some experimental work has been done on crested wheatgrass in this region since it was first imported from Siberia in 1898 (by the United States Department of Agriculture) but it attracted

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4. An "animal month" is defined as the amount of forage required in one month by an "animal unit". A 1000 pound steer or its equivalent is usually given as an "animal unit". A mature cow or 5 sheep are usually given as equivalent to a 1000 pound steer.

little attention until about 1915, and it was not until the native range was greatly affected by the extreme drought in the early 1930's that the grass came into extensive use. After crested wheatgrass had demonstrated its superior ability to withstand drought and produce under conditions of little moisture, the grass has gained rapidly in popularity. Its use has been encouraged by the Montana Agricultural Experiment Station, Montana Extension Service, and agencies such as the Soil Conservation Service and Farm Security Administration.

The recent increase in the use of crested wheatgrass in Montana is demonstrated by data included in the yearly reports on supplemental crops by county extension agents of 39 Montana counties. The estimated amount of crested wheatgrass for these counties in 1935 was approximately 4000 acres (See table III). Over half of this was cut for seed. At that time seed was selling for 50¢ to 60¢ per pound and whenever there was a good seed crop, this proved to be the most profitable use. As the value of the grass became more widely recognized and, as a result of study and experience, information was obtained concerning the planting, growing, and handling of the crop, its use became more widespread. In 1939, the estimated amount of crested wheatgrass on crop land in the 39 counties was 369,707 acres. Acres of seed crop for these 39 counties in 1939 was estimated at 48,206. This large acreage plus a good seed year has increased the supply of crested wheatgrass seed so that in the fall of 1939 the seed sold at 10¢ to 15¢ per pound. This low priced seed was an added incentive for sowing crested wheatgrass for hay and pasture, and reports from farmers, county agents and soil conservation men indicate that there has been a large increase in the number of acres sown in the fall of 1939.

TABLE III.--ACRES OF CRESTED WHEATGRASS ON FARM LAND IN 39 MONTANA COUNTIES, 1935 and 1939*

County	Acres of crested wheatgrass	
	1935	1939
Beaverhead	35	400
Big Horn		1,000
Blaine		25,000
Chouteau		12,000
Custer - Powder River		500
Daniels	54	18,000
Dawson		10,000
Fallon-Carter	214	16,000
Fergus		14,000
Flathead	10	24,000
Garfield - Petroleum		23,000
Glacier		775
Hill	500	20,000
Judith Basin	620	12,800
Lake	10	1,250
Lewis and Clark - Broadwater	250	4,000
Madison - Jefferson		1,950
Meagher		5,021
Park	800	3,000
Phillips	87.5	20,500
Pondera	483	7,245
Prairie	34	20,000
Richland	32	12,000
Roosevelt		6,500
Rosebud		8,000
Sanders		1,000
Sheridan	100	10,000
Stillwater	30	2,000
Sweetgrass		266
Toole	300	6,000
Valley	240	50,000
Wheatland		12,000
Wibaux	100	10,000
Yellowstone		5,000
Total	3,899.5	363,207

* Source - County Extension Agent's reports on supplemental crops to Ralph D. Mercer, State Extension Agronomist.

Natural Characteristics of Crested Wheatgrass.--Among the natural characteristics which make crested wheatgrass especially adapted to artificial reseeding for pasture in Montana are the following:[5]

1. Remarkable drought resistance. Crested wheatgrass, after it has become well established, will go into a dormant condition when weather becomes very hot and dry, but no amount of drought seems to kill it in Montana.
2. Longevity. The grass is a long lived perennial.
3. Marked cold resistance. Crested wheatgrass is not subject to frost injury or winter killing. For this reason it is very valuable in furnishing early spring and late fall pasture.
4. Adaptability to a wide variety of soil types. It is not, however, very alkali tolerant. Does best on light soils.
5. Excellent seed production.
6. Extensive root systems. To this characteristic its drought resistance is probably due. This extensive root system also adds fiber to the soil.
7. Palatability. Crested wheatgrass equals all other grasses in palatability, although there is a period during the summer when the plant goes into a dormant stage and the forage becomes harsh and non palatable.
8. Tolerance to close grazing and trampling. The grass is not killed out or damaged easily by heavy use.

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5. Stevenson, Clark, and MacIssaac, Seeding Crested Wheatgrass for Hay and Pasture, Pub. 557, Department of Agriculture, Dominion of Canada, Ottawa,

Its Role in the Ranch Management Plan.--Because of these characteristics, crested wheatgrass is of value in a unique way in regard to its role in the management plan of an individual ranch. The following is a statement of the value of crested wheatgrass as given in the yearly report of Ralph D. Mercer:[6]

> "From the experiments sighted above, from the Moccasin Station, and from observations of stockmen and Extension Agents, it appears that the main values of crested wheatgrass are to be obtained as follows:
>
> 1. From seed production for use on the same ranch where grown for sale.
>
> 2. From hay cut before the plant comes into bloom. Cut at this time, the hay is palatable and not coarse and hard as it is when cut later.
>
> 3. From heavy use in the early spring before other pastures are ready. Later allowing the plant to grow up for hay or fall pasture.
>
> 4. For early pastures for ewes and lambs or cows and calves near the headquarters.
>
> 5. For flushing ewes after hay has been cut from the field. Fields will make good growth after hay is cut and is good succulent pasture. This pasture is not so valuable when seed is cut because of lateness of cutting or because of high coarse stubble.
>
> 6. To raise hay and pasture on land too poor to raise any other crop under dry land conditions after the land has been plowed and found to be unprofitable."

It is the opinion of many farmers and agronomists of Montana that crested wheatgrass, in areas to which it is adapted, is superior to native grasses in that it gives a greater and more uniform production of forage over a period of years. This opinion has been confirmed by experiment in

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6. Mercer, Ralph D., Montana Extension Agronomist, Yearly Report, Bozeman, Montana, 1939, p. 65.

some areas. The chief reasons for this superiority are its remarkable drought resistance and its resistance to cold.

The drought resistance of crested wheatgrass is due in part to its extensive root system. Mr. J. K. Pavlychenko of the University of Saskatchewan found that a two-year-old clump of crested wheatgrass had "319 miles of roots probing through a mass of soil seven feet deep and four feet square".[7] Because of this root system, the grass is successful in weed control, a good forage plant, and a remarkably efficient binder of the soil against the wind erosion that starts dust storms. Mr. Ray Haight[8] raises the question; however, whether crested wheatgrass might not tend to "harvest moisture" as alfalfa has been found to do.[9] Because of the different moisture requirements, it is quite unlikely that the grass would have the same effect as alfalfa, but it is conceivable that long time planning estimates made for the purpose of planning entirely on the basis of the production of the first several years might be misleading. Even if the grass should thin out and lose some of its vigor in time, it might

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7. Thone, Frank, "Prairie Grass Roots," Science, Vol. 85, No. 2196, January 29, 1937, Supplement p. 8.
8. Haight, Ray, State Representative of the Bureau of Agricultural Economics, Division of State and Local Planning. Interview, December 22, 1939, Bozeman, Montana.
9. In some areas in the Dakotas alfalfa does quite well for a few years as the roots follow the moisture down, and then the plants die and for a period of years the field will not grow alfalfa. Alfalfa will not grow with the amount of moisture furnished by normal rainfall, but it will grow for a few years by making use of stored subsoil moisture. This process of using up subsoil moisture is spoken of as "harvesting moisture". Crested wheatgrass will grow with the amount of moisture furnished by normal rainfall, but its roots have the ability to go down deep after stored moisture, and it may yield a return while using up the reserve which it cannot maintain over a period of years.

still be a superior forage crop.

The fact that crested wheatgrass is resistant to cold not only protects it from winter killing but also allows for an early spring and late fall growth of forage. This not only makes for more forage because of a longer growing season, but there are several advantages in having the growth at these particular times. The early and late pasture reduces the hay requirement and consequently reduces the cost of feeding. It allows for better management of the native range because it reduces the temptation to turn on to it before it is ready. The green feed in the fall comes at a convenient time for flushing ewes for breeding and the early spring growth makes a good milk flow for lambs and calves. It is alleged that some ranchmen object to crested wheatgrass for range cows because of the necessity of milking out cows at calving time in order to prevent the udders from spoiling - a difficult practice indeed with some "wild" range cows.

By listing the advantages of crested wheatgrass as given by those who are enthusiastic in advocating its use, a case may be built for it which seems almost too good to believe. It is not an objective of this study to "sell" crested wheatgrass. There is substantial evidence that this grass does have certain advantages over native grasses, and consideration will be given these advantages in the model case which is to follow. It is our task to develop a method whereby it may be discovered whether the value of the grass will cover the cost of establishing and utilizing it under different conditions.

In view of the fact that there seems to be a tendency to oversell a new idea or new product, care should be taken to consider the possible