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A METHOD OF RURAL LAND CLASSIFICATION

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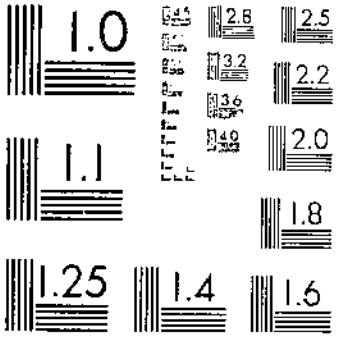

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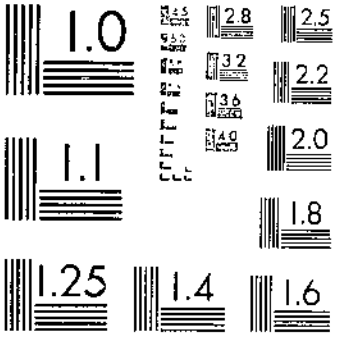

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TECHNICAL BULLETIN No. 469 FEBRUARY 1935

A METHOD OF RURAL LAND CLASSIFICATION

By

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UNITED STATES DEPARTMENT OF AGRICULTURE, WASHINGTON, D. C.

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UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

A METHOD OF RURAL LAND CLASSIFICATION

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FOREWORD

This bulletin discusses the general requirements of a method of land classification and presents an example of the method developed and used in western North Dakota. It must be emphasized that the method herein described has been developed for that particular section and cannot be used directly in other areas where local physical and economic conditions are different. The general logic of the method, however, may have a wide application, provided that the details are modified to meet the particular conditions where used.

OBJECTIVES AND REQUIREMENTS

A definition of land classification which would encompass all the various meanings attached to it may be impossible of conception. Nevertheless, any such expression, commonly being used by scientists, economists, and social planners, must be clearly defined if it is to have any meaning at all.

[1] The major part of the data for this bulletin was assembled while the senior author was professor of soils in the North Dakota Agricultural College.

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The general problem of classification is to place the objects classified into suitable categories, the better to study and remember their characteristics and to show their interrelationships. In the case of plants, animals, soils, rocks, and similar natural bodies this general statement defines the problem, and systems have been devised for their classification. Through the agency of these systems our knowledge is conveniently cataloged and remembered. In addition to a "natural" classification, however, there are frequently needed "practical" classificational systems, largely developed to meet some special problems. For example, it may be necessary to classify soils according to their lime requirement, fruits according to their edibility, or cows according to their milk production. In most instances, these practical classificational schemes are based, in a large part, upon the fundamental natural classification to which they are simply additions for the purpose of meeting some practical requirement.

It is apparent from the above that there are two general aspects to the problem of land classification: (1) The natural classification of land types on the basis of the inherent qualities of the land; and (2) the practical classification of land into categories defined in such a way as to achieve the particular objective for which it is needed. Not until these objectives are examined can a definition be made.

A difficulty of definition lies in the word "land" itself which connotes several attributes. This fact in itself does not necessarily create any special difficulty. But in the case of land, these attributes are the subjects of study in different, sometimes jealously guarded, branches of knowledge. Specialists are sometimes inclined to be jealous of intruders undertaking to study those subjects which fall, as they suppose, into their own narrow fields; and, at the same time, they are frequently unable to evaluate those subjects which lie outside their special fields. In ordinary usage "land" calls to mind certain physical qualities of surface feature, of position, of soil, of climate, of vegetation, and even of people and their cultural attributes. The character of these land types is of interest to geographers, geologists, botanists, soil scientists, and other specialists. Also, in ordinary usage, the term "land" connotes certain social and economic attributes. The geographical location is not only important in its relationship to climatic influences but in relation to markets as well. The accessibility to markets has a profound influence upon the management of land and upon the sort of utilization attempted.

Numerous suggestions regarding land classification have come, and are coming, from many people interested in the various physical and social aspects of land. Geographers, soil scientists, botanists, agronomists, economists—the list could be lengthened considerably—are all in the field. Most of these suggestions have been made from the limited point of view of the specialist, many of them with no definite objective for the classification in mind. To arrive at an effective, practical, and accurate method, the use or objective of the classification must be clearly borne in mind. The degree of detail to be indicated, the number of categories and their definition, and similar practical questions of the job can only be decided after the demands to be made of the classification have been set forth.

THE OBJECTIVES

The objectives in practical land classification have been variously stated, depending on the special problems of the moment and particularly upon the experience of the one advancing the proposals. As far as rural lands are concerned, there are two general, but not mutually exclusive, problems which can probably best be satisfactorily solved with a land classification: (1) The equalization of taxation on land according to the productive capacity of the land, and (2) the planning of land use. The second objective may simply imply the accumulation of data for general recommendations, or for the use of people on the land, or it may imply the accumulation of data and its detailed geographic expression for some method of rural zoning or other public policies with respect to land use.

The importance of these two problems can scarcely be overemphasized. Much of the distress in rural communities is due to wrong land use. A large percentage of the tax-delinquent land, now presenting a serious problem to those governments charged with its administration, would still be on the tax rolls and in the hands of private individuals, had the taxes levied on it been based upon its productive capacity in the use group to which it is fitted.

During the course of American history, social good has frequently been recognized in those situations and institutions which allowed opportunity for individual ruination as well as for individual development. But naturally when these cases of individual ruination grew into community and national ruination, the privilege became a social hazard difficult to ignore. People engaged in enterprises which give inadequate return for the labor expended become social charges. Attention is being turned to the problem of preventing disastrous failures, from which not only the individual, but society as a whole, suffers, and at the same time utilizing the land to the limit of its productive capacity, consistent with economy and conservation. The problem of land use is not simply a question of negation, but more especially a positive question: "What use for each piece of land?"

The question of utilization for any particular area of land then requires a positive answer: This, that, or the other piece of land may be best used for—(1) cropping, (2) grazing, (3) forestry, (4) mining, (5) recreational activities, (6) urban development, or mixed use groups such as forestry and crop, grazing and crop, or forestry and recreation. At first one may ask, what has the question of land utilization to do with land classification? It has this: A practical classification of the land in use is determined in part by the characteristics of the land and in part by the possible utilization. To illustrate: Two areas of land having the same physical characteristics may be so situated that one is surrounded by large areas of good crop land, whereas the other lies in a general area best adapted to forestry. Because of its economic and social isolation from an agricultural community, the second piece of land, although naturally adapted, let us say, to the production of field crops, must be placed in the forestry-use group. Its productive capacity for forest growth then determines its classification with that use group. The other area, however, may take its rating within the cropping-use group on the basis of its productive capacity for crops. In order to give land a definite rat-

ing in any practical scheme of classification, it must first be placed within its proper use group, and then finally the social land units—sections, forties, townships, farms, ranches, parks, or their equivalents—can be rated within the use group.

With these considerations in mind, it is now necessary to inquire: (1) Is our objective to classify land with reference to natural land types as a basis for study and for cataloging our information regarding land; or (2) is our objective to give an actual rating to lands, as affected by present conditions, considering necessarily transitory economic and social relationships for the purpose, let us say, of tax assessment or of rural zoning; or (3) both? The first classification is a natural one and can be made essentially permanent, whereas the second is a practical classification and must be subject to revision as social conditions change. The second rests, fundamentally, on the first with modifications to meet the special requirements.

LAND CLASSIFICATION DEFINED

A natural land classification can be defined as one in which the natural land types are placed in categories according to their inherent characteristics.

A practical land classification can be defined as one in which the social units of land are classified according to their capabilities for man's use with sufficient detail of categorical definition and geographic expression to indicate those differences significant to man.

CLASSIFICATION OF NATURAL LAND TYPES

A "natural land type" may be defined as land having a particular combination of physical features, principally climate, soil, relief, and stoniness, which define its natural productivity for plants. Although these physical features are not mutually independent, a sufficiently great variation exists to require their separate consideration. This is especially true when any crop plants are to be considered, as the actual productivity when used depends partly upon the workability of the land under methods of cultivation which man may employ, as well as upon fertility.

A classification of such natural land types is based on their natural productivity, especially for grains and grasses, but also for other adapted plants. In the sense that the accessibility to markets and other economic factors are excluded from consideration, the classification is a natural and not an economic one. It is necessary to add, however, that certain economic factors may sometimes influence the *reliability* of the ratings of the natural land types. For example, where economic considerations have made it inadvisable to grow corn in an area during the past, one has less data for determining the natural productivity of such an area for corn. There is no way to evaluate such economic influences definitely. As the study of the characteristics of soil types and the relationships between soils and plants is continued, these influences become less of a problem. Differences in farm management, of course, produce different yields upon the same land types.[2] A classification according to natural

[2] For example, when those classifying (or appraising) rural land for tax assessment do not recognize the importance of this point, they frequently base their ratings on the appearance of the farm, thereby penalizing good management and favoring poor management. Unfortunately such errors in assessment are not uncommon.

productivity must not reflect such differences; otherwise it will fail in its primary objective.

The logical approach by which the natural land types are given positions within the classification is both deductive and inductive. There is no philosophical difficulty involved in the inductive method, wherein the productive capacity is ascertained from a knowledge of the properties of the land, the demands of the plant, and their interrelations. But to the degree that science has not completely at its disposal the necessary information, the inductive method has limitations. Deductively, one can reason from the results of actual social units of land use and estimate the inherent nature of the land type. However, since types of management depend upon variable personal qualifications of managers, the method has limitations. These difficulties are essentially those of all the applied sciences, both qualitatively and quantitatively.

It must be stressed that, of the important basic physical data, information regarding the soil is of the utmost importance. Any plan for land classification or utilization, which is not based on a scientific classification of the soil, is likely to be of questionable value for any practical use where growing plants are concerned. Nevertheless, it is the natural land type—a sort of natural landscape—defined principally by the climate, soil, topography, and stoniness, that is evaluated as a whole.

CLASSIFICATION OF SOCIAL LAND UNITS

After having made the classification of natural land types, or the data required for such a classification, it may be desirable to proceed to the classification of social land units for such purposes as tax assessment or zoning. Although not wholly different in fundamental logic, the problems involved in the case of urban, recreational, and mining lands are not examined in this discussion.

It is necessary here to evaluate each natural land type in terms of its productive capacity, as influenced by such an economic factor as accessibility to markets. As heretofore pointed out, the land must first be classified as to its natural productive capacity in the several use groups. Then, after it is placed in its proper use group, it can be rated according to its productive ability, in an economic sense, within that use group. Whereas the classification of the natural land types is essentially permanent, the classification of social units of land, however devised, is necessarily somewhat temporary. But, given an accurate fundamental classification of the natural land types, it becomes a comparatively easy matter to make adjustments in the classification of social land units to meet changing social and economic conditions. This point needs to be stressed. In doing the practical work of classifying land, unless the physical data are kept clearly and definitely separated from transitory economic considerations, any revision of the work requires that everything be done again, including the taking of the field data. But if the physical facts of soil and relief are once accurately mapped, these maps of the basic data are essentially permanent. From them the practical classification of social units can be adjusted from time to time, as necessary, with little or no additional field mapping.

The relationship of the objectives to the general method of classification is shown by the following outline:

LAND CLASSIFICATION

1. Objective: Planning land utilization (basic physical classification for objective 2).

Climate, Soil, Relief, Stoniness, (Native vegetation) } *Natural land type.*—To be classified into categories according to relative natural capability in possible types of utilization

2. Objective: Tax assessment; rural zoning

Natural land type, detailed expression
Relationship to social groups—
(*a*) Economic
(*b*) Social

Social land unit—
To be classified—
(1) Into use groups—
(*a*) Crop
(*b*) Grazing
(*c*) Forestry
(*d*) Recreational
(*e*) Mining
(*f*) Urban or definite combinations
(*g*) Crop and grazing
(*h*) Crop and urban
And then—
(2) As to capabilities within the use group

SIZE OF CLASSIFICATION UNIT

The size of the unit of any natural land type is determined by two things: (1) The nature of the country and (2) the fineness of distinction between the categories required to satisfy the objective. Under the first objective shown in the outline, which concerns the planning of utilization, certain broad groups may be established, using relatively large units. Such a classification has a limited use.

If, however, the classification has as its objective the planning of utilization on individual landholdings, or especially if the objective contemplates tax assessment, a measure of detail must be obtained such that the practical differences will be clearly indicated.

For example, an area may be said to consist of a certain stone-free, gently rolling Miami silt loam soil with small irregular areas of Carlisle muck occupying about one-third of the land area. For certain broad objectives considering general utilization, such a characterization might be sufficient, but for any practical use, in case, say, general and truck farming were to be considered, this broad land type would certainly need to be divided into muck lands and uplands. Where variations, significant to the possible enterprises, exist within these groups, others more carefully defined would need to be established. *Individual land types of a size sufficient to influence significantly the capabilities of separate units of operation need to be separated.* In areas where some agricultural use group is possible, individual land types greater than a certain minimum (about 1 to 10 acres, depending upon the possible utilization) need to be differentiated in mapping the area. It would be difficult to overstress this essential point. Without sufficient detail, any conceivable scheme of land classification is an absolute and complete failure as regards

the second objective of the outline. The matter is especially important in the case of the agricultural use groups, where the success of the enterprise is so completely and intimately bound up with the natural productivity of the land type and where the individual social units are small. One must realize that these small units are the starting point for any practical application of utilization studies. Unless the land classification is sufficiently detailed to indicate comparatively and accurately the practical differences between these units, it has little value as a guide in rural zoning and is of no use in tax assessment.

THE GENERAL REQUIREMENTS OF THE METHOD

In this section the details of a method of land classification which fulfills the objectives set forth are explained. The cornerstone is the basic classification of the soils, made strictly in accordance with the modern knowledge of soil science. In addition to what might be considered strictly soil features, other physical characteristics, such as relief and stoniness, must be mapped in sufficient detail, both as regards the size of the areas separated and as regards the degree of difference between classes, to indicate practical differences. In uncultivated areas the native cover, grass or forest, needs to be classified and shown by maps. Important classes of streams, lakes, and other physical features, so far as they have a practical significance in relation to the objective, are necessarily shown on the map. The relative importance of these special features and their classification depends somewhat on the possible use group.

Various combinations of these features give the natural land type which can be assigned a definite rating of natural productivity. A map showing these types serves the first objective—general planning of land utilization.

Using the above ratings of natural land types and adjusting these ratings as they form parts of social units, such as farms, ranches, and parks, to existing social and economic conditions influencing production, a practical classification of these social units can be made. After adjusting the ratings of the natural land types for accessibility to market and other factors relating to the social unit, a definite appraisal of the social land unit is obtained. This attains the second objective of the outline—tax assessment or data for zoning.

THE METHOD[1]

The previous discussion of the logical requirements of a land classification indicated the necessity for detailed physical information regarding the land, in order to define the natural land type. It was further pointed out that economic considerations were important for the determination of the use group in which any par-

[1] As land classification requires the consideration of all phases of the "landscape", in the development of the method the writers have received assistance from numerous farmers, ranchers, and technicians in various fields; and they wish to express their gratitude to the following men who gave them special assistance: The county commissioners of McKenzie County, N. Dak., whose interest in the work, encouragement, and sound advice were invaluable; M. B. Johnson, ranch economist; H. L. Walster, agronomist; H. C. Hanson, ecologist; and W. A. Cleveland, economist—all of whom were with the North Dakota Agricultural College at the time the method was developed; and M. J. Edwards, Soil Survey Division, U. S. Department of Agriculture, who was in charge of the soil mapping and had a large part in the development of the method.

ticular tract of land may be placed. Also, such a geographic factor as accessibility to market is important in determining the actual productive capacity, in an economic sense, of a piece of land. Since economic and geographic factors are variable and are continually changing, whereas those determining the natural land type are essentially permanent, the data for the land classification must be recorded in such a way as to keep the permanent clearly separate from the transitory. Certain natural physical factors of great importance, owing to their possibility of change by man, must also be indicated separately. These include native vegetation, presence of stumps, and the presence of loose, easily removable field stones.

In order to describe the method clearly, it may be best to take a concrete example of land classification in some particular area, showing the procedure employed to fit the general requirements as well as special local conditions of the area. The example, from McKenzie County, N. Dak.,[4] is chosen because the physical complexity is about what could be expected generally; and as the classification was made for tax appraisal, the work is as detailed as necessary for almost any other purpose. From an economic point of view this area is comparatively simple, as there are only two important use groups—crop production and grazing. On the other hand there are many strongly contrasting types of soil in the area, usually occurring in intricately detailed patterns.

The reader must bear in mind that the following method for McKenzie County is only an example. Furthermore, the whole plan was arranged according to existing local laws.[5] Inasmuch as farm improvements are not taxed in North Dakota, these were not considered. In other areas special land problems will call for special data and treatment. In timbered regions the forest cover would need to be mapped in some detail. The presence of large, firm stumps of pine or similar trees must be recorded as a factor in the determination of the use group. Other areas have similar special problems. But the fundamental logic of the method remains the same for the various landscapes and use groups. Because of the intricate pattern of greatly contrasting soils, McKenzie County would seem to be an admirable place in which to test the method.

The whole procedure, as accomplished in McKenzie County, can be generalized under four steps: (1) Accurate mapping, in detail, of the important physical features of the land; (2) the determination of the natural productivity of each important combination of these physical features (the natural land type); (3) the determination of the use group (or combination of use groups) to which the various social land units belong; and (4) the evaluation or rating of each individual tract of land according to its capabilities within its use group

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[4] The work in this county was taken up at the request of the local county authorities. The soil survey (and other field work) was done by the Soil Survey Division of the U. S. Bureau of Chemistry and Soils in cooperation with the North Dakota Agricultural Experiment Station. The experiment station made up the land classification from the maps. Funds were furnished by the county to pay for the State expense. Work is being done on a similar basis in other counties. See also the following publication: KELLOGG, C. E. A METHOD FOR THE CLASSIFICATION OF RURAL LANDS FOR ASSESSMENT IN WESTERN NORTH DAKOTA. Jour. Land & Pub. Utility Econ. 9: [10]–15, illus. 1933.

[5] See North Dakota Session Laws, 1921. These laws do not provide for rural zoning regulations at present, nor for a reduction in assessment of productive cropping land in case it is used for grazing or forestry. It also provides that ideal grazing land shall be taken as equivalent to 30 percent of ideal cropping land.

MAPPING THE PHYSICAL FEATURES OF THE LAND

In McKenzie County, grazing and crop production, either separate or combined, are the chief use groups. For the purpose of land-utilization studies and for the land classification, maps of the physical data were prepared on a scale of 2 inches to the mile. Each class of information is discussed in the following paragraphs:

BASE MAP

A base map is prepared showing the natural and cultural features of the area, such as (1) natural—streams, lakes, springs, escarpments, and rock outcrops; and (2) cultural—section lines, roads (in three classes), houses, schoolhouses, cemeteries, and railroads.

SOIL MAP

The soils are mapped according to series and types as defined by the modern system of soil classification. Since McKenzie County is a very large county (almost 2 million acres) containing many general types of physiography, there are a great many different kinds of soil. These are classified in 16 series, 32 types, and 15 phases.

A soil series includes soils having essentially uniform physical and chemical characteristics as well as similar physiographic position, drainage, and usually similar parent material. A section through the various natural horizons, or layers, of soil is called the soil profile. Within a series all the soil profiles are essentially similar, except for variations in texture, especially of the upper part. Thus, if the upper plowed layer is loam in texture the complete name of the soil includes the series name, for example, Morton or Bainville, plus the word loam. Hence, we may have Morton fine sandy loam and Morton loam, each a soil type within one series. The general character of the land surface, parent material, color, structure, and other characteristics of the soils, except texture of the surface soil, are similar. Again, a soil may be nearly identical with a particular type, except for some one feature of importance in land use, such as drainage or included spots having hardpan. Such soils are classified as phases, thus: Morton loam, hardpan phase, or Cherry silty clay loam, poorly drained phase.

Inasmuch as a report[6] is being prepared describing the soils of McKenzie County in detail, only a very brief description of a few of the soils will be included here as examples.

Scobey loam is a brown loam or silt loam developed from glacial till. It has a mellow brown surface soil underlain at 3 to 5 inches by brown soil arranged in medium-sized, friable, vertical blocks. At about 19 inches are grayish-white limy materials, grading with depth into olive-gray, limy glacial till. The soil is one of the most productive for grains and grasses in the area.

Scobey clay loam is similar to Scobey loam, except heavier in texture and somewhat more difficult for tillage.

Scobey clay loam, hardpan (solonetz) phase, resembles Scobey clay loam, except for the invariable presence of numerous "scabby

[6] The soils of McKenzie County will be described in detail in the soil survey report being prepared by M. J. Edwards.

spots" described in more detail subsequently under the appropriate heading.

Patent clay loam includes brownish-gray clay loam soils occurring on long, sweeping slopes. The material from which the soil has developed consists of local alluvial clay originating from clay buttes. The soil is somewhat less mellow than Scobey clay loam, but when carefully managed it is nearly as productive of cereal grains.

Alluvial clay, undifferentiated, includes heavy material in the bottoms of drainageways. Where not salty it furnishes fair grazing but is not suitable for cultivation.

Grail silty clay loam is similar to Patent clay loam except that it is older, is darker brown in color, and is more friable or mellow in structure.

Morton loam is a brown loam or silt loam, developed from residual material weathered from fine sandstone and shales. Except for this substratum, the soil is similar to Scobey loam.

Bainville very fine sandy loam is a grayish-brown very fine sandy loam overlying yellowish-brown very fine sand at a depth ranging from 5 to 10 inches. At 12 to 24 inches is encountered grayish-yellow sand residual from fine sandstone. This soil is usually developed only on hilly land.

Bainville clay loam includes grayish-brown clay loam over yellowish-brown clay at 4 to 5 inches. This is underlain by gray or yellow laminated clay at 10 to 20 inches. This soil is usually developed only on hilly land.

Rough broken land consists of very hilly nearly barren clay buttes, having less than 50 percent of the soil covered by grass.

Patent clay includes nearly level, but essentially barren, fresh clayey alluvium from clay buttes.

LAY OF THE LAND

The lay of the land is mapped in five classes as follows:[7]

A. Nearly level to level land on which external drainage is poor or slow. About 0 to 2½ percent of slope.

B. Gently undulating land on which external drainage is good but not excessive and where there is very little erosion.[8] All types of ordinary agricultural machinery may be used with ease. About 2½ to 7½ percent of slope.

C. Gently rolling lands on which ordinary agricultural machinery may be used, but with difficulty for the heavier types. There is some likelihood of water erosion with intertilled crops. About 7½ to 15 percent of slope.

D. Strongly rolling land on which agricultural machinery cannot be used. External drainage is rapid, but a good grass cover usually maintains itself. About 15 to 25 percent of slope.

E. Steeply sloping and hilly land with such excessive external drainage that grasses are not well supplied with water. Frequently these slopes are partly barren of cover, as explained later. More than 25 percent of slope.

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[7] The classification in the text is the one now in use in Billings and Morton Counties, N. Dak., and elsewhere. In McKenzie County a less detailed and less satisfactory 4-class system was used as follows: A. Level or slightly sloping land (about 0° to 2° of slope). B. Undulating to gently rolling land, having some slope but not enough to interfere with the use of agricultural machinery or to cause any serious water erosion (about 2° to 5° of slope). C. Rolling to strongly rolling land, having such slope that heavy agricultural machinery cannot be used successfully (about 5° to 10° of slope). D. Hilly land that is unsuitable for any sort of agricultural machinery and can only support native forage vegetation (more than 10° of slope). (Of course, a 45° slope equals a 100 percent slope.).

[8] Soil erosion by water is not important in this general area, but in some places within the area there are soils subject to some washing where poorly managed. Wind erosion is not definitely a function of slope but is closely associated with the character of the soil type.

It must be emphasized that the definitions of the classes according to percentage of slope are made after a study of the local problems of the area. Boundaries between classes are selected on the basis of their significance in land use. For example, in the so-called "Palouse country" of southeastern Washington, different percentages of slope would define the classes. There special technics are developed for harvesting wheat by machinery on slopes up to 50 percent and over.

GRASS COVER

For the evaluation of lands in the grazing use group the carrying capacity in terms of animal units per acre is the important item. This is determined by the soil type and lay of the land as each combination of these has an approximately definite grass cover. In the steeper lands, however, and especially the E (or D of McKenzie County) class of lay of the land, the percentage of the surface covered by grass must be shown. A suitable method in use for this work is as follows:[9]

D or E indicates that more than 95 percent of the area is covered with grass.

D_1 or E_1 indicates that from 75 to 95 percent of the area is covered with grass.

D_2 or E_2 indicates that from 50 to 75 percent of the area is covered with grass.

Where the land is less than 50 percent covered with grass the area is mapped in the proper class (rough broken land, Scoria stony loam, or Patent clay) having no important vegetative cover.

In determining the percentage of grass cover all grasses and sedges (but not brush) are considered, regardless of species. The quality of the grass cover as a whole varies according to the relative percentage of the various species, which is largely determined by the soil type and, to a less extent, by the degree of slope.

STONINESS

In many areas, especially where the soils are developed from glacial drift, the degree of stoniness becomes an important item. In order to obtain a measure of this factor, the number of ordinary wagonloads of stones an acre are estimated and shown in the following classes:

S =none to 2 loads an acre.
S_1=about 2 to 20 loads an acre.
S_2=about 20 to 50 loads an acre.
S_3=more than 50 loads an acre.

Where an area of some soil type is so stony that all of it would fall in the S_2 or S_3 groups, it is shown on the soil maps as a stony phase of the soil type. The classes shown above are mapped on a secondary sheet.

DRAINAGE

Streams and drainageways are important as sources of water, as natural barriers for fields, and as natural drainage channels. These are shown in the following classes:

[9] Funds were not available for the more accurate method used by the Forest Service.

(1) Large rivers.
(2) Running streams or intermittent drainageways, having permanent water holes that may serve as sources of water for livestock during summer.
(3) Intermittent drainageways which cannot be crossed with agricultural machinery and consequently serve as natural boundaries of fields.
(4) Intermittent drainageways which can be crossed with agricultural machinery.

SCABBY SPOTS [10]

(Caused by differential erosion of solodized-solonetz soils.) This important feature is confined to the arid regions. Where the land includes many of these barren, shallow basins its value is greatly reduced. The soil in these spots is very hard when dry and very sticky when wet. The value of the land is considerably less for grazing purposes and greatly reduced for tillage. Where an area of soil is thus affected, a hardpan phase of the soil type is mapped; if the area is small, a special symbol is used.

GRAVEL

Special symbols indicate erratic surface gravel.

SHALLOW SOIL

Areas which have a significantly shallower surface soil than average for the type, owing to removal by erosion or other causes, are indicated by symbol.

SALTY AREAS

The presence of excess salts is indicated by symbol, as such land is less productive of either native or crop plants.

FOREST GROWTH [11]

It is necessary to indicate the type, size, and density of the forest growth. Forests are only to be found along such large streams as the Missouri River in this area. For example, "Cottonwood (12–24)" indicates a medium-stocked cottonwood forest with trees ranging from 12 to 24 inches in diameter.

Occasional other minor symbols are employed for special features that may be important. It is important that each symbol be well defined quantitatively as well as qualitatively. In North Dakota it was found convenient to have each symbol indicating some modifying soil feature represent some definite area, such as 2½ acres. Thus, one symbol is used for an area large enough to be significant up to 2½ acres. An additional symbol is used for each additional 2½ acres.

As a further notation on any area which is not adequately described by the conventional symbols employed, special notes are written by the field men. If the legend is logically constructed, however, such notes are rarely needed. For this work uniformity

[10] A detailed explanation of the morphology and genesis of these interesting and important features may be found in the following publication: KELLOGG, C. E. MORPHOLOGY AND GENESIS OF THE SOLONETZ SOILS OF WESTERN NORTH DAKOTA. Soil Sci. 38: 483–501, illus. 1934.

[11] The reader should consult such maps and reports as those of the Michigan Land Economic Survey for a detailed method.

is of the utmost importance, and standard, well-defined mapping symbols must be everywhere employed. Any need for copious field notes indicates at once that some part of the classification is illogically arranged.

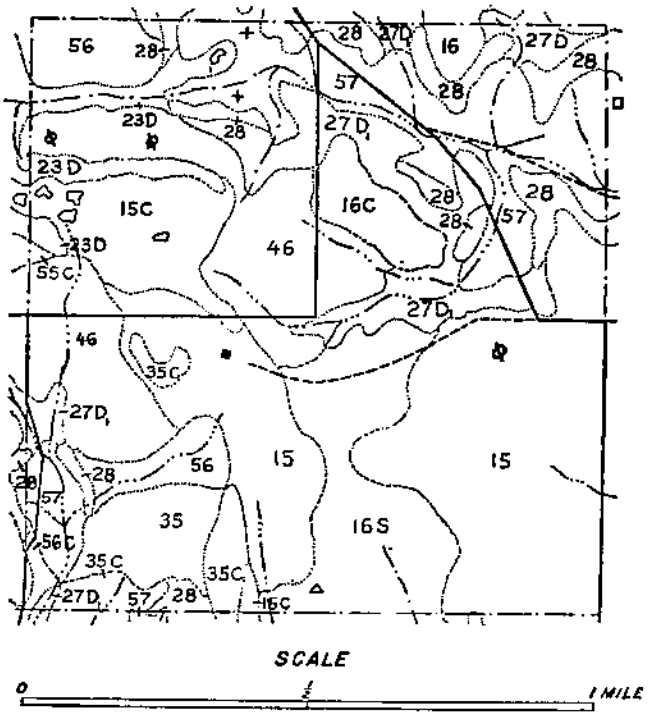
In order that these features may be mapped in the necessary detail for a classification of cropping lands, it is necessary that the field men traverse the area at intervals not greater than one-quarter mile. To further insure uniformity, it is necessary that some experienced individual make frequent contact with each of the workers in the field.

A sample copy of the field sheet for one section (640 acres) in McKenzie County, showing these physical features of the land is illustrated in figure 1 (p. 14). The map showing stoniness for the same area is presented in figure 3 (p. 18). The combination of the two maps gives a definition of the natural land types.

DETERMINATION OF THE PRODUCTIVITY OF THE NATURAL LAND TYPES

Following the logical procedure previously outlined, the next step is a comparative rating, according to productivity, of the natural land types (combinations of soil type, lay of the land, stoniness, and native vegetation in the uncultivated areas) in each of the possible use groups. For this area these are grazing and cropping. After extended observation and consultation with people familiar with the use of land, a table is constructed showing how each of the natural land types is to be rated in terms of the best cropping land, or the ideal, as 100 percent. The ideal is basic only for this particular project and, of course, is not directly translatable to other regions. For equalization between areas, additional factors, such as general climatic conditions, are considered. For obtaining the productivity or carrying capacity of the natural land types in respect to the grazing-use group, the assistance of ranchers and range ecologists was employed. The character of the native vegetation on the various lands determines their productivity as grazing lands. It must be emphasized here that these productivity ratings refer to the natural productivity; how these values are affected by important economic and geographic factors will be shown subsequently.

In table 1 is shown a portion of the general guide table giving the natural productivity of the various natural land types in the two principal use groups.



LEGEND

15 SCOBEY SILT LOAM
16 SCOBEY CLAY LOAM
16S SCOBEY CLAY LOAM (SOLONETZ PHASE)
46 GRAIL SILTY CLAY LOAM
56 PATENT CLAY LOAM
57 PATENT CLAY (BARREN) (A TO B SLOPE)
23 BAINVILLE VERY FINE SANDY LOAM
27 BAINVILLE CLAY LOAM
86 ALLUVIAL CLAY (A SLOPE)
28 ROUGH BROKEN LAND (LESS THAN 50% GRASS COVER)

CONVENTIONAL SIGNS

HOUSE OCCUPIED
HOUSE VACANT
PRIMARY ROAD
SECONDARY ROAD
SECTION LINES
DRAINS CROSSABLE
DRAINS UNCROSSABLE
SALTY SPOT
SURFACE STONE
SCABBY (SOLONETZ) SPOTS
SHALLOW SOIL

LAY OF THE LAND

A NEARLY LEVEL
B UNDULATING TO ROLLING
C STRONGLY ROLLING
D HILLY
D_1 HILLY (75 TO 95% GRASS COVER)

FIGURE 1.—Sketch map showing a copy of the field map for a sample section in McKenzie County, N. Dak. The original map was made on a scale of 2 inches to 1 mile. It will be noted that all the data, except stoniness (and forest cover in the river bottoms), are mapped on this one master map.

TABLE 1.—*A portion of the general guide table of basic ratings for the natural land types of McKenzie County, N. Dak., according to their natural productivity in the cropping and grazing use groups* [1]

Soil symbol	Soil type	Lay of the land [2]	Stoniness							
			S_0		S_1		S_2		S_3	
			Cropping	Grazing	Cropping	Grazing	Cropping	Grazing	Cropping	Grazing
			Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
15	Scobey silt loam	B	90–95	27½–30	80–85	27½–30	35–40	27½–30	------	17½–20
15C	....do	C	------	20 –22½	------	20 –22½	------	15 –17½	------	10 –12½
16	Scobey clay loam	B	75–80	27½–30	70–75	27½–30	30–35	27½–30	------	15 –17½
16C	....do	C	------	20 –22½	------	20 –22½	------	15 –17½	------	10 –12½
16S	Scobey clay loam, hardpan phase.	B	------	15 –17½	------	15 –17½	------	5 – 7½	------	2½– 5
56	Patent clay loam	B	80–85	27½–30	45–50	27½–30	------	25 –27½	------	10 –12½
56C	....do [3]	C	------	17½–20	------	------	------	------	------	------
57	Patent clay [3]	A–B	------	0 – 2½	------	------	------	------	------	------
46	Grail silty clay loam [3]	B	75–80	27½–30	------	------	------	------	------	------
32	Morton fine sandy loam [3]	B	40–45	10 –12½	------	------	------	------	------	------
35	Morton silt loam [3]	B	75–80	27½–30	------	------	------	------	------	------
35C	....do [3]	C	------	20 –22½	------	------	------	------	------	------
23D	Bainville very fine sandy loam [3]	D	------	10 –12½	------	------	------	------	------	------
27D	Bainville clay loam [3]	D	------	12½–15	------	------	------	------	------	------
27D$_1$	....do [3]	D_1	------	5 – 7½	------	------	------	------	------	------
28	Rough broken land [3]	C–D	------	0 – 2½	------	------	------	------	------	------
86	Alluvial clay [3]	A	------	22½–25	------	------	------	------	------	------

[1] The natural ratings are shown in percentages of the ideal cropping land. Ideal grazing land is taken as 30 percent of ideal cropping land, and for convenience ratings for both are shown in terms of ideal crop land as 100 percent.
[2] See footnote 7, p. 10, for a definition of these classes for McKenzie County
[3] These land types do not have stony equivalents.
[4] Note that all land naturally adapted to crops does not necessarily make ideal grazing land.

Supplementary to these fundamental ratings, cognizance is taken of minor physical features which modify the natural land type. The important symbols for this type of landscape are as follows:

(1) *Scabby spots.*—For each of these symbols, 2½ acres of the area takes the rating of the hardpan phase of the soil type shown.

(2) *Scoria symbol.*—Each symbol represents 1¼ acres of scoria (rating equals 0 to 1¼ percent).

(3) *Gravel symbol.*—Each symbol represents 1¼ acres of the gravelly phase of the soil mapped. (Such phases have lower natural ratings.)

(4) *Clay butte symbol.*—Each symbol represents five-eighths of an acre of rough and broken land. (Rating equals 0 to 1¼ percent.)

(5) *Salt symbols.*—On lowland types the rating is 0 to 1¼ percent because of the presence of poisonous plants in this area. Other types are reduced 25 percent for the area influenced by salt.

ADJUSTMENT OF RATINGS ACCORDING TO FOREST GROWTH

In a portion of the bottom lands along large streams, especially the Missouri and Little Missouri Rivers, cognizance must be taken of the forest growth. The presence of good timber raises the ratings of the naturally unproductive land types more than those of the productive types, but the presence of brush reduces the ratings of the

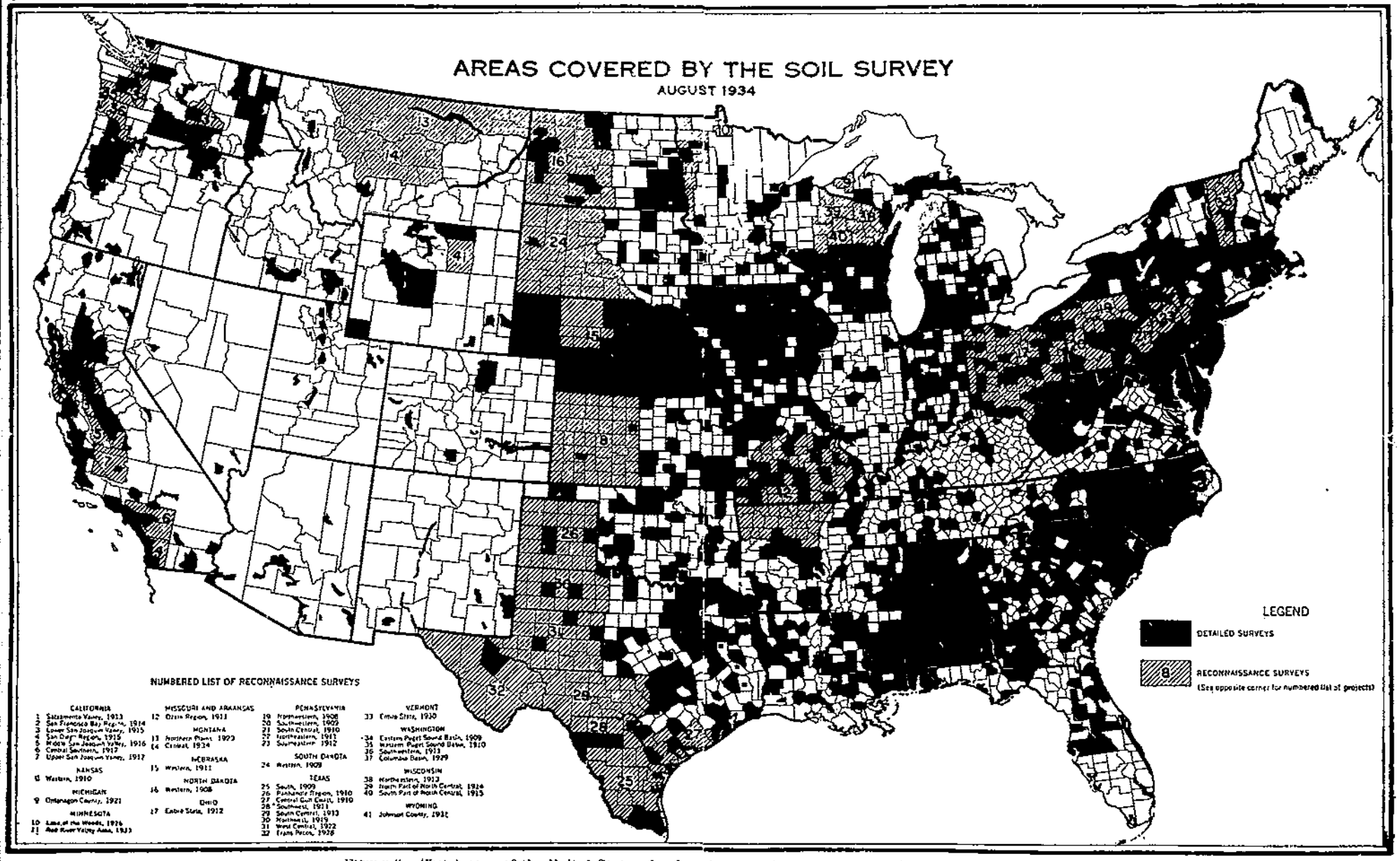


FIGURE 2.—Sketch map of the United States showing the general distribution of existing soil survey data.

naturally productive land types more than those of the unproductive types.

Estimates were obtained from experienced people regarding the cost of cutting timber, the value of the timber, and the cost of clearing land. The types of forest as mapped were classified in three general groups: (1) Good timber, (2) fair timber, and (3) brush. In an area, such as the northern Lake States, of course, the classification of the timber would need to be in much greater detail, but the relative importance of the forests and the differences to be found in this area do not justify greater detail. The group "good timber" includes the well-stocked stands of large cottonwood with occasional other species. The "fair timber" group includes stands of small trees suitable for poles and fence posts or medium-stocked stands of larger trees. "Brush" includes bushes and small trees of only slight commercial value but large enough and with a thick enough stand to require extensive clearing operations before the land can be cultivated.

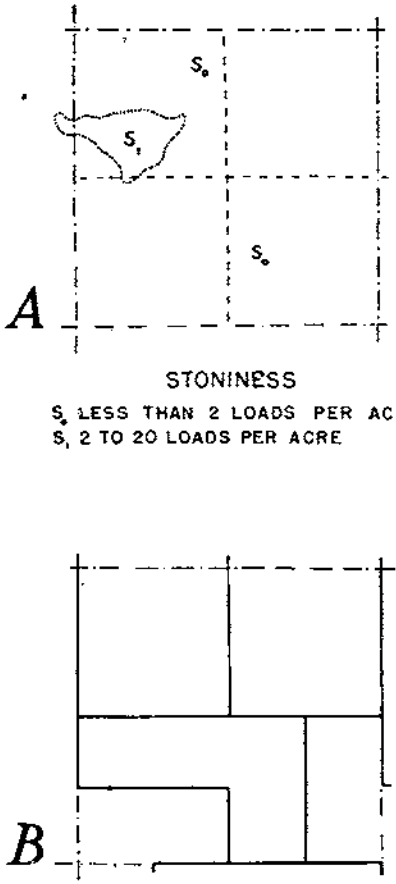


FIGURE 3.—Sketch maps of a sample section in McKenzie County, N. Dak.: *A*, Copy of the field map showing stoniness; *B*, ownership lines for the same section, as recorded in the office of the county auditor.

As this bottom land is stone-free and nearly level in topographic feature, these two elements of the natural land type are constant. For purposes of land classification an auxiliary guide table of ratings was constructed giving the ratings, in terms of ideal land, for the several soil types (or phases) where forest growth may be found. A small portion of this table for McKenzie County is shown in table 2. These ratings are substituted for those given in the general guide table for the lands having forest cover and were obtained by adjusting the natural ratings according to the value of the timber and the cost of clearing.[12]

[12] The authors realize that land naturally productive for crops is given such a high rating when forested as to discourage the use of the land for that purpose. The social desirability of laws to alter such a situation is not their responsibility to discuss here.

TABLE 2.—*A portion of the auxiliary rating table of natural land types according to forest cover, McKenzie County, N. Dak.*[1]

Soil type	Cover			
	Cleared	Good timber	Fair timber	Brush
	Percent	*Percent*	*Percent*	*Percent*
Havre silty clay loam	85 –90	85–90	40–45	10
Havre silty clay loam, poorly drained phase	15 –17½	80–85	30–35	4
Havre fine sandy loam	40 –45	83–87	37–42	7
Havre fine sandy loam, poorly drained phase	7½–10	79–84	29–34	3
Cherry silty clay loam	35 –40	80–85	30–35	4
Cherry silty clay loam, poorly drained phase	2½– 5	78–83	28–33	2
Banks fine sand	2½– 5	78–83	28–33	2
Banks very fine sandy loam	35 –40	81–86	31–36	5

[1] The ratings are expressed in percentage of the ideal cropping land as 100 percent.

RATING OF THE SOCIAL LAND UNITS

In this particular area the land is rated by 40-acre units (or fractions thereof), inasmuch as the land is shown on the tax rolls thus. But in considering the areas for the final ratings the land must be taken in farm (or ranch) units, as these are the actual units of operation from which any practical land classification must begin.[13]

The next step in the procedure is to determine the use group for the land within the 40-acre tracts. In such an area as the one under consideration where the soils occur in an intricate pattern, these units rarely consist uniformly of one land type. Before a tract can be considered in the cropping-use group sufficient arable land must be present within the farm unit for a worth-while unit of operation. For a consideration of the use group to which an area belongs, both natural and cultural boundaries must be taken into account. Primary roads, ownership lines, and uncrossable drainageways may have the effect of isolating small tracts of land types naturally adapted for crops as well as the type boundaries themselves. The following general principles to cover this point were carefully worked out and followed in the McKenzie County project.

(1) Isolated areas of a natural land type suited naturally for crops, but 5 acres or less in extent, were placed in the grazing-use group and subsequently rated within that group.

(2) Isolated areas (5 to 10 acres in extent) of a natural land type suited to cropping were given two-thirds their rating for cropping, if in the general region [14] of farming, and their rating in the grazing-use group, if in the general region of grazing.

(3) Isolated areas (10 to 20 acres in extent) of a natural land type suited to cropping were given 85 percent of their rating for cropping, if in the general region of farming, and their grazing rating, if in the general region of grazing.

(4) Isolated areas (5 acres or less in extent) of a natural land type suited only to grazing and surrounded by cropping land were given two-thirds of their grazing rating, if the slope was of the

[13] When these boundaries change, a slight revision is occasionally required in the office, as may be seen from the following statements.

[14] The outlining of these general regions must be a matter of judgment on the basis of the general distribution of the natural land types. In this case, as in most settled areas, the matter is greatly facilitated by an observation of current practice.

D class, and the full grazing value if the slope was of the C class.

On the basis of the character of the natural land types as amended by the considerations regarding isolation (local), the use groups to which the land belongs is determined. Then each 40-acre tract is given definite ratings [15] in terms of a percentage of the ideal cropping land of the area for the cropping land and for the grazing land in

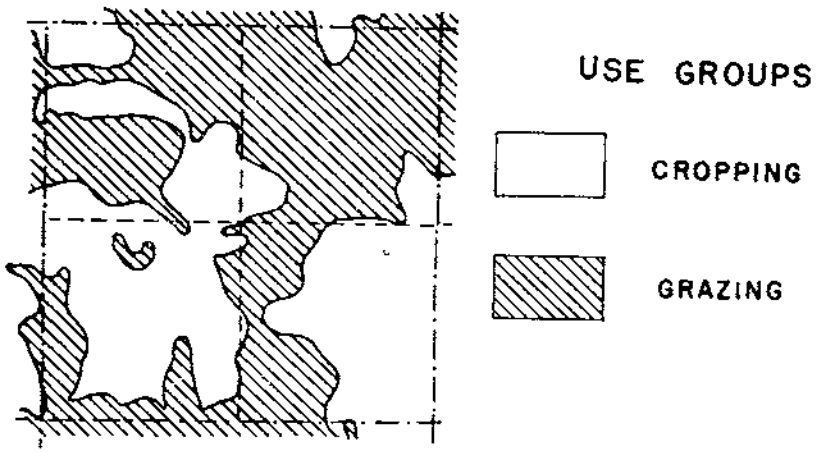


FIGURE 4.—Sketch map showing distribution of the two use groups within the sample section.

it as shown in figure 4. For the sample section these values are shown in the appropriate columns in table 3. It still remains for these values to be adjusted for accessibility to markets and water.

TABLE 3.—*Final ratings of a sample section in percentage of ideal*

Description	Distance to market (in terms of mileage of graded road)	Agricultural land			Grazing land				Final rating
		Area	Land rating	Rating after deduction for distance	Area	Land rating	Rating after deduction for distance	Rating after deduction for water supply	
	Miles	*Acres*	*Percent*	*Percent*	*Acres*	*Percent*	*Percent*	*Percent*	*Percent*
NENE	4	1	61	61	39	3	3		4
NWNE		2	61	61	38	4	4		5
SWNE		10	66	63	30	9	8.8		22
SENE		13	93	89	27	2	2		30
NENW		5	76	74	35	3	2.9		12
NWNW		30	54	51	10	13	13		42
SWNW		13	57	54	27	20	20		31
SENW		27	78	74	13	21	21		57
NESW		40	77	73					73
NWSW		35	76	72	5	4	3.9		64
SWSW		17	71	67	23	10	10		34
SESW		35	72	68	2	1	1		65
NESE		40	90	86					86
NWSE		15	93	89	25	16	16		43
SWSE		8	93	89	32	16	16		31
SESE		40	93	89					89

[15] These ratings each represent the weighted average of the ratings of the natural land types in the particular use groups (as adjusted for isolation if necessary). Areas of land were determined by the use of a fine grid laid over the map of the forty. The area of each natural land type, estimated for convenience in terms of sixteenths of a forty (2½ acres), is multiplied by its productivity rating. The sum of these products in each use group is divided by the total "parts" or sixteenths of that use group to give the weighted average. The weighted averages and respective acreages of grazing land and cropping land must be kept separate until after the adjustment has been made for accessibility to market. In unsectionalized areas the land could probably be more conveniently listed and rated by individual holdings.

ADJUSTMENT OF RATINGS ACCORDING TO ACCESSIBILITY TO MARKETS

After the social land units have been given ratings according to their productivity in their use groups, it still remains to harmonize these values in accordance with the distance from market, or rather the accessibility to market. The general method for the adjustment of land values according to accessibility to market (here taken as a trading center having a railway station) is based upon the following general principles:

The distance must be expressed in some uniform manner, eliminating any great variations in the character of the roads. The base map of the survey shows the character of the roads. As there were essentially no all-weather, hard-surfaced roads in this area the ordinary graded dirt road was taken as the standard. Each mile of ungraded road was taken as equivalent to 1½ miles of graded dirt road. In other areas having hard-surfaced roads each mile of such road must be counted as some determined fraction of a mile of graded dirt road if this type is used as the standard.

The two main use groups in the area are grazing and cropping. The factor to be applied will be different for land of the two use groups because of the differences in the cost of marketing the products per unit area.

Inasmuch as beef cattle constitute by far the greater portion of the products marketed from the grazing lands and wheat is the chief product marketed from the cropping lands, short periods of inaccessibility to markets on the graded dirt roads are unimportant. In other sections where, for example, whole milk is an important product, roads having short periods of inaccessibility would cause a great reduction in land ratings.

In the cropping-use group the data from the census and other sources show that as the distance from market increases, the organization of the farm unit so changes as to reduce the amount of grain marketed as such and to increase the amount marketed as livestock.

ADJUSTMENT FOR CROPPING LAND

According to the data of the United States Bureau of the Census in 1929, 61 percent of the acreage of harvested crops in McKenzie County was devoted to wheat, and that to barley, flax, and oats constituted 9.5, 8.5, and 3.6 percent, respectively. The barley and oats were largely used as feed; consequently wheat was chosen as the basis for calculation regarding cropping land. The following additional facts from the unpublished data of the census by townships were also considered.

The townships within 6 miles of a railroad station sold a greater amount of milk, cream, and butter.

These same townships had a lower percentage of the crop land in wheat.

The amount of plowable pasture in the townships adjacent to the market centers was larger than in those more distant.

In the townships bordering the Badlands, little plowable pasture existed and practically all the tillable land was cropped.

The townships situated from 6 to 12 miles distant from market usually carried the highest percentage of tillable land in wheat, with an approximate average of 52 percent of the tillable land devoted to this crop.

Although the data failed to show conclusively the interrelationship between the location of market and the type of crop grown, this rela-

tionship was evidenced in the older districts. Perhaps the comparative newness of the country, combined with the generally unquestioned acceptance of the belief that wheat is the crop to grow, partly explains the irregularities.

On the basis of the census figures and the data from the substations of the North Dakota Agricultural Experiment Station, a yield of 13 bushels per acre was taken as the average yield of wheat on the best, or ideal, cropping land in the area. With 52 percent of the plowable land given to the production of wheat, this means an average production of 270 bushels per 40-acre tract of ideal land. Seeding takes 1 to 1¼ bushels per acre. On an average, about 6 percent of the wheat grown remains on the farm to be used as feed. After these deductions are made, there are 230 bushels to be marketed from each 40-acre tract of ideal land in those areas of maximum wheat production, namely, areas 6 to 12 miles distant from market.

The prevalence of the use of the motor truck to market wheat makes it desirable to place the cost of marketing upon that basis. Since the capacity of the ordinary truck of the farmer ranges from 60 to 75 bushels, it was thought fair to place the number of trips necessary for hauling the marketed wheat from a forty of the best land at four. A mileage charge of 8 cents, to care for the cost of fuel, labor, and upkeep, was taken as the transportation charge. Accordingly, for every mile an ideal forty is distant from the wheat market, a charge of 64 cents is exacted for the marketing of its products. The capitalization of this charge of 64 cents at 5 percent gives $12.80 as the amount to be deducted from the value of the forty, per mile of distance. If the evaluation of the best land is placed at $20 an acre (or $800 per forty) a deduction of 1.6 percent of the land value of the ideal forty is deducted for each mile of distance to equalize the market costs.

It is necessary to provide for a correction in this figure of 1.6 percent a mile according to the change in the type of farming as the distance from market increases. On the basis of observations in the county it was assumed that at a distance of 40 miles essentially all the crops produced on the land in the cropping use group will be marketed as livestock and should, therefore, receive a rate of reduction equivalent to that of land in the grazing use group. The deduction for ideal grazing land (equivalent to 30 percent of the ideal cropping land) is 0.5 percent a mile or, expressed on the basis of 100-percent land, is 0.15 percent a mile. The method for calculating this rate will be explained subsequently. This rate for grazing land is uniform at all distances after the first mile. Thus, at 40 miles from market, ideal grazing land is reduced in rating from 30 to 24 percent.

There is no reduction for land 1 mile or less from market. For the next 5 miles, up to 6 miles from market, the reduction is uniformly 1.6 percent a mile. Thus, at 6 miles the rating for ideal cropping land is 92 percent.

For additional distances up to 40 miles, the rate of reduction changes progressively (as a straight line) from 1.6 percent to 0.15 percent a mile. Beyond 40 miles the reduction is uniformly 0.15 percent a mile as is that for grazing land. After making the appro-

priate calculations [16] the upper curve shown in figure 5 was drawn. This curve shows the rating of ideal cropping land as adjusted for distance from market. By the use of tables, or of a curve drawn on a large scale, the values can be seen at a glance for any particular distance. The unadjusted rating in percentage of any tract of land is multiplied by the rating in percentage of ideal land as shown on the curve for the appropriate distance, expressed in miles of graded dirt road, in order to make the adjustment for the accessibility to market.

ADJUSTMENT FOR GRAZING LAND

As a basis for calculations giving the rate of reduction for grazing land the following average conditions were taken: That a herd of

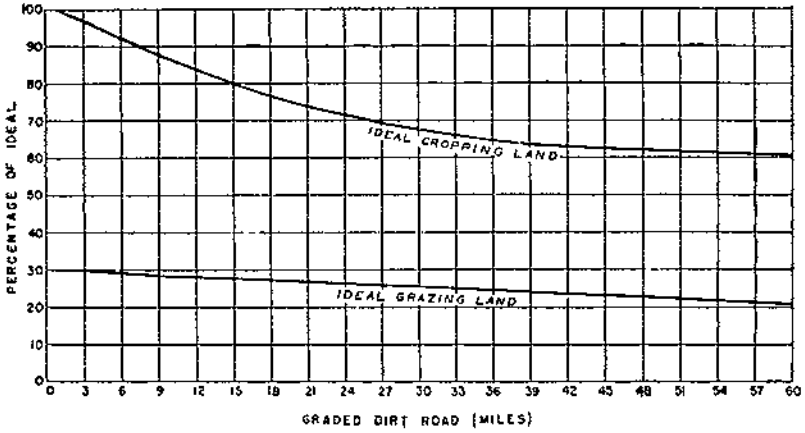


FIGURE 5.—The influence of accessibility to markets on ratings of ideal cropping land and of ideal grazing land in McKenzie County, N. Dak.

35 cattle would be taken to market by two men with saddle horses at about 10 miles drive a day. The charges for labor and horses would amount to an average of about $8 a day for the herd. Fifteen acres

[16] Points on that portion of the curve lying between 0 and 40 miles can be calculated as follows:

Where x = distance in miles of graded dirt road minus 8
y = percentage rating in terms of ideal land at the market as 100
$\frac{dy}{dx}$ = rate of reduction at x miles
$\frac{d^2y}{dx^2}$ = change in rate of reduction at x miles

As $\frac{d^2y}{dx^2}$ is uniform between the 2 values of x, 0 and 34, its value can be found from the straight-line equation

$$\frac{dy}{dx} = \frac{d^2y}{dx^2}x + b; \frac{d^2y}{dx^2} = 0.0428 \quad (1)$$

and
$$\frac{dy}{dx} = \int 0.0428\,dx \quad (2)$$
$$= 0.0428x + c_1$$

Where $x = 0$, $\frac{dy}{dx} = -1.6$, and $c_1 = -1.6$

Then $y = \int 0.0428\,dx - 1.6\,dx \quad (3)$
$= 0.0214x^2 - 1.6x + c_2$
Where $x = 0$, $y = 92.0$, and $c_2 = 92$

Therefore $y = 92.0 - x(1.6 - 0.0214x) \quad (4)$

Equation (4) may be used for calculations of the adjusted ratings of ideal land for points between 0 and 40 miles from market.

of the ideal grazing land would support one head of cattle on an all-year grazing basis. If ideal cropping land within a mile of the market is taken as worth $20 an acre, the value of ideal grazing land would amount to 30 percent of this, or $6. By capitalization of these averages, charges of 5 percent of the value of grazing land would be required to capitalize the marketing costs for each 10 miles of driving distance. Thus the reduction in value for the ideal grazing lands would amount to 0.5 percent a mile. As ideal grazing land is here taken to be equivalent to 30 percent of ideal cropping land, this percentage reduction amounts to 0.15 percent a mile on the basis of ideal cropping land as 100 percent. This reduction is shown graphically in the lower curve in figure 5.

These calculations are based on assumptions that are obviously somewhat arbitrary at a number of points. It is to be strongly emphasized, however, that many of these assumptions represent the studied opinion of local people familiar with local practices. Before the curves were accepted and used they were carefully checked in the field to ascertain their accuracy when compared with results obtained from marketing costs and other data on operating farms and ranches at various distances from market.

ADJUSTMENT OF THE RATING OF GRAZING LAND ACCORDING TO DISTANCE FROM WATER

After the rating of the grazing land is adjusted for accessibility to markets its location in respect to natural sources of water must be considered. The experience of cattlemen shows that cattle cannot be expected to make satisfactory gains where the distance they must walk for water is much greater than 1 mile. Such natural sources include springs and running streams, or streams having permanent water holes. These data are shown on the map. Grazing land situated more than 1½ miles from water must be used only at times of the year when surface water is found in small holes and depressions in the land or where additional capital is supplied for deep wells. The experience of ranchers using such land shows it to be about 25 percent less productive of cattle than land having water, other factors being equal. Thus for the land classification those grazing lands in the general region of grazing situated more than 1½ miles from sources of water are reduced 25 percent in their rating. Primary roads and ownership lines are considered as boundary lines in calculating these distances.

ASSEMBLY OF THE RATING FOR THE 40-ACRE TRACT

As the reduction for distance from market depends on the use group to which the land belongs, the separate factors are applied to the two kinds of land within the 40-acre tract. In addition the grazing land not supplied with water receives a reduction of 25 percent. When the final values for each of the 2 kinds of land are determined the 2 are combined, according to the respective amounts of each in the 40-acre tract, to obtain the complete, adjusted, final rating for the tract. These steps are illustrated in their application to the sample section in figure 4. It will be noted that as this particular grazing land is supplied with water, no reductions are necessary for that factor.

THE FINAL APPRAISAL

The last column of values in the table shown in figure 3 gives the final figure which is used for appraisal of the land. The county officials will fix the money value of ideal cropping land and then each piece of land in the area will be appraised at the percentage of this value given as its final rating. Ratings in terms of percentage are calculated for each 40-acre tract, or fractional tract, according to the land lines of the General Land Office.[17]

APPLICATION AND ADAPTABILITY OF THE METHOD

It is not the purpose, in this bulletin, to review the voluminous literature on land use and on the land problems of the country.[18] The fact that such an extensive literature exists, with portions contributed by people in nearly every walk of life, itself testifies to the seriousness of the problem and to its general interest and occurrence. Considerable attention has been given to a definition of land classification, particularly from the point of view of the objectives. It now remains to discuss the method briefly in relation to these objectives.

USE OF A LAND CLASSIFICATION

The method just described as an example is planned to fulfill the requirements for a classification of rural lands for purposes of tax assessment. Inasmuch as an assessment requires that a definite numerical rating be placed on each parcel of land, it would seem that such a method, if logically developed, would give data of value for other purposes, such as supplying the basis for plans leading to rural zoning. Other plans for land use, such as the establishment of parks and grazing districts, require accurate geographic expression of the physical data. The fact that these data in McKenzie County are being used for these very purposes at present by other agencies, in cooperation with the local governments, testifies as to their adaptability to such uses.

It must be emphasized that the first steps in the method are those most important for any purpose involving a change of land use. In the previous discussion, including the description of the method, it has been pointed out that the final classification of the social land units depends upon the character of the natural land types and the use group in which they fall. The use group for any piece of land is determined mostly by the natural land type, but by no means exclusively so. The important consideration of size and isolation of the areas of the various natural land types influence land use. Any change in utilization alters the position of the land in the classification of the social land units; whereas the more fundamental classification of the natural land types is essentially permanent. For example, should the boundaries of some proposed grazing or forestry district include present cropping land, a reclassification would need

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[17] Some discrepancies appear in the fractional tracts as compared to the original plats of the General Land Office, due to changes made by streams, especially the Missouri River, since their original survey was made. In some cases the margins of meandered streams have moved a mile or more during the time between the survey of the Land Office and the soil survey.

[18] UNITED STATES DEPARTMENT OF AGRICULTURE, BUREAU OF AGRICULTURAL ECONOMICS. LAND UTILIZATION. U. S. Dept. Agr., Bur. Agr. Econ. 1934. [Mimeographed.]

to be made giving this land its rating in the new use group in place of its rating in the cropping use group. Where the fundamental physical data are kept clearly separated from the economic or social, as the logic of the method demands, such changes are easily made without additional field work. It is also noted that in applying adjustments for accessibility to markets the rate of deduction depends upon the use group.

In cases where appraisal of the land for tax assessment is not an objective of the classification, the office work, beyond the determination of the productivity of the natural land types in the possible use groups, is unnecessary. For rural zoning, which necessarily concerns each social unit, the physical data must be of the character and detail described in the method. If the objective is not rural zoning, but to study land use in general, not related to any particular farm unit, then less detail of the physical data will suffice. It must be strongly emphasized that such schematic studies from cursory data have a very limited use. As the question of local taxation is one of the most important problems before a large proportion of the rural communities of the country, the demand is especially for the type of work which is sufficiently accurate and detailed to serve the objectives of tax assessment and/or rural zoning.

ADAPTABILITY OF THE METHOD IN OTHER LANDSCAPES

The method described in detail has been used for land appraisal in the northern Great Plains. Naturally the question arises as to the applicability of this method to other landscapes. That part of the work which includes the mapping and evaluation of the natural land types has been and is being done in several places throughout the country. Special mention should be made of the work of the Michigan Land Economic Survey, as this organization probably was the first to make a complete inventory of the physical features of a landscape having a wide range of possibilities for use. The modern detailed soil survey fulfills all or nearly all of the requirements as far as the permanent physical data are concerned. In areas having features of special or local importance, such as lakes or forests, data regarding these would need to be added to those of the soil survey.

Each type of landscape usually has special physical features, or special subtypes of possible land use serve to accentuate the importance of some one feature. For example, remaining large pine stumps in certain areas previously forested but now deforested may be important. Such a physical factor is not of a permanent character and needs to be considered separately from the permanent physical data. In other places, for instance, where irrigation is proposed, small differences in relief may be more important than is commonly the case in other areas and consequently might require special emphasis and detail.

In making up tables showing the productivity of the land in various uses, different plants will receive the major emphasis in different areas. In the grazing use group the native plants, even, will differ from place to place; and in naturally wooded areas the productivity

of introduced, but adapted, species of grasses could be used as criteria. In the cropping use group wheat may receive the major consideration, as it naturally did in McKenzie County; in other areas sugarcane or some other of dozens of crops might be the chief crop plant; or again, a combination of crop plants may need to be considered and a weighted average value obtained.

In those landscapes where a large number of crops are grown and the natural productivity of the various land types varies greatly for the different plants, the problem would be somewhat more difficult, in certain respects, than in the case of the example presented. For example, certain sandy soils in the southern part of the United States having a low natural productivity may be widely used where the supply of more productive land suitable for the same crops is limited. Here the problem would be further complicated by the wide use of fertilizers, and the tables of productivity would need to be constructed so as to show, not only the natural productivity but also that under standard types of farm management including those practices recognized as consistent with good economy. The authors fully realize the difficulties involved in such cases; nevertheless they feel that these are problems of detail and do not influence the logic of the method. It must be emphasized that the details will necessarily vary in different landscapes in following this logic.

THE USE OF EXISTING DATA FOR LAND CLASSIFICATION

In figure 2 (pp. 16 and 17) is shown a sketch map indicating the present progress of the Division of Soil Survey. The making of these maps has been in progress for a good many years, during which time the technics of the work have been greatly improved, owing to world-wide research in soil science and due to experience in using the maps and in interpreting the results of the surveys. During recent years the maps have been made more detailed than formerly because of the demands for, and need of, more precise information. In table 4 are listed the number of square miles covered during the years since the work was started.[19] The reconnaissance soil maps are not sufficiently detailed for land classification for purposes of assessment. These can be used, however, for the definition of broad, general land types, realizing that within each type variations within the areas larger than farm units are to be expected. The same applies to those maps made before 1907. The maps made between 1907 and 1917 are more detailed but in some instances would need revision before being directly usable in furnishing the necessary data on soils for the land classification necessary in rural zoning. Maps made since 1917, especially since about 1928, are in considerable detail as to soil types, but in many instances those made prior to about 1928 would need some additional data as to relief and stoniness, in order to make a detailed land classification for purposes of tax assessment.

[19] These data only include those maps made by the Division of Soil Survey or by them in cooperation with local organizations, especially the State agricultural experiment stations. A few other soil maps are available in addition to these, notably in Illinois, where the work has been done almost exclusively by the Illinois Agricultural Experiment Station, and in other places.

TABLE 4.—*Square miles surveyed and mapped in the United States by the Division of Soil Survey of the United States Department of Agriculture or by it in conjunction with other agencies*

Year of survey	Approximate area [1]		Year of survey	Approximate area [1]		Year of survey	Approximate area	
	Detailed	Reconnaissance		Detailed	Reconnaissance		Detailed	Reconnaissance
	Square miles	*Square miles*		*Square miles*	*Square miles*		*Square miles*	*Square miles*
1899	766		1913	30, 531	35, 147	1927	20, 490	
1900	4, 613		1914	37, 811	8, 352	1928	18, 607	31, 392
1901	9, 877		1915	35, 521	12, 607	1929 [2]	20, 230	41, 619
1902	16, 268		1916	36, 273	4, 448	1930	31, 978	9, 124
1903	27, 179		1917	37, 060	12, 460	1931	21, 973	
1904	25, 564		1918	29, 466		1932	30, 305	
1905	23, 956		1919	25, 974	19, 404	1933	31, 564	9, 133
1906	18, 652		1920	24, 419				
1907	19, 392		1921	25, 999	1, 314	Total	563, 731	543, 643
1908	29, 110	47, 352	1922	31, 083	26, 784			
1909	27, 697	67, 536	1923	25, 347		Grand total	1, 407, 374	
1910	22, 858	87, 330	1924	17, 788				
1911	35, 029	77, 328	1925	22, 876				
1912	32, 277	50, 994	1926	22, 168	1, 313			

[1] Net square miles corrected for any overlap of recent surveys over parts of older surveys.
[2] From 1929 on, the number of square miles surveyed is approximate; from 1931 on, only a small percentage of the areas is available in published form.

Although an accurate soil map must necessarily form the basis for land classification, it has been shown that other factors must be recognized. Some physical factors, such as kinds of streams and native vegetation, must be taken into account and are, in certain areas, of extreme importance. Also such economic or geographic factors as location in respect to markets and in respect to other areas of similar land are important.

In those areas where a modern soil map is available, considerably more than half of the field work required to make such a land classification as the one described in the previous pages has been done.

SUMMARY

The objectives of land classification are mentioned and discussed as to the amount of detail required for the definition of the categories employed and for their cartographic expression on maps in order to reach the various objectives.

The logical requirements of any method effectively reaching these various objectives are set forth and discussed briefly.

For purposes of tax assessment, land classification must be detailed and clearly indicate any significant differences between social land units. The procedure for reaching this objective may be summarized under four general steps: (1) Accurate mapping (in detail) of the important physical features of the land, (2) the determination of the natural productivity of each important combination of these physical features (the natural land type), (3) the determination of the use group, or combination of use groups, to which the various social land units belong, and (4) the evaluation or rating of each individual tract of land according to its capabilities within its use group.

A method meeting the logical requirements of a land classification for purposes of tax assessment is described in some detail, including

the mapping of the physical features, the determination of the productivity of the natural land types in the possible use groups, the determination of the use group to which each piece of land belongs, the rating of each social land unit in terms of percentage of ideal land for the area, and the adjustment of these ratings for accessibility to markets.

The applicability of the method to other landscapes is briefly discussed. It is pointed out that the logic of the method probably has a wide adaptation but that, following this logic, the details of the method will vary in different landscapes.

The data obtained by this method include those needed for rural zoning and for planning land use.

The limitations and possibilities of existing soil-survey data for land classification are briefly discussed, with estimates of the amount of such data available in the United States.

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