

ORGANIZED TEACHER

MATERIAL

CONSERVING FARM LANDS

FOR SOIL-EROSION CONTROL
WATER CONSERVATION, AND EFFICIENT LAND USE

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UNITED STATES
DEPARTMENT OF THE INTERIOR • OFFICE OF EDUCATION

CONSERVING FARM LANDS

PLANNING FOR
SOIL-EROSION CONTROL, WATER CONSERVATION
AND EFFICIENT LAND USE

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FOREWORD

Soil conservation and related problems have attracted increasing Nation-wide attention during recent years. All-too-frequent recurrences of higher flood crests on major streams, unprecedented dust-storms in the Great Plains area, severe gullying and abandonment of large acreages of cultivated land, and other disasters have aroused the Nation to the necessity for adopting land-use practices in harmony with the capabilities of the land as indicated by inherent characteristics of soil, climate, land form, native vegetation, water resources, location, and native animal life. More significant than the floods, duststorms, or gullies, however, is the fact that much of the better agricultural land has been seriously affected by accelerated erosion during the comparatively brief time it has been in use.

Vocational agriculture instructors throughout the United States, and especially in the Southern States, have been very active in the field of soil conservation. Millions of acres of land have been terraced and numerous other soil-conserving practices have been introduced under the guidance of vocational agriculture departments in public secondary schools. Considering, however, the numerous recent developments and advancements in the science of soil conservation resulting from the extensive research and demonstrational program of both State and Federal agencies, many vocational agriculture instructors have requested additional assistance.

The organized teaching material included in this bulletin is designed to assist teachers of vocational agriculture. Its primary purpose is to supply them with a reasonably complete inventory of the functioning content involved in planning a soil conservation program for a specific farm, presented in such a way that the material may be usable in systematic instruction on this activity.

The manuscript was prepared by Tom Dale, information specialist, Soil Conservation Service, United States Department of Agriculture, in cooperation with W. A. Ross, subject-matter specialist in agricultural education, Office of Education, working under the direction of J. A. Linke, Chief of the Agricultural Education Service, Office of Education, United States Department of the Interior. Acknowledgment is made to other specialists of the United States Department of Agriculture for their advice in the preparation of the manuscript.

J. C. WRIGHT,
Assistant Commissioner for Vocational Education.



Soil Conservation Service, U. S. D. A.

Figure 1.— Millions of acres of formerly productive farm land in the United States have been destroyed by water erosion and are now lying idle as abandoned land. Such lands represent tragedy for the former owner and a definite loss in natural resources.

Figure 2.— Wind erosion has progressed at an alarming rate, during recent years, over much of the land in the more arid sections. The erosion depicted above started in a wheatfield and, while it has not reached an uncontrollable stage has blocked the road and it is rapidly spreading to the adjacent pasture land.

Soil Conservation Service, U. S. D. A.



CONSERVING FARM LANDS

Planning For Soil-Erosion Control, Water Conservation, and Efficient Land Use

INTRODUCTION

The ultimate objective of soil conservation is the maintenance of permanent productivity of the land while using it for maximum economic production. To attain this objective it is essential that fertility be maintained and that the soil be held in place. Since the productivity of large areas of the agricultural land in most localities has already been seriously impaired by erosion and misuse, the problem is to develop, in those who use the land, conservation habits that will maintain the remaining land assets at a permanent level of economic productiveness.

Each of the 6,500,000 farms in the United States is a unit with distinctive differences and specific problems of its own. A practical soil conservation program must, of necessity, be based upon existing conditions which involve primarily the land, the people, and the climate. Each tract or parcel of land has certain characteristics. A sound program of soil conservation must provide for the use and management of each tract of land according to its adaptabilities and capabilities. If, however, the program is to be feasible it must also meet the economic and social demands of the farm of which the tract is a part and of the farmer who operates the farm.

Erosion control, to be permanently effective and economically practical, involves more than the installation and maintenance of engineering and vegetative measures. It involves also land-use planning, cropping practices, grazing practices, woodland management, and many other phases of general farm operation. In some instances it may even require a complete reorganization of the system of farming and the farm lay-out. The institution of such a program on any farm necessarily entails careful planning by individuals properly informed on the various technical, economic, and social factors involved.

Recent legislation by Congress has empowered several agencies in the United States Department of Agriculture and other departments of the Federal Government to conduct research in the field of soil conservation, to demonstrate soil-erosion control practices, to disseminate information on the subject, and to cooperate with landowners in developing and executing a Nation-wide program to establish sound

land-use practices. The activities of the several Federal agencies concerned in this field have added impetus to the already increasing demand for further action.

Of paramount importance also has been the adoption by many State governments of legislation directed toward the same general objective. During recent years a majority of the States have passed legislation that will permit the creation of State soil conservation districts. In most of the States these districts will have broad authority in the field of soil conservation, not only to plan a soil conservation program and attempt its execution by educational means and by tendering material assistance to voluntary cooperators but also to obtain technical assistance from Federal and State agencies. In most States these districts also have authority to pass, by popular referendum, land-use regulations that may compel the general adoption of soil-conserving land-use practices by all land occupiers within the boundaries of the district.

Most farmers and landowners, given a limited amount of guidance, are prepared and qualified to institute the conservation measures needed on their farms. They are usually not sufficiently informed, however, on recent developments in techniques to evaluate properly all factors concerned in planning the conservation practices and devices to be carried out on a given tract of land. Also lacking in many instances is the ability on the part of farmers and landowners to visualize and formulate a completely coordinated program for the farm as a whole.

Many farmers are attempting to install conservation farming methods without a definite plan to guide their operations. Thousands of landowners and farmers throughout the Nation are requesting assistance from various agencies in planning for their farms a practical program of soil conservation. There is, therefore, a great demand for the services of persons capable of planning a coordinated program of soil-conserving land-use practices for American farms.

Considering these conditions, it is increasingly important that vocational agriculture instructors, and other agricultural specialists, having educational responsibilities, be in possession of the most up-to-date information available in order to offer the greatest amount of assistance practicable on developing conservation plans for farmers desiring such assistance. A canvass of the vocational teachers and other agricultural workers concerned, however, reveals that in many instances they have been unable to keep informed on the latest authoritative recommendations regarding the proper land-use and soil conserving practices to follow in given situations. Even more important is the failure, on the part of many persons attempting to plan soil conservation programs, to consider all of the pertinent factors involved in deciding the practices to be used. A sound plan

cannot be expected in a complex situation except where the planner gives proper consideration to all factors involved and has the best information available.

This bulletin deals primarily with jobs pertaining to the planning phases of soil conservation. It includes: (1) Analyses of the training content on type jobs involved in planning a soil conservation program for a farm; (2) statements of interpretive science and related information of importance in connection with the jobs; (3) illustrations; (4) definitions of soil conservation terms; and (5) lists of references and visual materials. This organized teaching material should prove helpful in offering instruction to high-school students in vocational agriculture day classes, out-of-school young farmers in part-time classes, and adult farmers in evening classes.

The purpose of these analyses is to set forth facts and working data anyone should have who attempts to plan a complete coordinated program of soil conservation for a farm as a productive agricultural unit. *This bulletin does not discuss all of the numerous jobs that may be encountered in the actual execution of the program as planned, nor does it deal with the planning problems encountered in areas devoted to range, forest, and nonagricultural uses.* The organized teaching material presented in the bulletin is based on an extensive study of the work done by practical farmers and landowners throughout the United States and on conferences with specialists in the Soil Conservation Service of the United States Department of Agriculture.

The jobs analyzed are presented in the order in which they could normally be executed but *each job is a complete unit* and should, therefore, be taught at a time when it fits best into a well-organized program of instruction. Jobs I and II, concerned with making a soil-conservation survey of the farm as a basis for the plan, are analyzed as operative units. The procedure for making such surveys has been standardized by the Soil Conservation Service and is more or less uniform for agricultural lands throughout the country. Jobs III to X, inclusive, dealing with the development of a plan for a given farm, are analyzed from the managerial standpoint.

In view of the fact that standard procedures in soil conservation planning are relatively new to the field of agriculture, are considerably localized, and are changing as new developments evolve from research and demonstration, it seems advisable that teachers of vocational agriculture obtain additional information and training from local Soil Conservation Service offices and other reliable sources. While considerable variation will be noted in the evaluation of the various factors considered in making the managerial decisions involved in these planning jobs, the basic factors which demand consideration in arriving at sound decisions will be quite similar in most normal

situations. Instruction on jobs I and II may well precede instruction on other conservation jobs. Some instructors, however, may wish to use job III as a starting point.

After familiarizing himself with the analyses of the various jobs and the reasons for doing them, as shown under the heading "Interpretive Science and Related Information", in connection with each job analysis, the teacher should *select those jobs of importance to his locality and include them in a course of instruction*. He should then prepare teaching plans showing how he proposes to present each job to the individual, group, or class.

Operative analyses constitute work sheets setting forth the actual steps involved in performance. Mimeographed copies should, therefore, be placed in the hands of students during the latter part of the instruction process. Such sheets will assist them materially in learning to make the surveys.

The managerial analyses serve to bring to the teacher's attention a reasonably complete inventory of the functioning content involved in the activity under consideration and may also be used for training in constructive thinking. Managerial analyses, however, should be developed on the blackboard with the students rather than developed by the instructor and placed in the hands of students in typewritten or other form in advance of a class meeting. Teachers are cautioned against expecting or requiring students to develop managerial analyses exactly as set forth in the jobs in this bulletin. Not only will local adaptations affect the analyses when applied to a specific farm or situation but the teacher must also remember that one of the chief purposes of analysis work is to teach students how to think through actual problems in a systematic manner.

Before a person can discharge managerial responsibility effectively he must possess a certain degree of operative ability. In some cases it may be sufficient for one who is required to make managerial decisions to have only an appreciation of the work which an operator has to do. Field trips to soil conservation demonstration areas and to farms in the locality, on which complete, coordinated programs have been installed may serve to give students some appreciation of the work to be done in planning a program of this type. Likewise a study of farm plans that have been developed cooperatively by farmers and planning specialists of the Soil Conservation Service and other agencies, will be valuable for instructional purposes.

It is recognized that the completion of an accurate soil conservation survey for a farm is a job requiring the skill and technique of a specialist in this line. Nevertheless, the more advanced students should, by diligent application, acquire enough skill in the procedures involved to make a survey sufficiently accurate to serve as a basis for farm planning. Even though the survey be somewhat inaccurate and the

subsequent plan developed faulty in some respects, the training acquired by the student will be worth while and should serve as a basis for improvement and advancement. Some examples of what has been done by the various groups served by vocational agriculture are of interest in this connection.

SOIL CONSERVATION ACTIVITIES OF VOCATIONAL AGRICULTURE GROUPS

In the State of Georgia, conservation of soil, water, and wildlife is a definite part of the adult evening class program in vocational agriculture. The major objective of the program is farm planning. This objective is applied to the farming situation of each member of the evening class. It includes the replanning of the farm to guarantee soil and water as well as forest and wildlife conservation. Not only are the soil types determined but the slope and extent of erosion are considered. When this is done, decisions are made as to the cropping system to be used on the farm, the mechanical devices that may play a part in the conservation program, and the use to be made of each replanned field. A major consideration entering into this evening class instruction is the relation of the program of the individual farmer to the welfare of all the farmers of the community.

Out-of-school young men enrolled for systematic instruction in part-time classes in vocational agriculture have devoted considerable time, study, and effort to soil conservation. One such group of 74 in Iowa were enrolled for 20 meetings on soil conservation and farm management. The instruction included the carrying out of the following practices on their home farms in connection with the development of their individual farming programs: Testing soil for acidity; applying limestone; rearranging rotations; and erosion control.

A similar group of 29 young men enrolled in a course on farm management and soils in Ohio, conducted the following soil-improvement practices in connection with their farming programs: Testing soil, increasing legume acreage, inoculating legume seed, increasing the efficiency of fertilizers, growing green-manure crops, improving drainage, and preventing soil erosion.

Local chapters of the Future Farmers of America, which are organized as a part of day-school programs of vocational education in agriculture, have carried on some very excellent land conservation programs. The following examples are typical:

The members of an Oklahoma chapter, during a 12-month period, ran 79,294 yards of terrace lines on which 66,278 yards of terrace were constructed. The project involved 32 farms. In addition, individual members made fills, built rock outlets, and constructed soil-saving dams on their home farms.

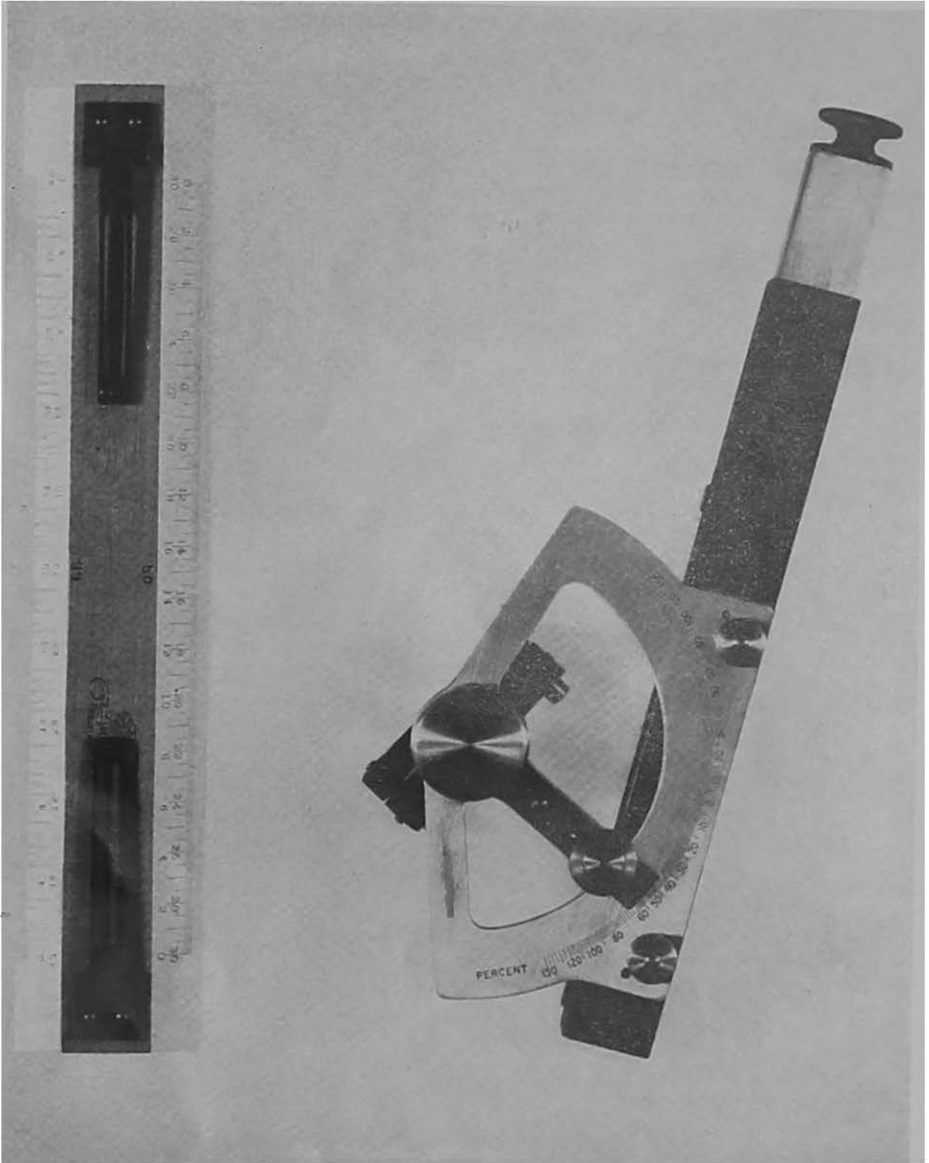
Two members of a California chapter undertook a unique community-service project. Certain parts of Southern California had been inundated by floods due largely to lack of forest cover. Interested in trees, these "Future Farmers" sought suitable conifers from which seed was obtained and planted in beds 3 by 4 feet. When the seedlings were a few inches high, they were transplanted in rows and later set in gallon cans. In this way 1,500 young conifers were made available for planting on hills and slopes where they were badly needed.

To protect 11,000 acres of fine alluvial farm land an Arkansas chapter assisted in completing the final 3-mile gap of a 5-mile levee built along the Red River.

An Alabama chapter persuaded over 40 local farmers in a single year to plant crimson clover as a soil-improving crop.

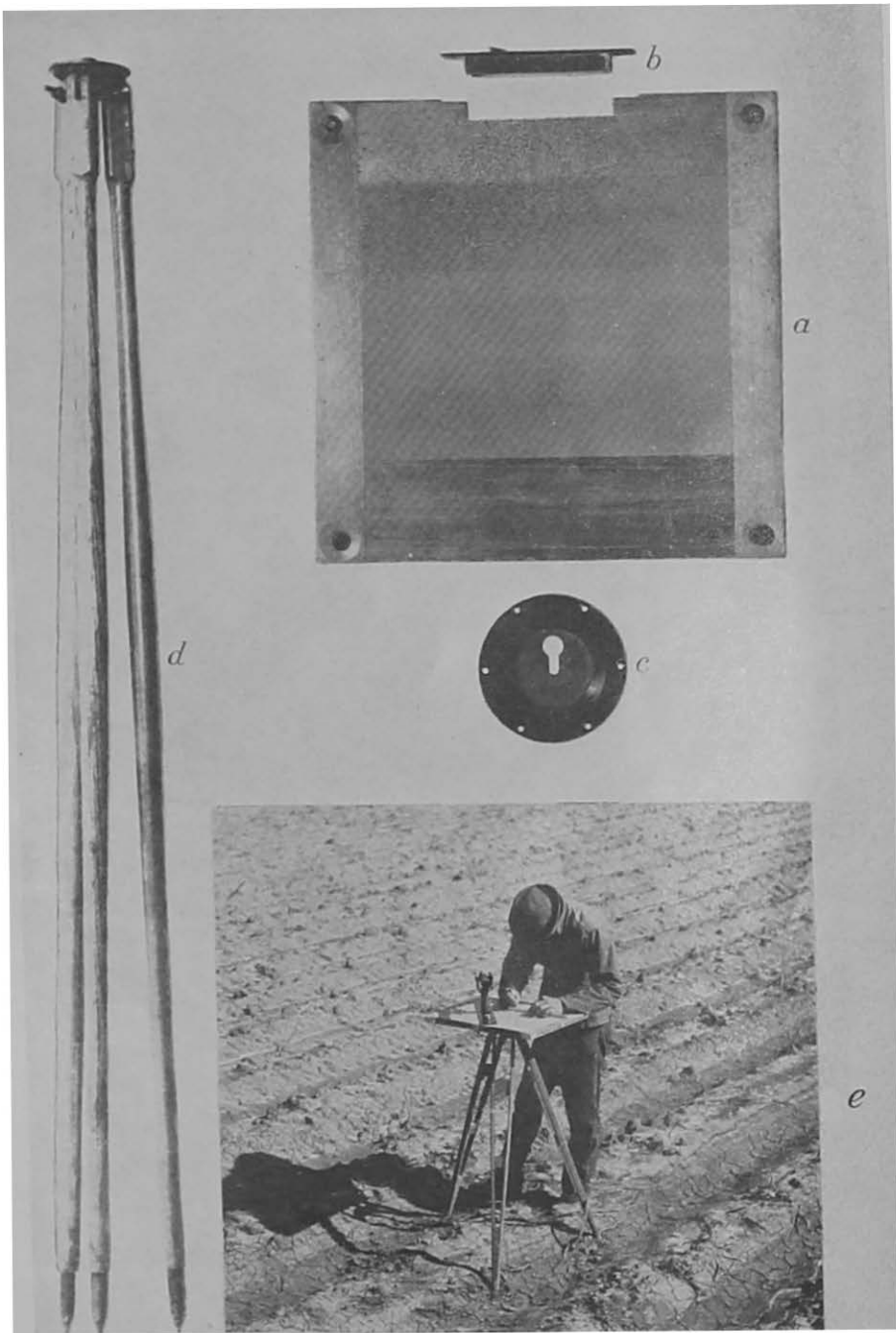
Future Farmers of America chapters in the State of Washington rendered an unusual service in gathering field data for a land-use survey. The work was carried out in cooperation with the State planning council and agencies of the United States Department of Agriculture. The boys not only completed very creditable soil maps but became well informed on the land-use situation in their home localities.

Following is a series of analyses of various jobs which may be undertaken in connection with a soil-conservation program on an individual farm. In connection with each job, the interpretive science and related information essential to carrying out the job are also presented and discussed.



Soil Conservation Service, U. S. D. A.

Figure 3.—Alidade (left) and Abney hand level (right).



Soil Conservation Service, U. S. D. A.

Figure 4.—The plane table unassembled and in use: *a*, board; *b*, compass; *c*, head; *d*, tripod; *e*, making a base map of a farm using the plane table method.

TRAINING CONTENT, INTERPRETIVE SCIENCE, AND RELATED INFORMATION FOR SOME TYPE JOBS INVOLVED IN PLANNING A SOIL CON- SERVATION PROGRAM FOR A FARM

Job I. Making a Base Map of the Farm ¹

ANALYSIS

Operations	Standard or accepted practice
1. Secure equipment and supplies.	<p>Find out whether aerial photographs of the area are available. If such photographs of the farm are to be had, obtain an enlargement on a scale of 1/7,920 (8 inches=1 mile), or other suitable scale, from the local office of the Agricultural Adjustment Administration, Soil Conservation Service, or direct from the United States Department of Agriculture, Washington, D. C., and proceed as outlined under operation 10 (p. 13).</p> <p>If aerial photographs are not available, proceed as follows:</p> <p>Assemble the following equipment and supplies: Plane table equipped with compass; alidade or engineers' scale; hard pencils and eraser; fine-pointed needle or pin; drawing paper; and 100-foot tape or pace counter.</p>
2. Fasten the paper to the plane table board.	<p>Fasten the paper to the board by means of brass, flat-topped screws if the plane table is equipped with them. If screws are not set into the board of the plane table, brass thumbtacks should be used. Place the paper squarely on the board, smoothing it free of wrinkles, so that it does not cover the compass. The paper should be so tightly fastened that it cannot creep or slip during the time the map is being made and should not be removed until the map is completed.</p>
3. Check pacing-----	<p>If pacing is to be used in lieu of actual taping of distances, the person doing the mapping should develop skill in measuring distances by pacing. The following procedure will be of assistance in developing accuracy:</p> <p>(a) Step a course of known length 10 times at an ordinary walking gait, counting the steps made each time. Record the observed number of paces required to cover the distance and compute the average length of pace.</p> <p>(b) Step a course of unknown length several times at a natural pace, observing the number of paces required to cover the distance. Find the true distance with a steel tape and again compute the average length of pace. Do this several times to check pacing.</p>

¹ See definition of soil conservation terms, page 93.

Job I.—Making a Base Map of the Farm—Continued
ANALYSIS—Continued

Operations	Standard or accepted practice
4. Size up area to be mapped.	Walk over the area to be mapped in order to get the "lay of the land." Note prominent terrain features, lone trees, buildings, fence corners, windmills, and similar objects that are widely visible which may be used later as orientation or control points. This is especially important if all of the area to be mapped cannot be seen from a commanding position.
5. Select a starting point for mapping.	Select a corner of the farm from which several good orientation points are visible and preferably from which another corner of the farm can be seen. This point will be known as station No. 1. Make sure that there are no objects near which will deflect the magnetic bearing of the compass; these may be electric transmission lines, railroad tracks, wire fences, metal culverts, or metal objects carried by the individual doing the mapping. If necessary, avoid the effect of magnetic interference by moving to another corner of the farm. In case a corner of the farm is inaccessible as a starting point, select a point on or near (preferably on) a boundary line from which objects on the boundaries and other prominent objects are clearly visible.
6. Set up the plane table....	Directly over the starting point set up the plane table by spreading the tripod legs of the plane table well apart and planting firmly in the ground. The table should be approximately waist high, so that the mapper may bend over the board without resting against it. The board should be approximately level.
7. Orient plane table....	If the plane table is equipped with a compass, release the compass needle and rotate table until the needle coincides with the north-south line in the compass box. Clamp the table securely in position and do not disturb until mapping is completed at this point. If a compass is not built into the plane-table board, an accurate pocket or box compass should be placed near one edge of the board and the table oriented by rotating it until the edge of the table is parallel with the compass needle.
8. Map the farm.....	<p style="text-align: center;"><i>Method No. 1</i></p> Place the alidade near one edge of the paper and sighting down it, bring the alidade parallel with a boundary line of the farm. Using a chisel-pointed pencil, draw a faint line (ray) on the paper to represent the boundary line. Place a pin on this line at a point representing the location of station No. 1. Place the edge of the alidade against the pin approximately parallel to the other boundary line of the farm and sighting down the alidade, bring it parallel to the boundary line. Now, draw a line from the pin on the paper to represent this boundary line. If roads parallel the boundary lines they may be drawn in to scale at this time.

Job I.—Making a Base Map of the Farm—Continued

ANALYSIS—Continued

Operations	Standard or accepted practice
8. Map the farm—Contd..	<p>In a manner similar to the procedure followed in drawing the second boundary line, sight in and draw rays in the directions of two or three other prominent objects located on or near the farm that may be used as orientation points or plotting stations. Buildings, windmills, poles, fence corners, and lone trees are desirable objects for this purpose. They should be widely visible and located at considerable distances apart. Most of them should be objects near which the plane table can be set up.</p> <p>Pace or measure with a tape the distance to any of the objects to which lines were drawn, that are near station No. 1 and locate them on the map by plotting to scale. Now erase the rays drawn to objects definitely located and identify the objects on the map by appropriate symbols or dots properly labeled.</p> <p>Pace or measure the distance from station No. 1 to another corner of the farm (preferably a corner that can be seen from station No. 1). While measuring this distance, notes should be taken as to the distance from station No. 1 to any other prominent objects on or near the boundary line that is being measured. If the distance is paced, it will be advisable to check the measurements on the return trip to station No. 1. Plot the distance to scale to the other corner and points along the boundary line that were measured and located during the pacing and indicate those points on the map by an appropriate symbol.</p> <p>Move the plane table to the new corner just located on the map or to another point that has been definitely located and from which station No. 1 as well as several other prominent objects are clearly visible. Set up the plane table at this point, to be known as station No. 2; orient with the compass as described in operation 7 (p. 10). Check the orientation of the table by backsighting² to station No. 1 or other definitely located point.</p> <p>In case other corners of the farm are obscured, select stations along the boundaries that are visible from a previous station. Proceed in this way until the mapping is completed.</p> <p>Place a pin in the map at the location of station No. 2. Using the alidade, sight to and draw rays in the direction of several prominent objects that are visible on the terrain, as done at station No. 1. Draw rays to as many of the objects that were sighted in from station No. 1 as are clearly visible and also to other usable objects. Where the rays drawn from station No. 1 and station No. 2 to the same object intersect is the location of that object on the map. When objects are so located they should be indicated on the map by an appropriate symbol and the rays to them erased.</p>

² Charles E. Kellogg. Soil Survey Manual. United States Department of Agriculture Misc. Pub. 274, 136 pp., illus., 1937.

Job I.—Making a Base Map of the Farm—Continued

ANALYSIS—Continued

Operations	Standard or accepted practice
8. Map the farm—Contd.	<p>Select a suitable point on the ground for station No. 3 and move the plane table to it. Continue the mapping as at station No. 2. The site for station No. 3 may be a point already located on the map by intersection of rays or an object visible from station No. 2 to which a ray has been drawn and the distance measured.</p> <p>As the mapping proceeds, it may be desirable to set the plane table up at a station that has not been previously located on the map. In this case the location of the station may be determined by resection³ as follows: Orient the plane table by compass. Place pins on the map at 3 previously located points that are clearly visible on the ground. Place the alidade against one of these pins and sighting down it in the direction of the object move it until the object is in the line of sight. Draw a ray from the pin toward the location of the plane table on the map. Repeat this procedure with the other 2 points. The 3 rays should intersect near a common point. Usually the intersection of the 3 rays will form a small triangle. The center of the triangle should be taken as the location of the plane table on the map.</p> <p>Continue mapping from points scattered over the farm or along the boundary lines of the farm. As the mapping progresses many points will be definitely located on the map and by reference to these points the details of the map may be filled in. Drainage features, fences, field boundaries, roads, boundaries of wooded areas, buildings, and other details should be indicated on the map by the proper symbols as the mapping proceeds. (See symbols following p. 14).</p> <p>Where large fields are encountered on which there are no clearly defined objects that may be seen from mapping stations, it may be desirable to place long stakes at appropriate intervals to use as control stations.</p> <p style="text-align: center;"><i>Method No. 2</i></p> <p>Much time may be saved in mapping if an outline map of the farm is drawn before going to the field. This is especially true where the farm has an irregular shape and an accurate guide can be secured from which to make the necessary outline. An outline map may be made from a surveyor's plot by measuring or tracing the angles at the corners and changing the lengths of boundary lines to the scale being used. The necessary information for making outlines may also be secured from the legal description of the farm as given in the deed.</p>

³ Charles E. Kellogg. Soil Survey Manual. United States Department of Agriculture Misc. Pub. 274, 136 pp., illus., 1937.

Job I.—Making a Base Map of the Farm—Continued

ANALYSIS—Continued

Operations	Standard or accepted practice
<p>8. Map the farm—Contd..</p>	<p>Fasten the outline map as previously prepared to the plane table and proceed as outlined under operations 2, 3, 4, 5, and 6. Orient the plane table as follows: Place pin in the map at the corner where plane table is located and at a point along one boundary line that is clearly visible on the ground and definitely located on the map; another corner of the farm is preferable. Place the edge of the alidade against these 2 pins and sighting down the alidade toward the other point, rotate the plane table until this point is in the line of sight. Clamp the plane-table board securely in this position. Check the orientation by sighting down the other boundary line in a similar manner. The plane table must be oriented at all stations in the same way, by backsighting at objects that are definitely located on the map. The plane table may be oriented by means of the compass, as outlined under operation 7, if the outline map is carefully placed on the plane table so that magnetic north on the map is parallel to magnetic north in the compass box.</p> <p>If the compass is used for orientation, the orientation should be carefully checked by backsighting in the field at station No. 1 to be sure that the outline map is correctly oriented on the board.</p> <p>Now proceed with the mapping as outlined in method No. 1 (p. 10), except that it will not be necessary to fill in farm boundaries. Corners and boundaries of the farm can always be used as definitely located points from which to map or check other points.</p>
<p>9. Ink in the maps-----</p>	<p>Soon after a map is completed, ink in all features that are to become a permanent part of the map. Different colored waterproof inks should be used to designate field boundaries, streams, fences, rock outcrops, etc. (See Standard symbols following p. 14). When the drawing is completely inked in, go over it with artgum in order to remove all pencil marks and dirt smudges.</p>
<p>10. Add details to aerial photograph.</p>	<p>If aerial photographs are used in lieu of home-made base map, proceed as follows: Fasten photograph to plane table and proceed as directed under method No. 2, operation 8 (p. 12), to locate and plot on the map all fences, field boundaries, power lines, pipe lines, and other structures or pertinent details that do not show up on the aerial photograph. Indicate also field boundaries, character of roads, streams, gullies, railroads, buildings, etc., that do not show plainly. Use standard symbols for designating all features plotted.</p> <p>Retouch the aerial photograph with ink to designate clearly all features that it is desirable to show on the base map. (See procedure under operation 9.)</p>

INTERPRETIVE SCIENCE AND RELATED INFORMATION

The use of an accurate base map of the farm on which to denote the surveyed conditions is highly essential. Experienced surveyors use maps of a scale 1/15,840 (4 inches=1 mile) but it will usually be desirable for inexperienced surveyors to use a map on a scale of 1/7,920 (8 inches=1 mile) and in the case of small farms, or where there is a great amount of detail to be mapped, it may be desirable to use a larger scale. Where conditions of the farm are of sufficient uniformity to require only a reconnaissance survey, a map of a scale 4 inches to 1 mile or less, ordinarily shows enough detail to make an accurate survey.

Aerial photographs have been made of many watersheds and counties throughout the United States by the Soil Conservation Service, the Agricultural Adjustment Administration, and other agencies. Aerial photographs can usually be secured on scales of 4 inches=1 mile, 8 inches=1 mile, 12 inches=1 mile, or 16 inches=1 mile. These photographs are preferable to home-made base maps because they are usually more accurate as to the detail shown, and less time and expense are involved in securing them. It is often necessary, however, to insert additional detail on an aerial photograph because fences and certain structures do not photograph clearly from the air. Aerial photographs can be enlarged, usually at small expense, to any desired scale. A slight distortion is always present on an aerial photograph, due to the angle at which the land is photographed except in the center of the photo where it is directly under the airplane. In country where the relief is great the distortion in an aerial photograph will be greater.

It has been found that maps already in existence, excepting aerial photographs, usually do not show sufficient detail to be used as base maps for a soil-conservation survey. Home-made base maps have an advantage over aerial photographs in that they are made on white paper and show only the necessary detail that the surveyor desires to include in them.

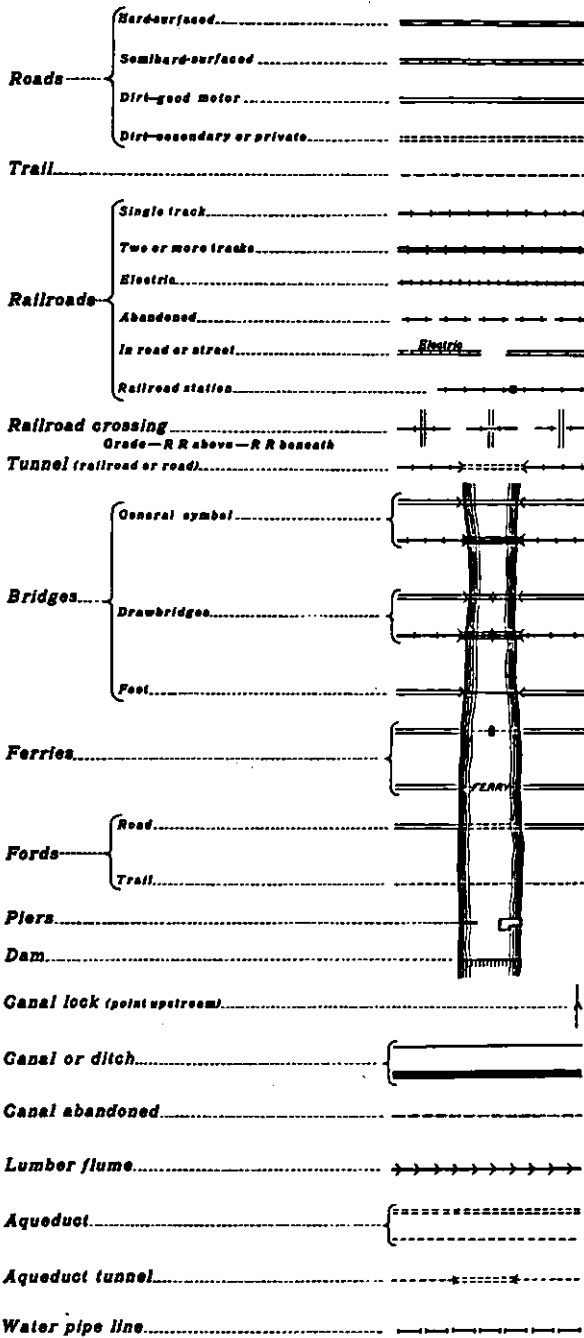
In mapping, one uses the geometric principle that two intersecting lines determine a point. For example, by sighting from 2 different stations to an object and drawing the lines of sight on the plane table the point where these lines meet represents the location of the object. In locating any straight line without setting the plane table directly over it one uses the geometric principle that 2 points determine a straight line. Such 2 points may be located as above or by measuring the perpendicular distances from 2 plane table stations to the line.

Experienced surveyors normally make the base map and fill in the conservation-survey data on the same trip to the field. The inexperienced surveyor will probably find it advisable, however, to complete the base map before attempting to fill in the conservation-survey data. A base map, to be most usable, should show all pertinent details existing on the lands of the farm that may affect farm planning.

Buried pipe lines across the farm should be located on the map because they may affect the construction of terraces or other structures. Power lines, fences, buildings, quarries, as well as other works and objects should be plotted because of the effect they may have on the location of field boundaries, waterways, and conservation structures. The character of existing roads may affect their movability and hence affect the farm plans. It is important that the character of all drainage features, such as springs, draws, gullies, streams, and marshes be mapped because their movability and their effect on farming operations may greatly affect the conservation program of the farm.









Standard symbols for mapping approved by the Soil Conservation Service are indicated in plates 1 to 6, inclusive, which follow.

WORKS AND STRUCTURES



SYMBOLS FOR USE IN MAPPING

WORKS AND STRUCTURES — CONTINUED

<i>Telegraph or telephone line</i>	T T T T T
<i>Power-transmission line</i>
<i>Buildings in general</i>	
<i>Vacant house</i>	o
<i>Cliff dwelling</i>	o
<i>Church</i>	+
<i>Schoolhouse</i>	+
<i>Creamery</i>	Y
<i>Windmill</i>	x
<i>Sawmill</i>	^
<i>Forest fire or lookout station</i>	A
<i>Cemetery</i>	
<i>Ruins</i>	
<i>Fort</i>	X
<i>Battery</i>	
<i>Indian mound</i>	^
<i>Mine or quarry of any kind (for open cut)</i>	X
<i>Prospect</i>	X
<i>Shaft</i>	o
<i>Mine tunnel</i> {	
<i>Opening</i>	^
<i>Showing direction</i>	
<i>Oil or gas wells</i>	
<i>Oil or gas pipe line</i>
<i>Pumping station</i>
<i>Levee</i>	
<i>Tanks</i>	
<i>Coke ovens</i>
<i>Airway beacon</i>	☆
<i>Lighthouse or beacon</i>	☆



SYMBOLS FOR USE IN MAPPING

DRAINAGE







<i>Permanent streams</i>		
<i>Intermittent streams</i>		
<i>Intermittent drainage without channel</i>		
<i>Lake, pond, or reservoir</i>		
<i>Intermittent lake or pond</i>		
<i>Spring</i>		
<i>Termination of stream in sink</i>		
<i>Termination of stream on flat or alluvial fan</i>		
<i>Flowing well</i>		
<i>Wells or water tanks</i>		
<i>Falls and rapids</i>		
<i>Wet spot</i>		
<i>Overflowed land</i>		
<i>Tidal flats</i>		
<i>Marsh</i>	<i>Fresh marsh</i>	
	<i>Salt marsh</i>	
	<i>Cypress swamp</i>	

SYMBOLS FOR USE IN MAPPING

BOUNDARIES, MARKS, AND MONUMENTS

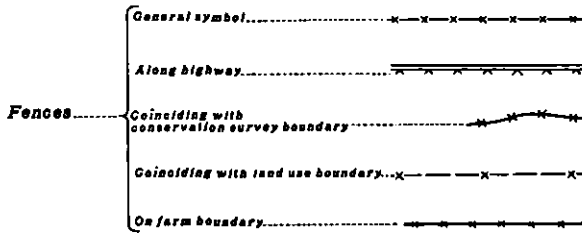
<i>National, State, or Province line</i>	-----
<i>County line</i>	-----
<i>Civil township, district, precinct, or barrie</i>	-----
<i>Reservation line</i>	-----
<i>Land-grant line</i>	-----
<i>City, village, or borough</i>	-----
<i>Cemetery, small park, etc.</i>	-----
<i>Boundary of area surveyed</i>	-----
<i>Township, section, and quarter-section lines (any one for township line alone, any two for township and section lines)</i>	
<i>Township and section corners recovered</i>	-----+-----+-----+
<i>Boundary monument</i>	-----□-----
<i>Farm boundary</i>	-----
<i>Triangulation station</i>	-----△
<i>Permanent reference point or primary traverse-station</i>	-----□
<i>Permanent bench mark (and elevation)</i>	----- 
<i>Supplementary bench mark (and elevation)</i>	-----xmsc
<i>U. S. mineral or location monument</i>	-----▲
<i>Soil sample location</i>	-----○
<i>Any located station or object (with explanatory note)</i>	-----○

MISCELLANEOUS

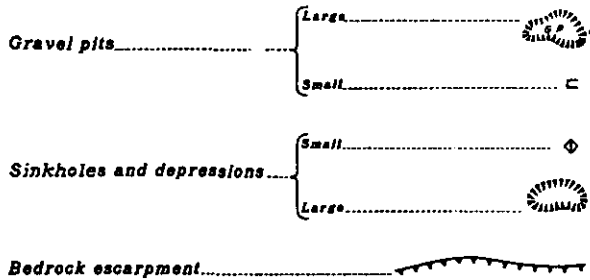
<i>Rock outcrop</i>	----- 
<i>Stone</i>	----- 
<i>Gravel</i>	----- 
<i>Chert fragments</i>	----- 
<i>Made land</i>	----- 
<i>Sand dune</i>	----- 

SYMBOLS FOR USE IN MAPPING

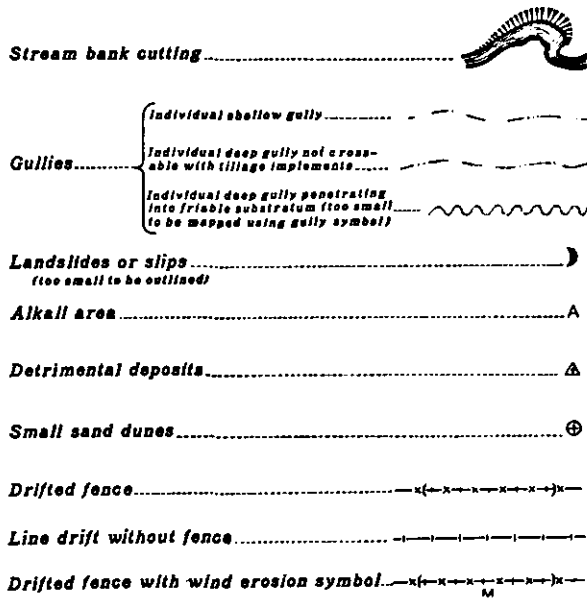
WORKS AND STRUCTURES



RELIEF



MISCELLANEOUS



SYMBOLS FOR USE IN MAPPING

ABCDEFGHIJKLMNOPQRSTUVWXYZ&

abcdefghijklmnopqrstuvwxyz

1.2.3.4.5.6.7.8.9.0.

ABCDEFGHIJKLMNOPQRSTUVWXYZ&

abcdefghijklmnopqrstuvwxyz

1.2.3.4.5.6.7.8.9.0

Names of natural land features, vertical lettering
Names of water features, slanting lettering

The traverse type plane table with a board at least 12 by 12 inches in size, mounted on a tripod in such a way that the table may be rotated and clamped in position, is preferable. The plane table should be equipped with a box-trough compass, set into the board near one edge, or a good pocket compass may be used. A satisfactory plane table may be made at little expense in the school shop. Steel thumbtacks may affect the accuracy of the compass needle and should, therefore, not be used on the plane table.

A peep-sight or telescopic alidade is preferable, but an engineer's scale may be used as an alidade by sighting down the top edge. The alidade should carry a scale of 1/7,920 or the scale used in making the map. If it does not, a scale should be made or secured that will serve for measuring distances on the map.

Pencils should be 6H or 7H; one should have a sharp chisel-edge point for drawing lines and one should have a sharp conical point for making dots. If distances are to be paced instead of measured, a tally counter should be used to assure accuracy in counting paces.

There are many variations of the procedure used in plane table mapping. Other suitable methods will be found in Soil Survey Manual, Miscellaneous Publication 274, United States Department of Agriculture, and in Agricultural Education, Vol. 13, Nos. 5 and 6, issued by the Department of Agricultural Education, Clemson College, Clemson, South Carolina.



Soil Conservation Service, U. S. D. A.

Figure 5.—A Completed Soil Conservation Survey Map Made on an Aerial Photograph of a Pennsylvania Farm. (See Interpretive Science and Related Information Under Jobs I and II, page p. 20, for Meaning of Symbols.)



Soil Conservation Service, U. S. D. A.

Figure 6.—There is a Definite Correlation Between Percent of Slope and Rate of Erosion on Practically All Lands. Proper Conservation Measures, as Shown, Control Erosion.

Figure 7.—Measuring the Slope of a Field with an Abney Level. This Surveyor is Making a Conservation Survey with an Aerial Photograph as a Base Map.

Soil Conservation Service, U. S. D. A.



Job II.—Making a Soil Conservation Survey of the Farm ⁴

ANALYSIS

Operations	Standard or accepted practice
1. Assemble equipment and supplies.	<p>Secure the following equipment and supplies:</p> <ul style="list-style-type: none"> (a) Base map. (b) Plane table. (c) Pencils, erasers, brass thumbtacks. (d) Soil auger. (e) Sharpshooter spade. (f) Abney level, or farm level and rod. <p>A base map (scale 8 inches=1 mile; greater if survey is of a small farm or if an unusual amount of detail is to be included) should be prepared in accordance with the procedure set forth in job I and prior to starting the soil conservation survey of the farm.</p> <p>Experienced surveyors often make the conservation survey of the farm at the time the base map is being made. Inexperienced surveyors will usually find it advisable, however, to prepare the base map in advance of making the conservation survey.</p>
2. Check on soil types and erosion conditions in the locality.	<p>Before going to a given farm to make a soil-conservation survey, observe and study soil types, soil characteristics, and erosion conditions common to the locality. Make a laboratory study of soil texture, structure, color, consistency, organic content, and other pertinent physical characteristics and note the relation of such characteristics to the erodibility, tilth, and production possibilities of the soil. Make tests for soil acidity and available plant food. Note the relation of chemical characteristics to the productivity of the soil. Study the apparent causes and the significance of various types of erosion represented in the locality.</p> <p>Make field trips to study soil and erosion conditions. Observe soil profiles at road cuts or by digging through A and B horizons with a spade. Measure depth of topsoil on various fields using spade, post-hole digger, or soil auger. Learn to identify, by observation, topsoils and subsoils of various textures and structures. Study the texture, permeability, and other characteristics of soils and subsoils encountered. Make determinations as to surface and underground drainage features.</p> <p>Learn to distinguish between various soil types found. By conferring with farmers and using other possible sources of information learn as much as possible regarding the productivity, erodibility, plant adaptations, and drought-resistant qualities of various soil types encountered. It may be desirable to group soil types of the community. (See "Interpretive Science and Related Information," page 22.)</p>

⁴ E. A. Norton, Soil Conservation Survey Handbook. United States Department Agriculture Miscellaneous Publication 352. 40 pp., illus., 1939. The text of this handbook was used freely in covering jobs II and III.


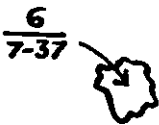
Job II.—Making a Soil Conservation Survey of the Farm—Continued

ANALYSIS—Continued

Operations	Standard or accepted practice
2. Check on soil types and erosion conditions in the locality—Contd.	<p>Assign numbers to the various soil types or groups likely to occur on the farm to be surveyed. The number thus assigned to each type will become the symbol to represent that soil on the conservation-survey map. It is desirable but not essential that all soil types thus classified be identified by the standard name assigned to them by soil surveys that may have been made in the locality. Study erosion conditions on several farms of the community and make notes. Learn to estimate the amount of topsoil lost from sheet or wind erosion by measuring the depth of topsoil on cultivated fields and comparing with the depth of topsoil on adjacent virgin fields of the same soil types that have not suffered from accelerated erosion. Learn to measure or estimate the amount and character of recent erosion accumulations on a field. Study various gullied fields encountered; estimate and check depth and frequency of gullies in the fields. Study eroded fields where the erosion has been partially or completely stabilized by vegetation and learn to identify such conditions when encountered. Study any other pertinent erosion conditions likely to be encountered on the farm to be surveyed. Consult standard symbols given under the Interpretive Science and Related Information section of this job. Become familiar with those symbols which will be used in the survey of the farm.</p>
3. Measure slopes-----	<p>With an Abney or farm level proceed to a farm where various degrees of slope are to be found. Make measurements of the percent of slope, using standard methods approved for these instruments until proficiency is attained in this operation. The Abney level, if available, is preferable to the farm level and rod because it is easier carried and measurements can be made more rapidly. If an Abney level is not available, a 100-inch rod, a carpenter's level, and a yardstick can be substituted. Hold the rod horizontally, placing one end of it against the slope to be measured. Place the level on top of the rod. Hold the rod level and with the yardstick measure the vertical distance from the other end to the ground. The number of inches, measured in this way, equals the percent of slope. The latter method is recommended in preference to any attempt at estimating slopes, since even the most experienced surveyor frequently cannot estimate slopes accurately.</p>
4. Map the farm-----	<p>Fasten the base map to the plane table as outlined in the Analysis of job I, operation 2. Go to the farm to be surveyed and select a starting point, preferably at some point on the farm that is clearly marked on the map. Set up the plane table as outlined in the Analysis of job I, operation 8, method No. 2.</p>

Job II.—Making a Soil Conservation Survey of the Farm—Continued

ANALYSIS—Continued

Operations	Standard or accepted practice
4. Map the farm—Contd.	<p>By careful inspection, determine for the area in the vicinity of the plane table:</p> <ol style="list-style-type: none"> (a) Soil type. Observe present depth of topsoil. (b) Percent of slope. (c) Character and degree of erosion. (d) The present land use or vegetative cover of the area. <p>The extent of the area to be mapped from any one position will depend upon the variability of conditions found, the visibility from the point, and the experience of the surveyor. It will usually be inadvisable, on variable terrain, to map an area larger than 300 yards in diameter from any one position.</p> <p>Particular attention should be given to the boundary lines between changes in any one of the factors being mapped. The procedure outlined in the analysis of job I, operation 8, should be used for locating boundary lines of surveyed areas on the map. With appropriate symbols designate the conditions found at the correct locations on the map.</p> <p>The soil type, the percent of slope, and the character and degree of erosion should be expressed by a composite symbol which should be arranged in fractional form.</p> <p>Example:</p> <div style="text-align: center;">  </div> <p>In the above example "6" represents the soil type; "7" indicates that the dominant slope is 7 percent; and "37" indicates that 75 percent or more of the topsoil or all the topsoil and less than 25 percent of the subsoil have been removed by sheet erosion and that occasional gullies more than 100 feet apart are found on the area. (See standard symbols.) An area too small to contain a complete symbol may be identified by placing the symbol at an angle of 45° to the other erosion symbols, with a small arrow leading into the area delineated, thus:</p> <div style="text-align: center;">  </div> <p>Sufficient space should be allowed to insert a symbol to designate the capability of land for use, immediately to the right of the composite symbol. A change in any of the 3 factors will necessitate the delineation of another area with a new complete composite symbol incorporating the change.</p>

Job II.—Making a Soil Conservation Survey of the Farm—Continued

ANALYSIS—Continued

Operations	Standard or accepted practice
4. Map the farm—Contd.	<p>The designation for present land use and cover should not be expressed in the composite symbol but shown independently for each field by an appropriate symbol.</p> <p>Present use of the land can be determined by observation, but where it seems advisable to map the condition of cover a careful inspection should be made. In the case of pastures it may be desirable to make a count of the type and density of plants growing on the area. This is made by counting the plants on a square foot of surface selected at random several places on the area. The type, density, and condition of cover should be indicated as a part of the land-use symbol. (See Interpretive Science and Related Information.) It is also desirable to designate the type and condition of cover on woodlands, idle lands, meadows, and other areas that are in permanent vegetation. It may be desirable to indicate the direction of slope on the map by the use of a small arrow. Length of slope may also be noted at the time of the survey.</p> <p>EACH AND EVERY 3-FACTOR AREA SHOULD BEAR THE COMPLETE COMPOSITE SYMBOL, AND EACH LAND-USE AREA SHOULD BE ADEQUATELY MARKED.</p> <p>When the mapping has been completed at the first station, the plane table should be moved to another point and the mapping continued, as at the first station, until the entire farm has been surveyed.</p>
5. Inking maps.....	<p>Soon after the survey has been completed, ink in all symbols with waterproof inks of appropriate color. Boundaries of areas that contain a composite symbol should be indicated by fine, <i>solid</i> black lines. Land-use boundaries, where departing from other boundary delineations, may be indicated by a black dashed line or a dashed line of different color.</p> <p>Numbers and letters used as symbols should be made with black ink, approximately 1/8-inch in height. After a survey has been completely inked in, go over it with an artgum eraser and remove all pencil marks and smudges.</p>
6. Indicate land-use capability on the map.	<p>When the survey of the physical land conditions has been completed a symbol should be inserted immediately following each composite symbol of soil type, slope, and erosion to indicate the land-use capabilities of the area represented by the composite symbol. For methods of making determinations as to the land-use capabilities, see Analysis of job III, p. 34.</p>

INTERPRETIVE SCIENCE AND RELATED INFORMATION

If a soil-conservation program for a farm is to be based on the physical conditions and capabilities of the land, it is essential that a complete inventory of the physical land assets be made as the initial step in planning the program.

Two major kinds of soil conservation surveys are recognized by the Soil Conservation Service, based on the intensity of observation and the detail of delineation. *Detailed surveys* are those in which the features studied are examined at close intervals and delineated in detail, and *reconnaissance surveys* are those in which the features are examined at wide intervals and are not delineated in detail. Reconnaissance surveys are very general in nature and will not be further considered here. Detailed surveys are made on farms where specific conservation practices are to be outlined.

Experience has shown that, even though the person planning the soil-conservation program be very familiar with the farm, a soil-conservation survey will be of immeasurable assistance in developing the farm plan. The possession of general knowledge and familiarity with the farm, gained from daily association with it, will seldom do away with the need for a survey that shows accurately the boundaries of all variations in physical conditions and adaptabilities of the land. The survey should show accurately all physical land conditions existing that will affect the land-use capabilities of any given area of the farm, including soil type, slope, character, and degree of erosion, and the present use of each tract of land on the farm. The type, density, and condition of vegetative cover should be mapped on farm pastures, meadows, woodlands, idle lands, and other areas covered with permanent vegetation, because this factor may considerably influence the conservation program.

Soil

Since several soil types may occur on one farm or even in one field, grouping of soil types to express significant differences may sometimes be desirable. On one farm, for example, the soils might be grouped into light-colored silt loams and dark-colored silty clay loams; on another, significant groups might be stone-free upland soils, stony upland soils, and bottom-land soils; still another might have well-drained soils and poorly drained soils. Any grouping that is made should be a practical one. If only three or four soil types occur on the farm, probably no grouping will be necessary.

Satisfactory groups can be established only after thorough study. Following are some of the factors which are considered in grouping soils:

1. External features:

Site: whether upland or lowland.

Original vegetation: timbered or grassland.

Topography: favorable or unfavorable for erosion control.

Drainage: well drained, poorly drained, or imperfectly drained.

2. Physical and chemical character of the soil horizons:

Reaction: neutral, mildly calcareous, strongly calcareous, mildly acid, strongly acid.

Alkali: free or slight, moderate, serious.

Texture: light, medium, heavy.

Structure: granular, columnar, single-grained, highly dispersed or dense, powdery or loose.

Consistency: open, compact, mellow, friable, crumbly, plastic, sticky, hard, or cemented.

Permeability: favorable or unfavorable.

Moisture retention: favorable or unfavorable.

3. Susceptibility to erosion:
 - Water erosion: slight, moderate, severe.
 - Wind erosion: slight, moderate, severe.
4. Present productiveness: high, medium, low.

The depth of topsoil remaining on the land should be observed and noted because of its influence on the future productive possibilities of the land. In some localities, as in the dark-colored soils of the Middle West, the present depth of topsoil can be readily ascertained. Elsewhere, as in the Northeastern States, there is no sharp distinction between topsoil and subsoil, and the plowed layer is in reality a mixture of several thin layers (called horizons by soil scientists) that could be distinguished in the original soil before it was plowed. In the former case the remaining topsoil is essentially like that which originally existed, except that its depth is less because part of it has been removed by erosion. With the latter, however, the apparent depth of topsoil has remained practically uniform (it is the depth of the plowed layer), but if any erosion has occurred, its composition has been changed gradually by the plowing up of additional subsoil material. The depth of topsoil, therefore, in some localities may be an important factor for consideration in the development of land-use plans, while in others it has very little significance.

Soil types should be designated by numerals in the legend that is to be set up for the survey. The soil symbols may vary for different surveys and should be shown in an accompanying legend. The numbers that represent soil types may start at 1 and run consecutively. If the Soil Conservation Service or some other agency is making a survey in the community, the use of their soil legend may be desirable.

Slope

The most desirable method of mapping slope is to make a detailed topographic map having a contour interval of 1 foot or less. Since it is impracticable to obtain such maps at the time they are needed, it is desirable to develop and map slope groups.

Percent of slope may be defined as the number of feet the land drops from the horizontal in 100 feet. Hence, when a rod 100 inches long is used to measure the horizontal distance, the reading in inches on a yardstick measuring the drop is also the percent of slope.

It is recognized that under natural cover a definite correlation exists between slope and profile development in mature soils and that every soil has a characteristic range of slope. This range is usually broad enough to include several recognizable degrees of behavior with respect to erosional processes. Fairly definite limits can be established (1) under which there is little or no danger of erosion where cultivation is practiced, (2) within which erosion can be controlled on cultivated land if adequate precautions are taken, and (3) above which permanent cultivation should not be attempted because of susceptibility to erosion. These limits may vary greatly for different soils or may be the same for a group of soils. In addition to erosion, other factors, such as amount of run-off, ease of cultivation, and fundamental differences in the character of the soil, must be considered in the development of slope groups. A suitable set of slope groups for each important soil or group of soils should be determined at the initiation of the survey, recognizing all of these natural relationships.

Significant physiographic units or land forms may be used as a basis for the separation of major sets of slope groups. For example, one set of slope groups may be applicable to alluvial flats and terraces, another to undulating and rolling plains, and still another to foothills and mountains.

If significant variations exist in the characteristics and properties of soil types, two or more sets of slope groups may be necessary on the same farm. For example, those soils having a dense claypan will require a different set of slope groups from those soils having open, porous subsoils. The slope groups established for those lands with claypan soils might be less than 1 percent, 1 to 4 percent, 4 to 7 percent, 7 to 12 percent, and 12 percent or more; whereas the slope groups established on lands where the soils have open, porous subsoils might be less than 5 percent, 5 to 9 percent, 9 to 15 percent, 15 to 20 percent, and 20 percent or more.

For convenience, these ranges will constitute slope groups which will be used in mapping. The dominant or controlling percent of slope, the slope group, or both, may be shown on the map for each area delineated. The dominant percent of slope is the land gradient that must be given primary consideration in combination with soil type and degree of erosion, in the making of land-use and erosion-control recommendations, and may not be the average percent. If the range of slopes in a group is narrow, or if the survey is of a reconnaissance type, so that dominant percent cannot be designated, it is permissible to use the letter symbol alone. On detailed surveys, if the range in the group exceeds 4 or 5 percent, the dominant percent should be shown.

In actual practice it will be found that the same slope groups will apply to a number, or possibly all, of the soil types within a survey. However, there may be certain soils that must stand alone, either permitting very wide slope limits or requiring very narrow ones.

Slope groups should be designated by capital letters, beginning with A to represent the nearly level areas, following with B, C, D, E, and additional letters if needed. The slope-group symbols need not appear on the map when the dominating slope is shown, but they should be given in the legend.

A typical arrangement of slope groups used on one survey is shown in the following table:

Kind of soil	Range of slope group				
	A	B	C	D	E
Well-drained and imperfectly drained soils derived from till and outwash, and all bottom land.	Percent Less than 5.....	Percent 5-15	Percent 15-25	Percent 25-35	Percent 35 or more.
Imperfectly drained soils derived from till.....	Less than 3.....	3- 8	8-15	15-25	25 or more.
Soils derived from lacustrine materials.....	Less than 2.....	2- 5	5-10	10-15	15 or more.

Mapping of Slope Groups

It should be emphasized that slope groups are to be used as the unit for mapping slopes. If the survey plan calls for the mapping of dominant percent of slope, the surveyor should determine the slope group to which a delineated area belongs. He should then indicate on the map the dominant or controlling percent of slope. Percent of slope within any group should not be delineated separately. For example, when mapping the slope groups as outlined in the preceding paragraph, no attempt should be made to delineate separately any areas of imperfectly drained till soil with slopes between 3 and 8 percent; a 4-percent slope in this group of soils should not be separated from a slope of 5, 6, or 7 percent unless there is also a difference in soil type or degree of erosion. Instead, it should be determined whether 3, 4, 5, 6, or 7 percent is the dominating slope within the single delineated area. A slope of 9 percent, however, would be delineated separately from one of 7 percent, because it occurs in a different group. The numeral placed on the map as a slope symbol therefore denotes two things: The slope group in which the delineated area has been placed and the dominating or

controlling slope of the land delineated. The dominating percent will be used for detailed land use planning on farms and fields, but the slope group is more useful in tabulation and interpretation of survey data and in general land planning.

Although steepness of slope is of paramount importance in a slope classification, other slope characteristics, particularly length, uniformity, direction, and pattern of slope must be considered in formulating a program of erosion control and land use. Examples of distinctive land forms which contrast sharply with the stream-formed surfaces prevailing over wide areas and which affect soil-conservation practices are the long southwesterly slopes of the Washington-Oregon-Idaho Wheat Belt, the short variable slopes characterizing the same type of relief in the glaciated Northeast, the mounds of eastern Kansas and of the Arkansas-Louisiana Coastal Plain, the sinkholes of the limestone sections of southern Kentucky and elsewhere, and the hog wallows of the great interior valley of California. Such features, if significant, may be recognized in the survey work plan and indicated by symbols. Where it is deemed necessary the direction of slope may be indicated by the use of small black arrows.

Erosion

Erosion is a geologic process that removes or wears away soils and geologic materials from the land surface through the normal action of natural agencies, primarily wind, water, and gravitational creep. Both normal and accelerated erosion are recognized.

Normal erosion.—Normal erosion is the erosion characteristic of the land surface in its natural environment, undisturbed by human activity, as under the protective cover of the native vegetation. This type of erosion is sometimes referred to as geologic erosion. It includes: (a) Normal soil erosion, or the erosion characteristic of the soil type in its natural environment under the native vegetation, undisturbed by human activity; and (b) rock erosion, or erosion of rocks, consolidated or unconsolidated (including soil material), on which there is little or no true soil, as in stream channels, high mountains, or badlands.

Accelerated erosion.—Accelerated erosion is erosion of soil or soil material over and above normal erosion, brought about by changes in the natural cover or ground conditions, including changes due to human activity and those caused by lightning or rodent invasion. Classes are established to indicate both the kind and the degree of accelerated erosion. Water erosion is designated by numerical symbols and wind erosion by letters. On any survey there may be areas with no apparent erosion and others with various stages or degrees of sheet, gully, and wind erosion. The degree of erosion is determined by estimating the percent of the original topsoil, subsoil, and parent material or substratum that has been lost from the land surface which existed prior to the initiation of accelerated erosion. Such an estimate can usually be made by comparing the profile of the soil on which erosion is to be mapped with a virgin soil profile which occurs under similar topographic conditions. Where the virgin topsoil is shallower than the average plow depth, the position and depth of the lower part of the solum may be used in estimating the degree of erosion. Other evidence, such as plant succession, erosion history, and visible evidence of active erosion may serve as additional indicators.

Erosion should be indicated on the conservation-survey map by standard symbols as listed below:

NORMAL (GEOLOGIC) EROSION

- O. No apparent erosion.
- W. Normal erosion (active):
 - Ws. Normal sheet erosion.
 - Wg. Normal sheet and gully erosion.
 - Ww. Normal wind erosion.

No apparent erosion will be indicated by the symbol O. This will be mapped on nearly level cultivated land as well as on land protected by vegetation, provided there is no evidence of erosion. Active normal erosion—that is, erosion that has not resulted from activities of man or natural destruction of vegetative cover—will be indicated by the symbol W. If it is desired to show the type of normal erosion, normal sheet erosion may be designated by Ws, normal sheet and gully erosion by Wg, and normal wind erosion by Ww. If it is desired to indicate both type and degree of normal erosion, W may be used with an appropriate symbol given under accelerated erosion, as for example, W2, W37, or WN.

ACCELERATED EROSION

WATER EROSION

Two results of erosion by water will be designated: (a) Removals, or erosion proper; and (b) accumulations resulting from removals on some other area. Removals include both sheet and gully erosion. To estimate erosion, the present thickness of topsoil and its range must be compared with the original thickness of topsoil and its range, as determined from examinations of undisturbed soils in comparable locations or from other evidence.

Removals

Classes of removals and the symbols used to designate them are as follows:

Sheet erosion.

1. Less than 25 percent of the topsoil removed. Erosion of class 1 is mapped where the effects of erosion can be identified but where the average removal has been less than 25 percent of the thickness of the original topsoil.
2. Twenty-five to seventy-five percent of the topsoil removed. If the thickness of original topsoil was about 16 inches and the present topsoil varies from 6 to 10 inches, sheet erosion of class 2 would be mapped.
3. Seventy-five percent or more of the topsoil removed, or all topsoil and less than 25 percent of the subsoil removed.
4. All topsoil and 25 to 75 percent of the subsoil removed.
5. All topsoil and 75 percent or more of the subsoil removed; parent material may be eroded.
6. The symbol 6 is reserved for conditions of local significance, such as slips or cat steps. Slips too small to be outlined on a map may be indicated by a crescent-shaped symbol, as shown on plate 5.

Gully erosion.

Gully erosion is that type of accelerated erosion by water which produces definite channels too deep to be obliterated by normal tillage. Three classes of gully erosion are recognized.

7. *Occasional gullies.*—More than 100 feet apart.
8. *Frequent gullies.*—Occurring less than 100 feet apart but including less than 75 percent of the delineated area.
9. *Very frequent or large gullies.*—This symbol will be used to designate an intricate network of gullies or an individual gully large enough to be outlined or any mappable area of which more than 75 percent is gullied.

Symbols 7 and 8 should be shown in conjunction with sheet-erosion symbols; that is, they should never be used alone. Symbol 9 should be used without sheet-erosion symbols. On land affected by erosion of class 9 some difficulty may be experienced in identifying the soil type and slope. In such cases the slope of the original land surface should be shown and a soil separation such as rough gullied land may be mapped if approved by the vocational agriculture teacher.

Depth of gullies.—Three classes of gullies with respect to depth are recognized and should be indicated wherever they occur.

7, 8, or 9 (without other designation).—Shallow gullies: Could be crossed with tillage implements but would not be obliterated by normal tillage; on range lands, could be easily crossed by stock.

⑦, ⑧, or ⑨.—Deep gullies (not crossable with tillage implements) that have penetrated into compact subsoil or through it into compact parent material.

7V, 8V, or 9V.—Deep gullies (not crossable with tillage implements) that have penetrated into friable parent material.

Individual gully delineation.—In regions where gullies are infrequent, line symbols may be used in red ink to indicate the location and depth of each gully. An individual shallow gully may be indicated by a solid red line and three dots, as shown in plate 5. An individual deep gully may be indicated by a solid red line and two dots (plate 5). An individual deep gully, rapidly erodible, or one that has penetrated into a friable parent material, may be designated by a wavy red line. (See plate 5.)

Accumulations

+ *Recent accumulations.* Recent accumulations resulting from erosion are frequently significant from the standpoint of effects on agricultural lands and urban property and from other points of view. The term "recent accumulation" (+) as here used refers primarily to accumulations resulting from accelerated erosion and not to young water-laid materials that have not yet formed well-developed soil profiles. On flood plains where there is no evidence of either erosion or deposition, normal (O) erosion should be mapped.

Detrimental deposits should be indicated by the symbol + within a triangle (pl. 5).

WIND EROSION

Two types of wind erosion will be designated, removals and accumulations.

Removals

- P. Less than 25 percent of the topsoil removed.
- R. 25 to 75 percent of the topsoil removed.
- S. 75 percent or more of the topsoil removed, or all of the topsoil and less than 25 percent of the subsoil removed.
- T. All topsoil and 25–75 percent of the subsoil removed.
- U. All topsoil and 75 percent or more of the subsoil removed; parent material eroded.

Areas on which wind erosion has penetrated into a deep friable parent material should be distinguished from those areas which are eroding only in the topsoil or subsoil or in a compact parent material. Areas eroding in deep friable material should be indicated by UV or by placing the removal symbol U within the V. On surveys where this condition is mapped, the symbol U, used alone, would indicate deep wind erosion in compact or nonfriable material.

Accumulations

- F. Shallow accumulations, less than 6 inches, either level or in hummocks.
- H. Moderate accumulations, level, 6 to 12 inches.
- K. Moderate accumulations, hummocky, 6 to 12 inches.
- L. Severe accumulations, 12 to 36 inches.
- M. Small dunes, 36 to 72 inches.
- N. Large dunes, 72 inches or more.

The proportion of the area covered by accumulations may be indicated by following the class letter with the numeral 1 to indicate less than one-third of the area affected, 2 to indicate one- to two-thirds of the area affected, or 3 to indicate more than two-thirds of the area affected.

Drifted fences may be indicated, if desired, as shown in plate 5. Sometimes it is desirable to indicate line drifts where there may never have been a fence or the fence no longer exists. Such drifts sometimes have an important bearing on land use, although too narrow to be included within boundary lines. They may be indicated as shown in plate 5.

Wind-erosion symbols for removal and for deposition will be used together or individually, as the conditions warrant. They will also be used in combination with water-erosion symbols if conditions warrant.

STREAM EROSION

Streams in flood cause a type of erosion that often requires special treatment to effect control. The area responsible may be far removed from the one affected. Removals caused by floods may be designated by the use of the minus sign (—) following numerical symbols that may be established to indicate the range in depth of the removals. Removals of less than 6 inches, for example, may be indicated by 1— and those of 6 to 12 inches by 2—.

It should be borne in mind that bottom lands subject to overflow that show no measurable recent deposits or removals should be mapped with the *O* erosion symbol.

If it is necessary to show stream-bank cutting, it can be indicated by the use of hachures placed along the banks, as shown in plate 5

EROSION UNDIFFERENTIATED AS TO CHARACTER OR DEGREE

The symbol Θ will be used to designate erosion undifferentiated as to character or degree. This symbol may be used on urban areas, farmyards, and similar areas, but it should not be used if erosion conditions are important and should be mapped.

EROSION CLASSES AND GROUPS

The foregoing symbols, except those denoting gully erosion, are to be used singly or in combination, as required to express the type and degree of erosion. Each erosion symbol or group of symbols used on the map designates an erosion class. Examples are 1, 2, 27, PF, and 27PF. The erosion classes to be mapped on each survey should be listed in the survey plan.

The number of erosion classes may vary from 12 or 15 on surveys of water erosion to 80 or more if wind erosion also has been mapped. These occur on different soil types and slopes. Obviously, each separation cannot have different treatment for erosion control and land use. Groups of erosion classes should therefore be established to express slight, moderate, severe, and very severe erosion, as well as no apparent erosion and recent alluvial or colluvial deposits. The groups should not be shown on the map, but they are necessary for interpretation and use of the survey. A grouping used for a survey in the Piedmont Plateau of Georgia is as follows:

Recent alluvial or colluvial deposits.....	+
No apparent erosion.....	0
Slight erosion.....	1, 17, Θ
Moderate erosion.....	2, 27
Severe erosion.....	28, 3, 37, 38, 4, 47
Very severe erosion.....	48, 5, 9

Where erosion classes cannot be clearly differentiated or are not significant, as in large forested or mountainous areas, combination classes may be mapped, or broader classes may be defined in the legend and indicated on the map by symbols.

Mapping Present Land Use

Four major land-use classes and a miscellaneous class should be recognized. Divisions of the major classes may be mapped if established as part of the survey plan. All divisions must be described definitely in the legend.

Land-use boundaries should be drawn independently of those used to delineate soil, slope, and erosion. Red ink may be used for land-use boundaries if desired.

The following land-use classes are recognized:

L. Cropland.—Cropland will include all land planted to crops and, in addition, fallowed land, orchards, and land seeded down several years to grass, alfalfa, or other forage crops grown in rotation for hay. Meadows cut for hay and then grazed in a later part of the season should be included in this class. Specific crops may be indicated by divisions, such as *L1* or *L2*, carefully defined in the legend.

X. Idle land.—Land either void of vegetation or maintaining plant growth of little economic or agricultural value will be mapped as idle land. (The plant cover on idle land may have considerable value as a food source for wildlife.)

Class *X* should be subdivided into *X1*, *X2*, or other divisions to express additional information, as land formerly cultivated, available for future agricultural use; land formerly cultivated, unavailable for future agricultural use; or land never cultivated and unsuited to agricultural use, such as riverwash, rock outcrop, mines, or dumps.

P. Pasture or range.—Pasture includes grazing land or range other than pastured woodland, and land in grasses or legumes that is devoted primarily to grazing. Since this class includes a wide variety of conditions, the following subdivisions should be recognized if they occur: Wild grassland used solely for hay, land used for pasture in rotation, and land with small woody vegetation that normally does not grow beyond the browse or shrub stage. Additional subdivisions may be established to express the kind and condition of cover.

F. Woodland.—Woodland includes land with 40 percent of the ground covered by the spread of woodland or forest species of any age, and land devoted to forest plantations. Pastured woodlands and virgin woodlands should be divisions of this class. To indicate type and condition or any additional desired information, *F* may be subdivided.

H. Miscellaneous.—Urban areas, large farmyards, golf courses, and areas not otherwise classified will be included in class *H*.

Index Maps

If a survey consists of several sheets, an index map (fig. 8) should accompany the sheets, showing the number of each sheet and its relative location, the boundary of the survey, and one or more prominent tie-in features, such as a railroad or a creek.

Detail of Mapping

The detail of mapping will be determined by practical application. No designation should be shown that is too small to be of significance for practical recommendations for land use and land treatment. On the other hand, on detailed surveys all conditions should be indicated that are important for the development of a program for land use or water conservation. The degree of detail shown will be determined by the purpose of the survey.

The soil is ordinarily the first factor to be delineated in any survey. Many variations in the characteristics of soils occur, and the surveyor must decide on those variations that have significance and can be mapped consistently. After the soil-type boundary has been delineated, erosion and slope are considered in turn, and additional boundary lines are drawn if necessary.

Method of Recording Data on Maps

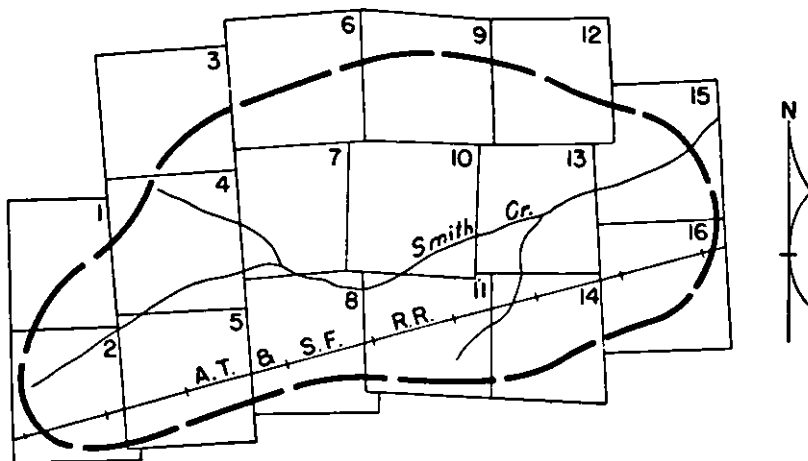
Every survey should show the following: (1) The physical condition of the land, including soil type, slope, and character and degree of erosion; (2) present land use; and (3) land-use capability. Methods of appraising each of these factors separately and the symbols by which they are to be designated have been presented in detail.

Boundaries are drawn to show all significant changes in soil types, slope groups, and erosion classes. Delineations of these factors are to be indicated by solid boundary lines drawn in black ink, and each delineated area is to be identified by a three-part compound symbol. Symbols should be arranged in fractional form, with the soil-type symbol in the numerator and the slope and erosion symbols, separated by a dash, in the denominator. A lineal or vertical arrangement may be used where the size and shape of the area do not permit the fractional form.

Present land use should be shown independently, using broken boundaries consisting of dashes about one-eighth inch in length. Where a land-use boundary coincides with a soil, slope, and erosion boundary, a separate line need not be drawn. Land-use symbols are separated from the composite symbol that denotes the three physical factors. Usually only one land-use symbol is needed in each field or other delineation, but additional symbols should be used if there is any possibility of doubt regarding the correct interpretation.

The boundary lines of every delineated area must be completely closed except where a double-line stream or a large body of water forms a part of the boundary.

Each field sheet must be complete within itself. In order to facilitate matching of adjoining sheets, features should be inked to, but not beyond, a line which is common to both sheets as indicated below:



Soil Conservation Service, U. S. D. A.

Figure 8.—Index map of conservation survey.

Conservation surveys are being made by soil surveyors of the Soil Conservation Service in many areas. Likewise, soil conservation districts in many States are doing survey work of this type. If conservation surveys of the farm have been made by an experienced surveyor of any agency, it will be advisable to use such surveys because of the greater accuracy and detail that may be expected. Soil surveys which describe various soil types have been made by the Bureau of Chemistry and Soils, United States Department of Agriculture, for many counties in the United States. These surveys, if available for the locality, will be invaluable for use in the study of soil types. For additional information about the mapping of soil erosion and related land-use conditions and for assistance in training students to make conservation surveys the local office of the Soil Conservation Service should be consulted.



Soil Conservation Service, U. S. D. A.

Figure 9.—Level, nonerodible lands are adapted to cultivated crops; no erosion-control measures other than good farming methods are necessary. Such lands as this are designated as Class I in the conservation survey.

Figure 10.—Gently sloping and slightly erodible lands are adapted to clean-tilled crops through the use of simple erosion control measures. Strip cropping and contour tillage are controlling erosion satisfactorily on this Texas field. Such lands are designated as Class II in the conservation survey.

Soil Conservation Service, U.S. D. A.





Soil Conservation Service, U. S. D. A.

Figure 11.—Many sloping and erodible lands are adapted to clean-tilled crops if intensive erosion-control measures are used. Terraces, strip cropping, permanent buffer strips, and contour tillage are satisfactorily controlling erosion on this Wisconsin field. Such lands are designated as Class III in the conservation survey.

Figure 12.—Steep, highly erodible lands unsuited to clean-tilled crops may be safely used for close-growing crops or permanent cover but as erodibility increases, adaptability for use becomes narrower. The lands shown are designated as Class IV and V in the conservation survey.

Soil Conservation Service, U. S. D. A.



Job III.—Determining the Use Capabilities of the Lands Included in the Farm

ANALYSIS

Decisions to be made	Factors to be considered	Necessary working data
<p>1. What are the use capabilities of each tract of land on the farm.</p>	Soil type-----	<p>Information as to the texture, structure, consistency, color, tilth, permeability, water-holding capacity, character of subsoil, depth of topsoil, surface and underground drainage, site, susceptibility to erosion, and other pertinent physical characteristics of the soil found on the tract considered; classification of the soil as to type.</p> <p>Information on the present and apparent potential productivity of the soil; suitability of the soil for the production of various types of plants adapted to the climate; reaction of soil—neutral, calcareous, acid.</p>
	Slope-----	<p>Facts regarding the degree of slope; uniformity of slope; direction of slope; length of slope; and other pertinent topographic conditions found on the tract considered.</p>
	Erosion-----	<p>Facts as to the amount of topsoil removed by sheet or wind erosion; the size, type, and frequency of gullies in the tract considered; the rate at which erosion has been progressing during recent years; alkali spots, galled spots, or other localized erosion conditions; the kind and amount of accumulations of silt or sand on the tract that have been deposited by wind or water; uniformity of accumulations over the tract; rate at which accumulations have been deposited during recent years; the probable cause of any unusual or localized erosion conditions found.</p>
	History of the tract.	<p>Facts regarding present and past use of the area; conservation practices used; crops grown; yields obtained; fertilizers or amendments used; vegetation growing in virgin state.</p>
	Foreign drainage.	<p>Information as to the kind and amount of run-off from adjacent lands that flows onto the area; frequency and extent of floodwaters from adjacent streams that overflow onto the area; possibilities of diverting foreign drainage from the area.</p>

Job III.—Determining the Use Capabilities of the Lands Included in the Farm—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
1. What are the use capabilities of each tract of land on the farm—Contd.	Climate----- Vegetative cover.	Information on the expected intensity of rainfall; the total annual precipitation; the character of precipitation; the velocity and direction of prevailing winds; the seasonal distribution of high-velocity winds; the expected periods of freezing and thawing of the ground; types of trees, grasses, crops, and other vegetation that are adapted to the climate. Information as to type, density, and condition of vegetative cover on woodlands, permanent pastures and meadows, or other lands in permanent vegetation.

INTERPRETIVE SCIENCE AND RELATED INFORMATION

The physical and chemical characteristics of the soil which determine its type have a definite relation to its erodibility and capabilities for use. Numerous experiments show that there is considerable variation in the erodibility of different types of soils even under the same land-use and climatic conditions and with the same slope. The texture, structure, consistence, adhesive qualities, permeability, water-holding capacity, and other physical conditions of the soil have a direct bearing on the amount of run-off and erosion that may be expected from any given rain. The texture, structure, and consistence of the soil also affect the tilth and hence have an effect on its capability for cultivation. The depth of the topsoil and the depth and character of the subsoil may affect the installation of terraces and other conservation measures, and thus, its capability for cultivation. The amount of topsoil remaining on the land is also an important indicator of the potential productivity and affects the capability of the land for the production of various types of vegetation. The character of the subsoil may affect the under surface drainage and permeability of the soil and hence its erodibility as well as its capability for production of deep-rooted plants.

It would, quite obviously, be a mistake to decide that a tract is capable of cultivation if the present and potential productivity of the land is too low to yield a profitable return. Acidity or alkalinity in the soil may preclude the use of an area for some purpose to which it otherwise might be adapted, if present in quantities which make its neutralization or removal impractical.

Numerous experiments have shown that on areas where the soil type and land use are similar, the amount of run-off and erosion is proportionate to the steepness of the slope. Steep slopes must be considered also in relation to their possible effect on the operation of farm machinery or on the construction and maintenance of terraces and other conservation measures.

Extreme irregularity in slope may cause an area to be unsuitable for cultivation because of inconvenience in the operation of farm machinery and susceptibility to erosion. Considerable variability in steepness and direction of slope will also seriously interfere with a system of terracing, contour tillage, or strip cropping on cultivated lands. The direction of the slope is usually important only as it affects

moisture content, light intensity, and temperature in relation to crops, or causes exposure of the soil to prevailing winds, dashing rains, or snow accumulations and inopportune freezing and thawing.

Where sheet or wind erosion has been responsible for removal of a large portion of the topsoil, or for deposition of foreign soil material, the texture or structure as well as the productivity may differ greatly from that of the original soil. Removal of the topsoil by sheet or wind erosion normally decreases the amount of organic matter in the soil; hence it decreases its water-absorbing and water-holding capacity, and adhesive qualities, with the resulting effect that both run-off and erosion are usually accelerated as erosion progresses.

Gully erosion tends to speed up drainage or run-off from the farm and often results in a lowering of the ground-water table where the gullies attain considerable depth. Gullies also make the operation of farm machinery difficult. Where excessive gullying occurs, the possibilities of land use are usually confined to permanent vegetative cover regardless of other characteristics of the land.

The rate at which erosion has been progressing may in many places be taken as an indicator of the amount of erosion to expect in the future. It is important to know the history of each tract of land surveyed, because knowledge of the past uses and abuses to which the land has been subjected assists in determining the erodibility of the soil and the rate at which erosion may be expected under various kinds of usage. The type of vegetation that grew on the land in its virgin state is usually a reliable indicator of its potential possibilities.

Accumulations of overflow deposits of subsoil material from eroded lands may cover productive soils with infertile sand, gravel, or clay, causing an almost complete loss of the productivity of the land. Deposits of silt or sand from wind or water may kill out certain types of vegetation which it would be desirable to grow on a field. Depositions may also fill terrace channels or render other conservation structures worthless. Wind-blown hummocks of sand may prevent the use of desirable types of farm machinery. The rate and time at which depositions were made is an important indicator of accumulations that may be expected in the future. Where unusual erosion conditions or accumulations occur on a field it is important to determine the cause of such conditions in order that proper soil-conserving land-use practices may be planned.

Where foreign drainage flows onto a field, it must be given consideration in determining the capabilities of the field. If such drainage can be diverted by means of a diversion terrace then consideration must be given to the cost of diversion. It may be more economical to change the land use than to divert foreign drainage. Quite often it is impracticable to attempt diversion of overflow floodwaters from adjacent streams. If foreign drainage cannot be diverted, its effect on the crops to be grown and its erosive effect on the soil under various types of use must be taken into consideration.

Intensity of rains, seasonal distribution of precipitation, and character of precipitation are more important factors in determining land-use capabilities than the total annual precipitation, because most water erosion is caused by a few rains of high intensity or by rains falling on a heavy snow cover during critical seasons when the ground is bare, frozen, or unabsorptive. The total annual precipitation is relatively unimportant, except as it affects plant adaptations.

Temperature not only affects plant adaptations but may be the indirect cause of serious erosion on unprotected areas in the spring of the year when frozen ground makes the soil unabsorptive at the time the snow begins to melt and spring rains fall. Freezing and thawing of the ground may also accelerate erosion by producing a crumbly physical condition of the soil or by causing a cracking or sloughing of fragments of the soil.

Wind velocity is also important in determining land-use capabilities in areas susceptible to wind erosion and during seasons when the ground is not protected. The seasonal distribution of winds of high velocity must be considered in planning land use for wind-erosion areas. It is essential in such areas to use the land in such a way that the maximum cover on it will be provided during seasons of high wind velocity. The direction of prevailing erosive winds may influence the use capabilities of a tract, especially where the shape or location of the tract is conducive to erosion or to deposit of erosion material onto adjacent lands.

The climatic adaptations of erosion-resistant vegetative types must necessarily govern the capability of any given tract of land with respect to its use and management. Undisturbed woodlands make an ideal erosion-control cover for steep and erodible lands where there is sufficient precipitation, but grass or other vegetation must be used in arid climates. Dense-growing, erosion-resistant cover crops, grown in a strip rotation, may permit cultivation of steep, erodible areas, but if an arid climate prevents such crops from growing densely enough to furnish an erosion-resistant cover, they lose most of their effectiveness.

On woodlands, permanent farm pastures, meadows, and idle lands, it is necessary to consider the present vegetative cover of the land in determining its capability for use, because of the influence such cover may have had in producing the existing land conditions and because of the value it may have as an indicator of the production possibilities of the land.

Determinations as to the use capabilities of any given tract of land can be made only within broad limits. The final decision regarding the use of an area will always be governed, to some extent, by economic and social conditions. It is essential, however, that conclusions concerning the physical capabilities of the land be sound. Faulty conclusions in this respect may result in an unsound program of land use that will necessitate a revision of it as erosion progresses on misused areas.

Classes of Land According to Use Capability ⁵

Classes of land according to use capability may not be permanent in character. Permanent changes, such as removal of topsoil by accelerated erosion, accumulation of toxic salts, artificial drainage, or an increased availability of water for irrigation, may subsequently necessitate reclassification of the areas involved or reappraisal of the classifications. Introduction of new crops or of farming methods not previously known to be applicable may have a similar effect. Experience may demonstrate that some established practices do not insure adequate protection of the land, so that some reclassification or reappraisal of the previous classification may be necessary.

Classes of land according to use capability are defined in general terms. Before they are used on a specific survey, they must be sharpened or modified with reference to local conditions and practices. The classes developed for different areas, therefore, may not be precisely comparable, but they must conform with the principles of the general definitions.

In formulating general definitions of use capability an effort has been made to hold the number of classes to a minimum. A similar effort should be made in establishing classes on each local survey. Usually four or five classes will express the most significant variations in physical factors. In cultivated regions the symbols I, II, III, IV, and V are used to designate degrees of use capability ranging from areas in which the land can be cultivated safely (I) to those in which the land, because it cannot be cultivated safely, should be maintained in permanent vegetation for protection (V).

⁵ Soil Conservation Survey Handbook, United States Department of Agriculture Miscellaneous Publication 352.

Classes of land according to use capability are determined wholly on the basis of physical characteristics of the land, that is, of the soil and its climatic environment. At least four groups of factors must be considered: (1) Permanence of the soil when cultivated (susceptibility to erosion); (2) productivity of the soil as conditioned by native fertility, capacity for retention and movement of water, salt content, aeration, or other factors; (3) the presence of any factor that would interfere with cultivation, such as stoniness or a hardpan layer; and (4) the climatic environment, particularly temperature and precipitation.

To aid in the determination of use capability a table similar to table 1 should be prepared at the beginning of each survey or as soon thereafter as possible, showing significant variations in the physical factors (soil type, slope, and degree of erosion) such as govern land-use capability within the prevailing climatic environment. When properly completed, the recommendations for land-use capability will furnish the necessary physical information to serve as a definite basis for soil-conservation operations on the land. In those areas where detailed studies and surveys and work on the land have been carried out, sufficient information may be available to develop the table at the start of the survey. In all instances the table should be developed as rapidly as the information can be assembled and completed before the survey is finished. After completion of the table the land-use capability will be designated by the surveyor on the field sheets.

TABLE 1.—Classes of land according to use capability for 3 soils in Winona County, Minn.

Field symbol and soil name	Slope and erosion characterizing class ¹				
	I	II	III	IV	V
87. Bertrand silt loam.	A+, A1, Aθ	A17, A2, B1, B17, B2.	B27, C1, C17, Cθ.	-----	B28, B9, C2, C27, C3 D1, D17, D2, D27, E1, E17, E2, E27, F1, F17.
59. Carrington silt loam.	A1-----	B0, B1, B2, B27.	C1, C17, C2, C27.	D27-----	
35. Dubuque silt loam.	-----	A1, B1, B2-----	-----	B27, C0, C1, C17, C2.	B28, C27, C28, C3, C38, D1, D17, D2, D27, D28, D3, D37, D38, E1, E17, E2, E27, E28, E38, F17, F27.

¹ The slope classes are: A, less than 3 percent; B, 3-8; C, 8-15; D, 15-25; DD, 25-35; and E, 35 or more.

In the general definitions no attempt has been made to consider the soil requirements of different crops. Some lands that are classed as I, for example, may not be wholly satisfactory for the production of all crops adapted to the region, but any land placed in this class must give moderate to high yields of one or more crops.

Classes of land according to use capability have been defined without reference to profitable or unprofitable cultivation, since the possibility of profit is frequently governed by such factors as accessibility of markets rather than by the nature of the soil or its climatic environment. The classes I, II, III, IV, and V express progressively increasing degrees of difficulty involved in the safe and permanent utilization of land for crops. It must be emphasized, however, that frequently the dividing line between any two classes necessarily is somewhat arbitrary.

Moreover, the statements giving the limitations for cultivation in each class have been formulated in terms of prevailing methods of land management. Lands of class IV, for example, are designated as unsuitable, either because of erodibility or for some other reason, for safe cultivation on a permanent basis. This means that from the standpoint of safety the cultivation requirements of these soils would be too exacting or difficult for practical use on a field scale; under different economic conditions, however, even more drastic measures, such as bench terraces on steep class IV lands, replenishment of topsoil on eroded IV lands, or extensive drainage operations on IV lands, might be entirely practical. The lands would still be classified as IV, but the difficulties involved in their utilization could then be met effectively.

Five classes of land according to use capability are recognized in regions of arable soils. Three classes, I, II, and III, indicate land that can be recommended for cultivation. The other two, classes IV and V, indicate land that should not be recommended for cultivation. In brief, the classes designate land that is—

- I. Suitable for cultivation without special practices.
- II. Suitable for cultivation with simple practices.
- III. Suitable for cultivation with complex or intensive practices.
- IV. Not suitable for continuous cultivation.
- V. Not suitable for cultivation.

Class I

Land which, from the standpoint of inherent soil characteristics and environmental features, can be cultivated permanently and safely with the production of moderate to high yields of the adapted farm crops without special practices or measures belongs in class I.

Land placed in class I must have all of the following characteristics: (1) It is suitable for cultivation; that is, cultivation is not impeded by stones, rock ledges, a permanently high water table, or any other condition that would interfere with the use of machinery for tillage; (2) it can be cultivated safely and permanently without special practices for the control of erosion; that is, erosion-promoting crops such as corn or cotton, can be grown on it without danger of accelerated erosion; (3) it retains and supplies enough moisture and contains sufficient plant nutrients for the maintenance of those physical, chemical, and biological conditions in the soil that favor continued production of moderate to high yields of farm crops. Ordinary soil-building practices, including crop rotations and the use of fertilizers and soil amendments, may be commonly used on land of class I.

In regions where accelerated water erosion is prevalent, class I lands occur only on gentle slopes. In regions of wind erosion, class I lands are of still more limited occurrence, since level land, as well as sloping land, is subject to wind erosion.

In the North Central States, where class-I lands are of extensive occurrence, subdivision of the class may be desirable in some localities. The highly productive soils, such as Muscatine and Marshall, could be separated from the moderately productive soils, such as Miami and Clinton, that also belong to class I, as defined in this publication. Where such distinction is made, the symbol "Ia" should be applied to the more productive types and the symbol "Ib" to the less productive types.

Examples of the different classes of soils may be cited. Adequately tile-drained Brookston clay, a nearly level upland soil derived from glacial drift, would be classified as I, while another area of the same soil, undrained, would be placed in a lower class, probably II, because special treatment is necessary to fit it for cultivation. Level, uneroded areas of Hagerstown silt loam, a productive soil derived from limestone, would probably be classified as I, but Hagerstown stony silt loam would not be placed in class I, even though level, because the stones interfere seriously with cultivation. Such land would be placed in another class, probably class IV. Huntington silt loam, a flood-plain soil with rapid internal drainage, would be assigned to class I unless susceptibility to frequent overflow requires a lower classification. Marshall silt loam, a productive soil suitable for the grains commonly grown in the Corn Belt, includes large areas of I (or Ia) land, but, where it is moderately or severely eroded or subject to such erosion as requires strip cropping, controlled disposal of excess run-off water, or other soil-conserving practices, the land would be placed in class II or class III.

It is apparent that the Marshall soils, even though they are highly productive, may be placed in class I, II, or III. Productivity is only one factor in the determination of land-use capability and is considered only in those instances where it is a limiting factor. A sloping area of Marshall silt loam, assigned to class III, may be much more productive than a level area of Grundy silt loam, although the latter would be assigned to class I because it needs no erosion-control or other special practices in order to produce moderate yields. Similar considerations would apply to such soils as the Newtonia, Houston, or Decatur.

In every instance the capability appraisal of the land is to be based on conditions existing at the time of mapping. In this connection it is well to recognize the fact that where an uneroded or slightly eroded cultivated area is sufficiently steep to be susceptible to destructive washing, this susceptibility is in itself a present condition.

Class II

Land which, from the standpoint of inherent soil characteristics and environmental features, requires one or more special practices that are easily applied, in order to be cultivated safely and permanently with the production of moderate to high yields of the adapted farm crops belongs in class II.

Special practices include soil-conserving measures, such as contour tillage, strip cropping, and terracing; the removal of stones that would interfere with cultivation; the installation of tile drains; or any other practices that require special attention. Soil-improving practices, such as rotation of crops and the use of fertilizers and lime, have become well established as ordinary practices in many parts of the country and are not generally considered special practices in those areas. Where these practices are not commonly used, they are to be considered as special practices.

Class III

Land which, from the standpoint of inherent soil characteristics and environmental features, requires complex or intensive measures in order to be cultivated safely and permanently with the production of moderate to high yields of the adapted farm crops belongs in class III.

Classes I, II, and III, as has been stated, include all lands that can be recommended for regular cultivations.

Land of classes II and III may be characterized by one or more of at least three different sets of factors: (1) Susceptibility to erosion if cultivated; (2) some physical obstacle such as stoniness or poor drainage; or (3) low productivity that

requires special soil-improving practices other than those common to the locality for production of at least moderate yields of crops. Any one of these factors will cause land to be classified as II (rather than I), and in general two or more coexisting factors of such a nature, as well as a single factor of sufficient degree, would cause land to be placed in class III.

Examples may be cited to illustrate this point. The Cecil soils of the Southeastern Piedmont, for instance, are extensive and occur on relief ranging from nearly level to steep. They are moderately productive under prevailing practices. Areas of Cecil soils having gentle slopes would be classified as I. Moderate slopes of 3 to about 12 percent would be placed for the most part in classes II and III, although eroded areas, stony areas, or other areas not suitable for cultivation would be placed in class IV or class V.

Norfolk sandy loam, under practices, such as the use of fertilizer, which are common in the localities where it occurs, is moderately to highly productive. Level areas of this soil, not subject to erosion, would be placed in class I. Areas of Norfolk sand in the same locality are less productive and would be placed in class II or some lower class, even if not subject to erosion. For moderate yields, this soil requires fertilization in heavier amounts than are commonly used. Obviously, gentle slopes that require simple erosion-control measures would never be placed in a class higher than II, regardless of the productivity of the soil.

Undrained Brookston clay probably would be classified as II because, while it can be made very productive, artificial drainage—a special practice—is necessary to make it cultivable.

In the semiarid portion of the Southern Plains, smooth areas of the Pullman soils would probably be classed as II. These soils are deep and fertile, but special practices, such as level terracing for water conservation and special crop management, are necessary to preserve the soil and maintain permanent production of moderate yields. On the other hand, those areas of Pullman soils which have been affected by moderate to severe erosion and are deficient in coarse organic matter probably would be classed as III because of the need for considerably greater intensity of treatment, such as water-conservation measures, terracing, contour tillage, and repeated addition of crop residues, to maintain a constant supply of coarse organic matter.

The Zita soils, which are shallower than the associated Pullman soils, would be classed as III or IV. Where these soils have suffered moderate erosion, they probably would be classed as IV.

Class IV

Land which, from the standpoint of inherent soil characteristics or environmental features, is not suitable for regular or continuous cultivation with the production of moderate to high yields of the adapted crops, but is suitable for other uses which may involve short periods of cultivation, with adequate protection belongs in class IV.

Land in class IV may be characterized by steep slopes; severe erosion; physical obstacles, such as stoniness or very poor drainage; low productivity; or other qualities which make it unsuitable for regular cultivation. Some of the land in class IV may be safely used for limited or occasional cultivation, such as plowing to renew the stand of permanent pasture. In some regions land placed in class IV because it is too steep for row crops may be used for annual legumes or close-growing grains, provided such crops are planted to maintain effective cover throughout critical erosion periods.

Examples of such soils are the Houston soils in the Black Belt of Texas which have slopes between 6 and 10 percent and are classified as IV, since they cannot be cultivated permanently without destructive erosion. The corresponding range for the Cecil soils of the Southeastern Piedmont is generally from 12 to about 15 percent. Some land of both the Houston and Cecil soils having more gentle slopes might also be classed as IV because of advanced erosion. Some stony areas are classed as IV regardless of the slope.

Class V

Land of class V is that which, because of one or more inherent soil characteristics or environmental features, is not suitable for cultivation.

Most land of this class in humid regions can be utilized as woodland or for wildlife purposes. Some areas of class V land which are too steep for even occasional cultivation but which will support good grass may be suitable for permanent pasture. Land in class V is characterized by steep, rough, or broken topography; extreme stoniness; very severe erosion; very poor drainage; or some other feature which prevents even occasional cultivation.

Summarizing this classification of land according to use capability, class I land is that which can be cultivated, giving at least moderate yields of some crop without special practices. Land of class II is suitable for cultivation with simple practices, and class III is suitable for cultivation but requires complex or intensive practices. Land on which continuous cultivation is not recommended but which is suitable for other uses that may involve limited cultivation is assigned to class IV. Class V includes only land that is not suitable for cultivation.



Figure 13.—A water disposal system on a Wisconsin farm laid out according to the natural drainage features of the land. These waterways adequately care for all surplus run-off and help to furnish hay for the farm.

Figure 14.—This South Carolina farm has an artificially constructed waterway between field boundaries emptying on a well-sodded pasture. Note also the extension of the terraces from the cultivated field in the foreground onto the pasture in order that the terrace water may not cause erosion in the pasture.



Job IV.—Planning a Water-Disposal System for the Farm

ANALYSIS

Decisions to be made	Factors to be considered	Necessary working data
1. Where to locate permanent waterways.	Topography of the farm.	Information in regard to location of natural waterways on the farm; direction of natural drainage of each field of the farm; area drained by each natural waterway; possibilities of diverting drainage from present course.
	Present location of artificial waterways.	Facts concerning the location of existing artificial waterways, if any; areas drained by artificial waterways; stabilized road-drainage ditches adjacent to the farm; cooperative attitude of road supervisors.
	Land use-----	Information in regard to location of pastures, woodlands, meadows, or other vegetated areas that would make desirable waterways or outlets; type of land use on fields dissected by present waterways; type of use and cover on fields draining into various waterways.
	Field boundaries--	Information concerning probable location of boundaries of cultivated fields; possibilities of changing boundaries of cultivated fields.
	Conservation structures.	Information regarding probable location of terraced fields, diversion terraces, contour furrows, farm ponds, or other conservation structures that may affect the flow of run-off from the farm.
	Foreign drainage--	Facts in regard to amount and kind of foreign drainage flowing onto the farm; course of foreign drainage across the farm; possibilities of diverting foreign drainage.
	Soil conditions----	Information regarding erodibility of soil in natural waterways and proposed locations for artificial waterways; productivity of soil, ability to grow a good vegetative cover; suitability of soil for supporting baffles or other permanent structures; amount and kind of erosion in present waterways; probable control measures necessary to stabilize erosion in proposed permanent waterways.

Job IV.—Planning a Water-Disposal System for the Farm—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
1. Where to locate permanent waterways— Continued.	Outlets.....	Information regarding location of outlets for natural waterways and proposed artificial waterways; type of soil and vegetative cover on outlet areas; relation of outlets to permanent streams; probable damage to other land and property from outlets; probable control measures or structures needed to control erosion at outlets of waterways or to lower water to base grade.
	Water disposal laws.	Information regarding State or local laws regarding the changing of water channels or water disposal.
	Cost.....	Estimated cost of stabilizing erosion in waterways considered; cost of diversion; cost of stabilizing erosion at outlets; cost of maintaining waterways and outlets.
	Convenience.....	Information in regard to conveniences or inconveniences that may result from having permanent waterways in various locations.
2. What type of permanent waterways to provide.	Volume and character of run-off to be handled.	Information concerning size of area to be drained by the waterway; maximum run-off expected from drainage area considering soil type, slope, cover, conservation practices, rainfall intensity, etc.; time required for run-off to reach critical points in waterway; amount and kind of silt that may be carried by the water.
	Gradient of waterway.	Facts concerning maximum degree of slope of waterway; variations in slope.
	Soil conditions.	Information regarding erodibility of soil in waterway; suitability of soil for growing various kinds of erosion-resistant vegetation; ability of subsoil to support a permanent structure; eroded or gullied condition of soil in waterway.
	Standard practices.	Information regarding types of waterways used on soil conservation demonstration areas or on local farms; apparent success or failure of various kinds of waterways; recommendations of Soil Conservation Service, agricultural experiment stations, and other agencies on the maximum safe gradient for vegetated waterways on various soil types; recommended types of vegetated waterways for the locality; recommended types of permanent structures for various conditions.

Job IV.—Planning a Water-Disposal System for the Farm—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
2. What type of permanent waterways to provide.—Con.	Vegetation-----	Information regarding the kinds of grasses or other erosion-resistant vegetation adapted to the soil and climate; ability of adapted vegetation to withstand silting; availability of seed or sod of desirable vegetation.
	Cost-----	Estimated cost of grading waterway; cost of preparing seedbed; cost of seeding or sodding; cost of maintaining vegetative cover; cost of materials for permanent structures; labor cost for building structures; cost of repairing damages and maintaining structures; value of land occupied by waterway.
	Other uses-----	Information regarding possible uses that may be made of meadow strips or other vegetated waterways; estimated returns from other uses.
	Convenience-----	Facts relating to the convenience or inconvenience of different kinds of waterways in carrying on farm operations.
	Experience and training of farm operators.	Information concerning experience and training of farm operator in constructing and maintaining various kinds of structures or vegetated waterways; possibilities of securing necessary or additional training; possibilities of securing services of an agricultural engineer to install waterways.

INTERPRETIVE SCIENCE AND RELATED INFORMATION

A suitable drainage system of permanent waterways that will conduct surplus run-off from the heaviest rains off the farm without damage to the land is an essential part of a soil and water conservation program. The plan for permanent waterways should normally be developed as one of the first steps in the farm plan. By planning the water-disposal system prior to laying out permanent field boundaries, a natural pattern for the field boundaries may be established by the waterways. This can easily be developed so that field boundaries will follow largely the natural boundaries of physical land conditions.

Locating Waterway

In some situations it will be advisable to locate field boundaries and determine the land use of various tracts before waterways are permanently located. It may also be desirable to plan the program of conservation practices for the various fields before permanent waterways are planned. It will usually be found, however, that a drainage system developed from the topography of the farm and the physical land conditions will be satisfactory to meet other demands that may arise. In humid climates or regions with torrential rainfall possibilities the most important problem in erosion control is to conduct excess run-off from the farm without damage to the land; hence, a logical approach is to develop the farm plan around a practical water-disposal system.

The simplest and often the least expensive way to dispose of surplus run-off is to have permanent waterways follow closely the course of natural drainageways existing on the farm. Natural waterways will usually be quite adequate to care for surplus run-off, if properly protected against erosion, and will probably be so located that they will make desirable field boundaries. Natural drainageways for permanent waterways should normally require less expense for grading and the installation of erosion-control measures than artificial waterways.

In cases where the area draining into a natural waterway is large and the flow of water is so great that erosion control is difficult, it may be advisable to divert a part of the drainage to another waterway. Where fields drain directly onto public roads or other farms it will often be advisable either to divert the run-off to a waterway on the farm or to install an artificial waterway along the property line to care for the run-off from the field. In planning water diversion by diversion terraces or other means it is necessary that the contours of the land be established and provisions made for a suitable place to empty the diversion terraces in order that the discharge will not damage other lands or property.

If run-off from the farm drains into a drainage ditch of a public road, it will often be possible for the landowner to make a cooperative agreement with the road supervisors whereby erosion is stabilized in the roadside ditch so that it can be used both for draining the road and the farm land. Under such agreements it is customary for the farm owner to furnish a part of the land included in the waterway and to assist in constructing it and instituting erosion-control measures. The road supervisors usually agree to maintain the waterway. It may be inadvisable to make such agreements with road supervisors if the road does not receive regular and careful maintenance.

Where artificial waterways of sufficient size are already established and the erosion in these is stabilized, it will ordinarily be advisable to use them. In cases where established waterways are poorly located, improperly constructed, show severe erosion, or lack sufficient channel capacity to carry expected run-off, it may be advisable to move them or divert the water from them.

In selecting sites for permanent waterways first consideration should be given to natural waterways that already have an established erosion-control cover of grass, trees, or other vegetation. Where natural waterways dissect productive cultivated fields it will usually be advisable to divert drainage from them to other courses or to change the field boundaries to coincide with the waterways. Artificial waterways should not be so located that they will dissect cultivated fields unless a change of field boundaries is contemplated.

It will often be desirable to divert water to permanent pastures, meadows, and woodlands by means of terraces or diversion terraces, even though no natural drainage channel exists on these areas. Such upland areas, if well covered with vegetation, will not suffer erosion and the water running across them may supply additional needed moisture for plant production. Consideration must be given, however, to the fact that eventually the run-off from pastures, woodlands, and other vegetated areas will seek the natural-drainage channels of the land and these channels must be so protected that they will carry the excess run-off without erosion damage.

In planning the location of waterways consideration should be given not only to the acreage of the area that is to be drained but also to the type of use, the conservation practices to be used, the soil type, and other physical characteristics of the land, that may affect the amount of run-off reaching the waterway. Waterways should be located at such intervals that they will carry expected run-off from the heaviest rains without an undue concentration of the water in any channel.

In some instances it may be necessary to establish waterways along field boundaries for the sole purpose of serving as terrace outlets. Usually such waterways need to be only tributaries to the main drainage channels of the farm. The location of diversion terraces, contour furrows, contour ridges, or other conservation structures may also affect the need for water-disposal channels in specific locations.

Where suitable sites for farm ponds exist, it may be desirable to direct the farm drainage toward such sites by diverting the course of natural drainage. This should not often be necessary, however, because natural drainage will normally be in the direction of suitable pond sites.

The farm water disposal system must not only provide for farm run-off but for foreign drainage that may come onto the farm. Overflow floodwaters from adjacent streams cannot be handled normally by the farm water disposal system, but, if destructive, must be managed by a special system of dikes, drainage ditches, or other means. Conservation practices on the watershed of the stream and other flood-control measures may decrease flood hazards to farm lands. Foreign drainage from adjacent fields and roads can usually be handled by the farm waterways or diverted away from the farm with little expense. Where the amount of foreign drainage is large, it may be necessary to use expensive erosion-control measures on the farm unless the owners of property from whence it comes can be induced to control such run-off.

Erosion in waterways often becomes destructive and may cause severe gulying. The problem of erosion control in the waterway will be simplified and the expense of constructing the waterway reduced, therefore, if locations are selected where a broad, shallow drainage channel, not highly susceptible to erosion, is available and the soil is capable of growing a good vegetative cover. Occasionally it may be advisable or necessary to install permanent baffles or other structures of concrete or masonry in waterways to prevent erosion. Such procedure will usually not be necessary, however, if the location of the waterway is properly selected. If permanent structures are contemplated in a waterway, the subsoil must be capable of supporting the structures. It is always advisable to estimate carefully the expense involved in controlling erosion on sites selected as permanent waterways.

Waterways that empty onto other lands, roads, or property may cause serious damage from erosion and silting. Permanent waterways should be so located that they will empty onto a well-vegetated pasture, meadow, woodland, or other area where erosion can be controlled without excessive expense. Where waterways are emptied into permanent streams it will often be necessary to lower the water to the base grade of the stream. This may involve considerable expense.

A careful study and consideration of State and local laws that pertain to water diversion and related matters should be made in planning the location of waterways, if the natural course of the water is to be changed. Many States have laws that make a property owner liable if diverted watercourses cause real or assumed damage to adjacent property.

Types of Waterway

In planning the type of waterway to establish in any specific location the volume and character of run-off to be carried is an important factor. The expected run-off from various fields of the farm and from foreign areas drained by farm waterways can best be estimated by the use of run-off tables prepared by a competent agricultural engineer who is familiar with local conditions. In estimating expected run-off the acreage, rainfall intensity, land use, slope, soil type, conservation structures, the density and type of vegetative cover, and the condition of saturation of the soil

of the area drained must be considered. It is also essential that consideration be given to the distance of the drained area from the waterway and the time that will be required for run-off to reach critical points in the waterway. The amount of silt or sand that may be carried by run-off flowing down the waterway will influence the installation of erosion-control measures in the waterway since many kinds of erosion-resistant vegetation are incapable of withstanding depositions of silt.

The gradient of the waterway may determine to a large extent the practicability of various erosion-control measures in it. The maximum safe gradient for waterways controlled entirely by vegetation will depend on various factors, including the erodibility of the soil, the volume of run-off, the erosion-resistant qualities of the vegetation used, the width of the waterway or depth of the water flowing over it, and others. In most localities the suitability of various erosion-control measures in waterways can best be determined by observing practices on soil conservation demonstration areas or on local farms. Recommendations of State colleges of agriculture, agricultural experiment stations, and other agencies are usually reliable, if specific enough to be used in given situations.

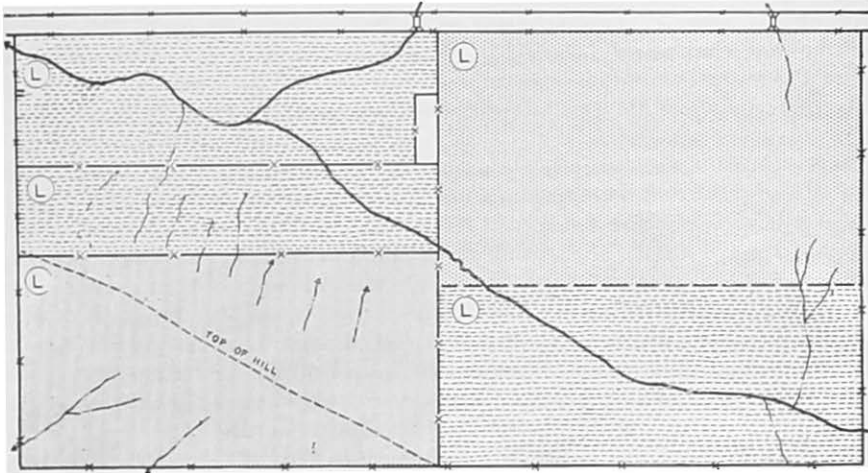
In humid or semihumid climates where there is a great variety of erosion-resistant vegetation adapted to the area and where sufficient rain normally falls to produce maximum growth of vegetative cover, it will seldom be necessary to use mechanical structures to control erosion in waterways. Although the volume of water in the more arid climates is usually not as great as in humid climates, mechanical structures will often be necessary because of the erodible character of the soils and the slower growth and lack of erosion-resistant qualities of adapted vegetation.

Normally the most desirable waterways are those that are broad and shallow and have good vegetative cover that can be used for other purposes without endangering the stability of the waterway. Meadow strips, meadows, pastures, and well-established woodlands usually come in this category. Properly managed vegetative waterways will not only protect the watercourse with a minimum of expense for maintenance but they also may provide considerable income to the farm from pasture, hay, or wood products.

The cost of stabilizing waterways against erosion is always an important factor. If desirable vegetation can be established in the waterway by the use of farm labor, the expense will usually not be excessive. If permanent structures of concrete or masonry are necessary, the cost may be excessive in instances where it is necessary to buy the materials for such structures.

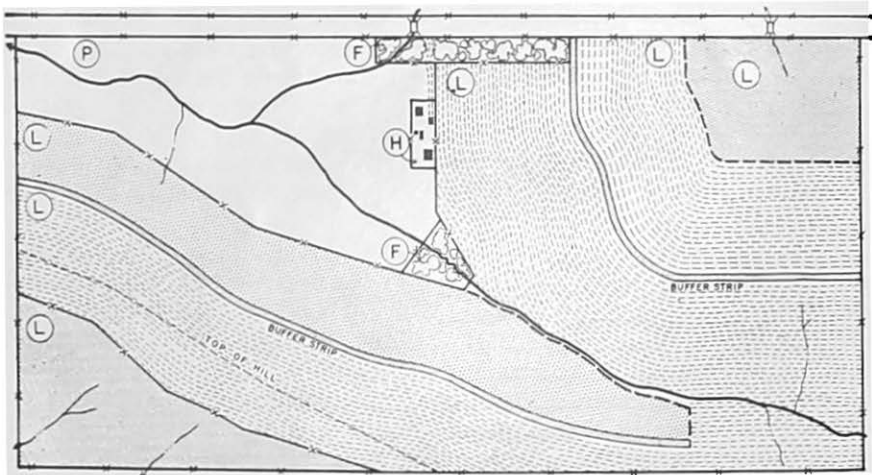
Waterways that are controlled by the use of mechanical structures are usually narrower than vegetated channels and hence occupy less land. The narrower waterways, however, usually have no other economic use than for water disposal, while the broader, vegetated outlets may serve as valuable pastures, meadows, or woodlands. Narrow, deep waterways controlled by mechanical structures or otherwise are often of considerable inconvenience if so located that it is necessary to transport farm machinery across them.

The problem of constructing and maintaining waterways may require the experience of a skilled engineer in many cases. Waterways that will entail considerable expense should not be planned without the advice of a competent agricultural engineer, since the farm operator may lack the necessary training and experience properly to install and maintain waterways that involve intricate engineering calculations.



Soil Conservation Service, U. S. D. A.

Figure 15.—An 80-acre Nebraska farm having field boundaries laid out along rectangular lines, without regard for the topography and land conditions. Such a lay-out favors erosion and is not adapted to conservation measures.



Soil Conservation Service, U. S. D. A.

Figure 16.—The same farm as shown in figure 15 after field boundaries were changed to fit the natural lay of the farm land. This lay-out is adapted to conservation farming methods.

Job V.—Replanning the Farm Lay-out

ANALYSIS

Decisions to be made	Factors to be considered	Necessary working data
1. What changes to make in location of field boundaries.	Land-use capabilities.	Facts from the conservation survey in regard to the location of the boundaries of areas that have similar capabilities for use.
	Contours-----	Facts concerning the location of the contours of the land; relation between the contours of the land and boundaries of changes in physical land conditions.
	Location of waterways.	Information concerning the location of permanent waterways; possibilities of changing waterways to coincide with proposed field boundaries.
	Land use-----	Information concerning the probable use to which each tract of land will be put; possibilities of changing land use to a type of use better adapted to the size and shape of field proposed.
	Conservation practices.	Information regarding the probable location of terraces, diversion terraces, or other conservation structures planned for each field; probable conservation farming practices to be used on each field.
	Machinery used---	Information concerning size and shape of fields best adapted to the machinery that will be used on the farm; possibilities of securing machinery adapted to use on fields laid out according to the natural land conditions.
	Present lay-out----	Facts on the present lay-out of field boundaries; relation of present boundaries to boundaries of areas of similar land-use capabilities and to the contours of the land; efficiency of present lay-out for water disposal and conservation-farming practices; efficiency of present lay-out with respect to convenience of location; desirability of shape and size of present fields for operation of farm machinery.

Job V.—Replanning the Farm Lay-out—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
1. What changes to make in location of field boundaries— Continued.	Farming system followed.	Information in regard to size and number of fields needed for cultivated crops, taking into consideration crop rotations, economic demands, and other pertinent factors; size and number of pastures needed for livestock considering number of livestock kept, grazing capacity of pastures, pasture rotations, and the like; size and number of areas needed for woodland, wildlife, and other purposes; possibilities of changing farming system in order that it may better fit the physical conditions and capabilities of the land.
	Natural obstructions.	Facts regarding natural obstructions on the farm, such as streams, gullies, hills, marshes, and woodlands, affecting field boundaries; possibilities of moving such obstructions.
	Artificial obstructions.	Facts regarding artificial obstructions such as fences, roads, irrigation ditches, drainage ditches, and property lines, that affect field boundaries; possibilities of moving such obstructions.
	Cost of making changes.	Estimate of labor and other expense involved in changing field boundaries, including cost of relocating roads, fences, and waterways; cost of moving other obstructions.
2. Where to locate roads and lanes.	Needs.....	Information regarding the location of fields or pastures to which a road or lane is necessary.
	Field boundaries..	Information regarding the location of permanent field boundaries.
	Contours.....	Information regarding the location of contours of the land.
	Use.....	Information concerning the extent and type of use to which roads and lanes will be subjected; probable effect such use will have on construction and maintenance of road.
	Erosion.....	Information from conservation survey on erodibility of soils over which roads or lanes will pass; estimated damage that road or lane erosion may do the farm or other lands and property.
	Cost of making changes.	Estimated cost of changing location of roads and lanes including cost of grading, relocating fences, stabilizing erosion, and value of land occupied.

INTERPRETIVE SCIENCE AND RELATED INFORMATION

A complete reorganization of the farm lay-out will sometimes be necessary as one of the first steps in planning a program of soil and water conservation. Diagrams and sketches made from time to time as the work progresses will be found helpful. On most farms it will be found that the farm lay-out was not developed to best fit conservation farming methods. Field boundaries laid out along rectangular lines or made to follow arbitrary property lines do not usually follow natural boundary lines of topography and land changes.

Field Boundaries

In order to plan a land-use and conservation program according to the capabilities of the land, it is important to lay out field boundaries along the boundary lines of areas of similar land-use capabilities. If field boundaries follow closely the natural boundaries of land changes, the job of determining land-use and conservation practices for each field becomes much simpler, because each tract or parcel of land can then be treated according to its adaptabilities and can be put to the highest type of economic use in which it can be permanently maintained without the risk of misusing other land.

Locating field boundaries so that areas with distinct differences in physical land conditions are not included in the same field, as well as having fields convenient and of suitable size and shape for normal operation and the economic demands of the farm, may prove to be a complicated problem in many situations. It is essential, nevertheless, that a feasible lay-out be planned if a permanent program is to be instituted. *It should be remembered that the soil is the basis of all replanning and improvement.*

Areas of considerable variation in physical land conditions should be divided according to their capabilities unless it is planned to use the entire area for a purpose to which the most erodible land is adapted. The temptation to include a small irregular-shaped area of highly erodible land in the same field with a larger area of less erodible land should be guarded against unless adequate provisions can be made for the control of erosion on the erodible area.

The location of the boundaries of cultivated fields approximately on the contour is often a desirable practice. Changes in the degree of slope and in soil type often follow closely the contours of the land. The location of the upper and lower boundaries approximately on the contour of fields that are to be contour-tilled will result in distinct convenience in farming operations by the elimination of point rows.

The construction of fences on the contour has been objectionable to many farmers because of the extra care required for maintenance. Many farmers who have constructed contour fences, however, claim that the inconvenience of maintaining fences is more than offset by other conveniences and advantages. A fence on the contour insures a permanent contour field boundary and discourages straight-row farming.

It is usually desirable to have boundaries of fields that may be used for cultivation follow permanent waterways. The location of waterways may sometimes be profitably changed to coincide with desirable field boundaries, but in most instances it will be more practical to have the field boundaries follow lines that are desirable for use as waterways.

In some cases it may be advisable to determine the use to be made of the land before locating field boundaries and in other cases it may be desirable to plan the program of conservation practices for various fields before their boundaries are

definitely located. Fields that are to be cultivated should have a size and shape that will facilitate farming operations. The types of crops to be grown and the kind of machinery to be used may influence the desirability of shape and size of cultivated fields. Pastures or other areas that are to be fenced should be so shaped that the cost of fencing will be economical.

Terraces and diversion terraces often make desirable field boundaries. Other conservation structures or practices, such as contour tillage, strip cropping, and shelterbelts, may influence the location of field boundaries. Sown strips in a system of strip cropping may often be used to advantage in taking up odd corners of fields where contour tillage is being practiced, thus preventing point rows. The division of the farm into rectangular fields, with the long axis perpendicular to the direction of prevailing winds, will make farming operations more convenient on comparatively level lands in wind-erosion sections where field stripping and rough tillage across the path of prevailing winds are to be followed.

Since changing field boundaries usually necessitates some labor and expense, such changes should be made only where a definite advantage is to be gained, and each change should be a step in the development of a permanent plan. It should constantly be kept in mind, however, that only immovable objects prevent changes and that a permanent farm plan should not be unduly influenced by temporary inconveniences and the comparatively small expense involved in making such changes. If a permanent program is the objective, only the comparative efficiency of the present lay-out and a reorganized lay-out should be given major consideration in deciding the location of field boundaries.

The labor and expense involved in relocating fences, moving roads, and removing obstructions in connection with changing field boundaries can rightfully be charged to permanent improvements and the cost distributed over a period of years.

The size and number of fields needed for different uses or types of crops to be grown may have some bearing on the location of field boundaries. In soil conservation planning, however, the system of farming is being planned to fit into a program of soil and water conservation, and it is often impossible to plan a system of conservation that will fit the existing system of farming. Where the capabilities of the land permit, it may be advisable to have fields of similar size for convenience in planning crop rotations and pasture rotations. Since, however, a system of strip rotation within a field may be substituted for the past practice of rotating crops from field to field, the problem of laying out cultivated fields of a similar size becomes of less importance.

Natural obstructions, such as streams, marshes, and hills, may often be determining factors in the location of field boundaries. Many natural obstructions can be moved. Marshes or swamps may be drained. Stream channels may be changed. Woodlands may be cleared. The expense of moving such obstructions, however, may make their removal impractical.

Most artificial obstructions that determine field boundaries, such as fences, private roads, or lanes, can be moved or changed to suit the convenience of the owner. Property lines can ordinarily be moved only by the acquisition of the adjoining property, but this may sometimes be the most practical solution of a problem. Public roads usually cannot be moved and hence may arbitrarily determine field boundaries.

Convenience in size and shape of fields for the operation of farm machinery has often been considered of paramount importance in determining the location of field boundaries. This factor can easily be overemphasized. The increased

value of the land and increased income eventually resulting from the installation of a program of conservation farming will usually more than offset any inconvenience involved in farming odd-shaped fields.

Roads and Lanes

Roads or lanes should be so located that each field is accessible from the farmstead and from other points on the farm from which travel may be necessary. It is desirable that commonly used roads or lanes follow the shortest practical axis between the points they connect. It is usually necessary to have roads or lanes follow field boundaries, especially if fields are cultivated. Roads or lanes following the contours of the land may be longer than need be, but the draft on such roads is easier and the stabilization of erosion much simpler and less expensive than on roads or lanes running up and down hill. Cattle trails and wagon ruts running up and down hill have been responsible for much serious erosion and often develop into bad gullies. Special precautions should be taken not to route roads or lanes over galled spots, alkali spots, or other areas having highly erodible soils.

The cost of moving roads or lanes, including the value of the land occupied, the cost of grading, and relocation of the fences may sometimes seem excessive. A large part of this cost, however, may be offset by the lesser cost of maintenance where the roads and lanes are properly located and by the value of the protection given from erosion damage to adjacent lands or property.

A reorganization of the farm lay-out may, in many instances, be desirable for efficiency in operating the farm, even if changes are not to be made in the conservation farming practices. A farm lay-out that is suitable at the present time may become unsuitable in a few years if erosion is permitted to accelerate and it becomes necessary to retire some fields from cultivation or change the use of fields.

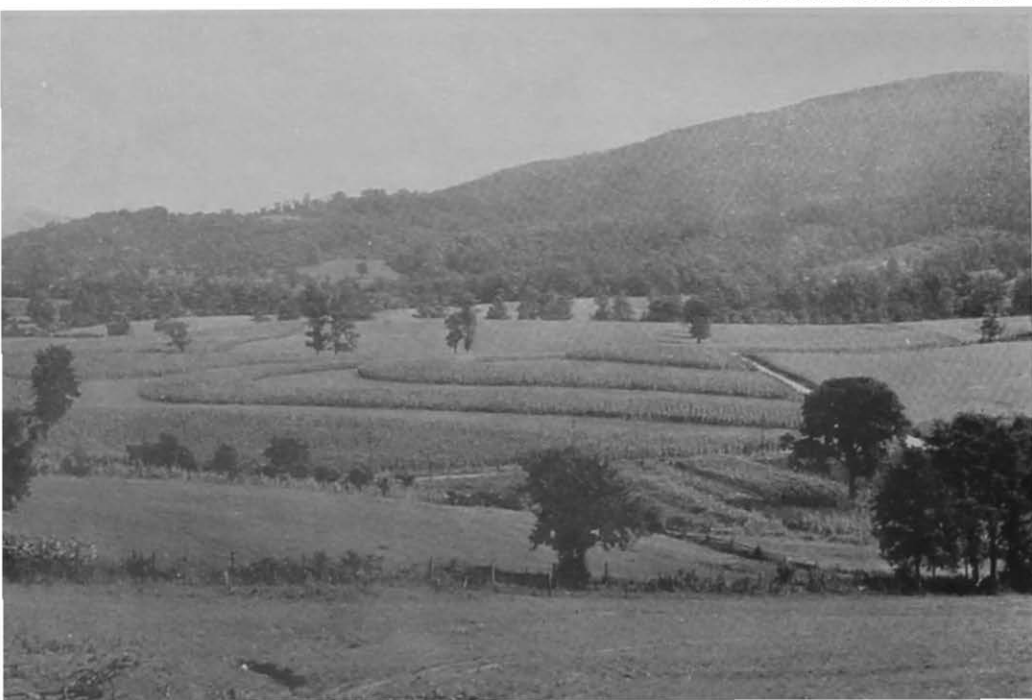


Soil Conservation Service, U. S. D. A.

Figure 17.—Improper land use. Regardless of economic necessities which prompt the cultivation of steep erodible slopes, the use of land for purposes to which it is not adapted inevitably results in accelerated erosion and eventual destruction.

Figure 18.—An illustration of proper land use. Each tract is used for a purpose to which it is adapted and is being conserved by proper practices.

Soil Conservation Service, U. S. D. A.



Job VI.—Planning a Land-Use Program for the Farm ANALYSIS

Decisions to be made	Factors to be considered	Necessary working data
1. What use to make of each tract of land on the farm.	Use capabilities of the land.	Information concerning the use capabilities of each tract of land as determined from the physical land and climatic factors; variation in capabilities over the entire tract as determined by the survey.
	Diseases and pests---	Facts regarding common plant diseases; insect pests in the soil and locality; rodent infestations on the land; infestations of noxious, persistent weeds on the land; possibilities of removing or controlling diseases and pests.
	Present use-----	Facts regarding present use of the tract; conservation structures on the tract; type, density, and condition of cover on the land.
	Size and shape of the tract.	Facts regarding the size and shape of the tract; convenience of size and shape for operation of available farm machinery; convenience of size for fitting into crop-rotation or pasture-rotation system.
	Location of tract----	Facts regarding the location of the tract and its accessibility to the farmstead and other fields by roads or lanes; relative location to other lands or property that might be damaged by run-off or erosion from the tract.
	Conservation practices necessary.	Information concerning the kind and intensity of conservation practices that will probably be required under each type of use.
	Economic returns----	Information concerning estimated yields of cultivated cash crops, feed and hay crops, pasture crops, woodland products, wildlife products, or other products that might be produced on the area from various types of use; available markets and market conditions for each type of product that might be grown; reasonable expectation of profit from each type of use considered; stability of income and quickness of returns from each type of use; estimated labor income from each type of use; estimated value of protection from erosion or run-off to the tract and to adjacent lands or property that may be expected from each type of use.

Job VI.—*Planning a Land-Use Program for the Farm*—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
1. What use to make of each tract of land on the farm—Continued.	Capital requirements.	Information in regard to additional capital outlay required for machinery, power, work stock, breeding stock, seed, planting stock, fertilizer, lime, and other equipment or supplies needed to place and maintain the tract in each type of use considered; cost of installing and maintaining conservation measures needed for each type of use.
	Labor requirements.	Information in regard to labor requirements for managing tract in each type of use considered; seasonal distribution of labor; conflict with labor requirements for remainder of farm; labor requirements to clear land, plant vegetation, install needed conservation practices, and to do other jobs that may arise in changing the use of the tract.
	Farming system.	Information concerning the farm demands for cultivated cash crops, feed and hay crops, pasture, wood products, and other crops under the present system of farming, estimated acreage of land required to supply farm demands for each type of product needed.
	Acreage and capability of other lands on the farm.	Facts regarding the size, capability, and productivity of other fields on the farm that might be used for purposes considered for this tract; possibilities of increasing the size of the farm by buying or renting additional acreage.
	Possibility of changes in the farming system.	Information on desirable changes that might be made in the farming system that would change farm demands for acreages of various crops and yet maintain an adequate farm income.
	Governmental regulations or laws.	Information regarding the regulations of the Agricultural Adjustment Administration on acreage of various crops for the farm, for maximum benefit payments; land-use regulations or laws of soil conservation districts or other governmental bodies operating in the locality.

Job VI.—Planning a Land-Use Program for the Farm—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
<p>1. What use to make of each tract of land on the farm—Continued.</p>	<p>Experience of operator.</p> <p>Attitude of owner and operator.</p>	<p>Facts concerning the experience and knowledge of the farm operator in managing woodlands, live-stock, or crops that are contemplated; possibilities of operator gaining needed training or experience to manage the tract efficiently in the type of use considered.</p> <p>Does owner consider the farm an agricultural investment or is he interested in the land only for speculation or mineral rights; does tenant-operator have a long-time lease and is he interested in future productivity of the land; are owner and operator interested in conserving the land for future use of Nation, State, community, and heirs?</p>

INTERPRETIVE SCIENCE AND RELATED INFORMATION

It is assumed that before an attempt is made to decide the use to make of each of the various tracts of land on the farm, the farm lay-out will have been reorganized and field boundaries located largely on the basis of the use capabilities of the land.

The major uses of farm land may be classed as follows:

1. For cultivated crops; i. e., all crops that require tillage of the soil during any stage of their production.
2. For permanent pastures or meadows.
3. For woodlands.
4. For wildlife and recreation.

A program of soil conservation cannot be considered effective and permanent until each tract of land on the farm is placed in a use in which it can be permanently maintained, without a decrease in productivity, by the use of proper conservation practices. If only the more level and less erodible areas are used for cultivated crops and the steeper and erodible areas are used for pasture, meadow, woodlands, or other purposes according to the capabilities of the land, conservation practices will become a much simpler proposition.

Land Conditions

Recommendations regarding the land-use capabilities, based on the physical land conditions and climatic factors involved, should be determined before an effort is made to decide the use to be made of the land. (See Analysis of job III, p. 34.) Extreme caution should be exercised to see that a type of land use is not attempted on any tract that is more intensive than the recommendations covering its use capabilities indicate it can support.

If there is any considerable variation in the physical conditions of a tract of land, its use should be largely determined by the capability of the most erodible land on the tract or it should be divided into more than one field. If there is a

doubt concerning the use in which the land can be permanently maintained, it is always advisable to use the land safely if economic necessities permit. This procedure will usually result in a greater long-time income from the area.

The presence in the soil of plant diseases, specific for certain types of plants, may be a determining factor in planning its use. Although most plant diseases on cultivated lands can be controlled by crop rotations or by discontinuance of the affected crops for a period of years, situations may arise under which the presence of disease in the soil would make it advisable to retire from cultivation an area that was otherwise adapted for clean-tilled crops. Numerous other situations may arise under which plant diseases will govern to some extent the use of the land.

In a like manner the presence of noxious persistent weeds on the land or the presence of insect pests in the soil may influence the determination of the purpose for which it is to be used. If practical means of removing or controlling plant diseases and insect or weed pests are available, these factors need not influence the land-use program, except as the control measures do so.

Rodent infestations on an area may temporarily influence the land-use plan. Usually it will be expedient to exterminate any serious pests of this kind, regardless of the use to which the land is put, but the extermination process may extend over a period of months or years in some cases and in most instances will affect the practical possibilities for use during this period.

Land Use

The present use of a tract of land affects its possible future use largely because of the cost that may be involved in making the change to another use. The planner must be careful not to permit the fact that a tract of land has been used for a certain purpose for the entire period of time that he has known it, influence him to decide that it can be properly used for that purpose only. The capability of any tract of land for any given use will change as its productivity or topography is changed by erosion or other causes.

The conservation structures that are already on a tract of land can usually be moved or destroyed but sometimes at considerable expense. The presence of conservation structures may be a deciding factor in determining its use where the land capabilities are in conformity with structures on the land. The type, density, and condition of cover on pastures, meadows, woodlands, and other vegetated areas may influence the owner in deciding whether the land should be left to its present use. The cost of revegetating areas with a poor cover may be almost as great as the cost of changing the area to another type of use.

Cultivated fields should be of a proper size and shape to facilitate the operation of machinery used on the farm. It does not follow, however, that cultivated fields should be rectangular in shape, because other shapes are often more convenient, especially where contour tillage is practiced. It is often desirable to have cultivated fields approximately the size of other fields in order that they may fit into a balanced crop rotation, although this is not important if strip rotation is to be practiced within the field as a conservation measure. Likewise, it may be desirable to have pastures of similar size or grazing capacity when a system of pasture rotation is used. Areas of distinctly different capabilities from the surrounding land, too small or irregular in shape to be practical for a cultivated field, may be profitably utilized for woodlands, wildlife purposes, or pasture.

Cultivated fields and pastures should be so located that they are accessible by roads or lanes either from the farmstead or an adjacent field. A small field located at considerable distance from the farmstead or from other fields of similar use is ordinarily not desirable as a cultivated field or pasture because of its inaccessibility.

Tracts of land having considerable slope or erodible areas from which considerable run-off may be expected and so located that they will damage lower lying lands, should be used for a purpose that will tend to check the amount of run-off or erosion. Undisturbed or well-managed woodlands suffer little or no erosion and permit a minimum of run-off. Properly managed meadows and pastures normally permit much less run-off and erosion than do cultivated lands even when protected by the best conservation measures.

Economic Returns

The present or potential productivity of a field should be high enough to justify the cost of conservation practices needed and normal production costs involved in the type of use to which it is placed.

The profitable disposition of the products which may be produced on a tract of land should be considered in deciding the use of the area. Available markets, market conditions, and prices should be considered. Profitable home uses for the products may preclude the necessity of catering to market demands. It is often possible to create a market for certain products in sections where a market does not now exist.

Numerous farms throughout the Nation lack adequate pasture and meadowland to supply the farm with the amount of forage needed for the livestock kept. Other farms are under-stocked because of the lack of pasture and forage crops. Often farms can be so reorganized that a larger area is devoted to pasture and meadow and the number of livestock increased accordingly without impairment of the farm income. Generally speaking a desirable market in a community can be found for livestock or livestock products of some type.

Many farms do not produce sufficient wood and timber to supply the farm demands for firewood, fence posts, fuel wood, and similar needs. Markets for fence posts, fuel wood, railroad cross ties, pulpwood, poles, piling, saw logs, naval stores, maple syrup, Christmas trees, and other special wood products can usually be found by a farmer or group of farmers with the initiative to produce the products and seek a market.

Considerable satisfaction may be derived from devoting a part of a farm that cannot be profitably utilized for other purposes to the production of wildlife. A certain amount of income may also be derived from the wildlife crop. Other advantages of a wildlife crop, such as the eradication of insects and providing recreational areas, should also be considered.

Immediate profits from a tract should not be the only consideration in determining its use. A land-use program that can be permanently maintained will usually bring in larger profits, over a period of years, than a program of exploitative farming. The stability of income from various uses and the quickness of returns which may be expected also deserve attention. Livestock farming produces a comparatively stable income. Likewise, the income from woodlands will be stable if rightly handled but quick returns cannot be expected from a newly planted woodland nor from certain livestock enterprises.

The expense of buying additional machinery, seed, fertilizer, or livestock, or the necessity for additional operating capital brought about by making changes in the use of a tract of land should be counted as a part of the cost of changing. Likewise, the cost of clearing the land, planting trees or vegetation, and the cost of installing and maintaining conservation practices that will be needed for the type of use contemplated, should be considered in deciding the changes to be made in the use of the land.

Labor

The farmer with a small labor income may well give some consideration to the labor income that will be derived from any specific use. Woodlands and some livestock enterprises may furnish a profitable labor income during slack seasons of the year. On farms where the labor requirements are more or less seasonal, the allocation of certain areas to the production of woodlands or livestock will often assist in balancing the labor requirements throughout the year. Where a considerable amount of hired labor is used on a farm the changing of the use of certain tracts from crops that require a large labor output to a use that has fewer labor requirements will often result in a direct saving in farm income.

The amount and seasonal distribution of labor required to change an area from its present use must also be given consideration. The labor requirements for planting woodlands, planting shrubs, or sodding grass on an area are often high. Assistance in the form of labor for such tasks may possibly be obtained through a Civilian Conservation Corps camp, soil conservation district, or other agency operating in the community.

A farm plan will not be workable if it fails to provide a way for the farm as a whole to produce an adequate income and a satisfactory standard of living for the family farming it. Sometimes the farm unit is too small or the land is too poor to produce an adequate living for a family. In such cases the soundest approach to the problem is to seek additional land to be added to the farm either by renting or through purchase.

Plans made by the individual farmer to comply with the recommendations of the Agricultural Adjustment Administration with respect to crop acreage, may influence his decision regarding the use of certain fields. It will usually be found, however, that such requirements will be met if the land-use program is planned according to the capability of the land. Also it may be found in some instances that land-use regulations or zoning laws passed by soil-conservation districts or other governmental bodies may designate the use to which certain tracts of land may be put. Such laws or regulations, however, will usually be in conformity with sound land-use practices.

The effectiveness of the plan for the practical use of the various tracts of land on the individual farm will depend to a large degree upon the experience, training, and ability of the farm operator. A farm operator who has had no experience in handling livestock would probably make a failure of managing a farm on which livestock feeds and forage were the principal crops produced. Likewise, the man inexperienced in timber growing may be very inefficient in managing woodlands unless he has a background of training, experience, and intelligence enabling him to acquire the knowledge and skill necessary for managing such areas. The temperament and individuality of the farm operator will also affect his success with any program of land use.

The attitudes of the landowner and farm operator will influence his final decision in regard to the use to make of various tracts of land on the farm. It is futile to plan a sound land-use program for a farm when neither the owner nor the operator is interested in changing the uses of the land in order to conserve and maintain its permanent productivity. If the farm is not owner-operated, it is important to take into consideration the length of lease the tenant holds and his probable interest in a program of land use that would provide the greatest long-time income but a more meager immediate income.

Specialists in charge of demonstration projects of the Soil Conservation Service, soil conservation districts, and agricultural experiment stations will usually have definite recommendations to make regarding land-use practices. These recommendations may vary greatly for different localities and there may be a difference of opinion among authorities with respect to the land-use practices which should be followed even in the same locality. Usually it is possible to observe the success of various types of uses and conservation measures on a nearby demonstration area of the Soil Conservation Service or on neighboring farms. It must be kept in mind that each tract or parcel of land presents specific problems of its own and the final decision regarding its use should be made on the basis of actual existing conditions.

Improper land use has been largely responsible for the destruction of 50 million acres of formerly productive cultivated land. It must be remembered, also, that erosion cannot be controlled on many fields, even where the most intensive type of conservation measures practical to American agriculture are in operation, as long as the field is retained in cultivation.



Soil Conservation Service, U. S. D. A.

Figure 19.—Terraces alone will not control erosion on most of the erodible farm lands used for clean-tilled crops. To be permanent and effective a terrace system must be supported by other conservation practices according to the needs of the land.

Figure 20.—A terrace system supported by strip cropping, contour tillage, and a strip rotation of crops within each field. Cover crops or catch crops are also used on the clean tilled land and maximum use is made of crop residues in maintaining the organic matter of the soil.

Soil Conservation Service, U. S. D. A.





Soil Conservation Service, U. S. D. A.

Figure 21.—Level terraces and contour listing on this Kansas farm conserve moisture as well as soil.

Figure 22.—Field stripping across the path of prevailing winds, with wheat and grain sorghums, is a useful erosion-control practice on much of the level land in wind-erosion areas. Grain sorghum is headed and the stalks left on the field during the critical erosion season. Maximum use is made of crop residues to maintain the organic content of the soil.

Soil Conservation Service, U. S. D. A.



Job VII.—Planning Conservation Practices for Cultivated Lands
ANALYSIS

Decisions to be made	Factors to be considered	Necessary working data
<p>1. What conservation practices to use on each field.</p>	<p>Physical land conditions and capabilities.</p>	<p>Information in regard to soil type, slope, character and degree of erosion, and other physical land conditions that might affect the conservation practices planned for the tract; capability of the land for cultivation and intensity of erosion-control measures needed.</p>
	<p>Climate-----</p>	<p>Information in regard to total annual precipitation, seasonal distribution of precipitation; character of precipitation; expected intensity of rainfall; maximum wind velocities; seasonal distribution of high-velocity winds; direction of prevailing winds that cause erosion; expected periods of freezing and thawing of the ground.</p>
	<p>Foreign drainage----</p>	<p>Information in regard to the kind and amount of foreign drainage that may flow onto the field from adjacent lands or streams.</p>
	<p>Water disposal-----</p>	<p>Information regarding the location of permanent waterways adjacent to the field; suitability of adjacent waterways for carrying run-off from the field.</p>
	<p>Conservation structures already on the field.</p>	<p>Facts concerning conservation structures now on the field; suitability of existing conservation structures; labor and expense required to move or change existing structures.</p>
	<p>Approved practices.</p>	<p>Information concerning the soil and water conservation practices used on soil conservation demonstration areas and on farms of the locality; apparent effectiveness of different practices under various conditions; recommendations of Soil Conservation Service, soil conservation districts, agricultural experiment stations, State agricultural colleges, and other agencies in regard to practices adapted to the locality; benefit payments of the Agricultural Adjustment Administration for various practices; opportunity to observe standard practices and gain knowledge about installing and maintaining them.</p>

Job VII.—*Planning Conservation Practices for Cultivated Lands*—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
1. What conservation practices to use on each field—Contd.	Cropping system----	Information concerning farm demands for various crops from the field considered; regulations of the Agricultural Adjustment Administration on agricultural conservation program payments for designated acreages of various crops; percentage of clean-tilled and erosion-resistant crops expected from the field; possibilities of shifting crops to other fields on the farm; possibilities of changing farming system in order to change cropping system of the field.
	Crop adaptations----	Information concerning crops adapted to the soil and climate of the field; desirable crop rotations adapted to the field; erosion-resistant crops adapted to the field; effectiveness of adapted crops in controlling run-off and erosion; economic usefulness of adapted erosion-resistant crops; seasonal cover provided by adapted erosion-resistant crops.
	Toxic and diseased conditions of the soil.	Information concerning the presence in the soil of substances toxic to any species of plants; plant diseases in the soil; acidity of the soil; possibilities of correcting or controlling various toxic or diseased conditions.
	Pests-----	Information concerning kinds of insect pests prevalent in the locality; habits of insect pests; weeds; rodents; and other pests that might affect desirable conservation practices; possibilities of controlling various pests.
	Available equipment and supplies.	Information concerning machinery and equipment available on the farm for the construction of terraces and other conservation structures; equipment available for planting, cultivating, and harvesting various erosion-resistant crops considered; adaptability of farm machinery for various conservation-farming practices considered; possibilities of securing needed equipment; availability of seed for erosion-resistant crops planned.

Job VII.—Planning Conservation Practices for Cultivated Lands—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
1. What conservation practices to use on each field—Contd.	<p>Capital requirements.</p> <p>Labor requirements..</p> <p>Economic returns....</p> <p>Convenience.....</p> <p>Experience and training.</p> <p>Attitude of owner and operator.</p>	<p>Information regarding additional capital required for various practices, including machinery and equipment hire; purchase of additional equipment; cost of additional seed, fertilizer, or lime; cost of hired labor; cost of additional breeding stock or work stock needed; other costs incidental to installing and maintaining various practices.</p> <p>Information in regard to farm labor required to construct various conservation structures; labor required to maintain and repair damages to conservation structures; additional labor required for producing erosion-resistant crops; additional labor required to carry out conservation-farming practices; seasonal distribution of labor requirements.</p> <p>Information in regard to comparative expectation of profits from various crops considered in the conservation-farming system and crops now grown on the field; increased value of the land resulting from various conservation practices; protection to other lands or property afforded by various practices; expected increase in crop yields resulting from moisture conservation or conserved fertility.</p> <p>Information concerning conveniences or inconveniences in farming the field which may result from various conservation practices employed.</p> <p>Information concerning the experience and training of the farm operator in using conservation-farming practices; experience in constructing conservation structures; experience and training in growing various erosion-resistant crops; ability of the farm operator to acquire knowledge and skill necessary for the installation and maintenance of various practices.</p> <p>Information concerning the attitude of farm owner and operator toward conserving the land for future use of the Nation, State, community, and their heirs; attitude toward sacrificing immediate gains for greater future gains.</p>

INTERPRETIVE SCIENCE AND RELATED INFORMATION

It is assumed that before any attempt is made to plan the soil and water conservation program for the farm, the field boundaries will have been so located that the physical land conditions of each field will be rather uniform over its entire area.

Before the conservation practices for any cultivated field are planned, a determination of the use, capabilities and erodibility of the land should be made, based upon the physical land conditions found in making the conservation survey, and a land-use program for the farm should be planned. (See Analyses of jobs III and VI.) It is assumed that the field to be cultivated has a use capability of class I, II, III, or in some instances of class IV. (See Analysis of job III.) No attempt should be made to plan conservation practices for land to remain in cultivation if its physical characteristics indicate that its only safe use is permanent vegetative cover class V).

Consideration must be given to existing land and climatic conditions over and above the consideration given in determining its use classification. Although it may have been determined that a field is capable of class III use, from the standpoint of physical features and also for the production of clean-tilled crops by the use of intensive erosion-control measures, the owner must decide which specific conservation practices to use on the field.

The problem of planning the conservation practices to follow may be quite complicated. For checking soil erosion and controlling the water that comes onto a field, numerous successful devices and practices have been developed that have a wide variety of adaptabilities. Terraces, diversion terraces, contour tillage, rough tillage, contour strip crops, field strips, windbreaks, and gully checks are some of the mechanical devices commonly used on cultivated fields. Temporary and semipermanent cover crops, crop rotation, maintenance of organic matter, and other farming practices play an equally important part in the conservation program on most lands. In many sections localized conservation practices not enumerated above have been developed to meet existing problems.

A steep or erodible hillside of class III may be controlled by a permanent or semipermanent cover of vegetation without any mechanical structures, but if the farming system demands that the field be partially used for clean-tilled crops, then an extensive system of mechanical devices may become necessary to control run-off and erosion.

Convenience of cultivation, farm demands for various crops, the expense and labor involved in instituting practices, and many other factors will tend to govern the decision as to what conservation practices to use on a field, but the farm planner must bear in mind the fact that the land and climatic conditions should be the deciding factors if the program is to be effective and permanent.

When doubt arises as to the conservation measures needed to assure permanent erosion control, a safe rule to follow is to use all adapted practices available that will fit into a practical farm program. Even if more intensive measures are used than are necessary for stabilization of erosion they will usually prove profitable because they will increase the productivity of the land.

Land Conditions

Extremely steep slopes should ordinarily not be terraced because of the necessity of spacing the terraces close together and the difficulty of farming the lower slopes of the terraces. In addition, also, the disposal of water from terrace outlets may be difficult and expensive on steep slopes, especially if they are of considerable length. A long slope should be broken by a system of terraces or contour

strip cropping when practical. Terrace construction and contour farming are often not practical on slopes that are extremely variable or irregular. Hummocky land is usually not suited to terracing or contour farming. In northern climates the direction of the slope may influence the freezing and thawing of the ground and, in turn, the suitability of certain erosion-control measures. Unusual topographic conditions may require adapted localized conservation practices.

The existing sheet erosion on a farm is important not only because of its effect on the productivity and capabilities of the land but also as an excellent indicator of the erosion potentialities of the soil. A good depth of topsoil on the land will normally make it possible to construct terraces without disturbing the subsoil.

Gullies on a cultivated field usually require the construction of terraces or gully checks of some type for their control. Contour-farming and strip-cropping operations on gullied fields tend to concentrate water in the gully channels and are usually not successful unless the field is terraced or other measures are taken to control the gullies. If it is impractical to control gullies with terracing or gully checks a permanent vegetative cover should be established in them.

Accumulations of silt or sand on a field will, in many cases, change the productivity and tilth of the soil and thus change its adaptability for the use of various conservation practices. Erosion debris blowing or washing from adjacent fields may fill up terrace channels or silt over and kill out desirable types of vegetation. Wind-blown hummocks on a field often make it impractical to use available farm machinery. Shifting sand dunes may require expensive control measures, but it is usually necessary that they be controlled for the protection of adjacent lands.

Galled spots occurring in cultivated fields present a serious problem in the installation of conservation practices. Terraces constructed across galled spots often fail because the texture and character of the soil will not withstand the impoundment of water above them. Erosion-resistant vegetation usually cannot be established on such spots. Usually it will be practical to exclude serious localized erosion areas from the remainder of the field in order effectively to control erosion on them. It is advisable to determine the cause of any unusual erosion conditions existing on the field before a program of control is formulated.

Water and Wind

In planning a soil and water conservation program it is important to determine whether the program of water control should be directed primarily toward water conservation or toward conducting surplus run-off from the farm in an orderly manner.

It is important that the erosion-control program be planned to take care of the maximum intensity of precipitation that may reasonably be expected. Erosion-control vegetation is useless and ineffective if it does not cover the ground during the critical erosion periods. Terraces and other conservation structures may do more harm than good if they will not control run-off during heavy erosion-producing rains, because their failure may start field gullies.

High wind velocities are responsible for most wind erosion, but wind erosion normally occurs only when the ground lacks proper vegetative cover. The seasonal distribution of high velocity winds is a more important factor to consider in planning a wind-erosion-control program than the maximum velocity that the wind may reach during noncritical seasons.

The contours of the land may run approximately in the same direction as prevailing winds; hence terraces, contour tillage, and contour strip-cropping operations are sometimes ineffective on comparatively level lands in wind-erosion areas and may not be as satisfactory as rough tillage, straight-row listing, or field stripping across the path of prevailing winds.

Heavy accumulations of snow during winter and spring months may necessitate a more intensive use of mechanical control measures, such as terracing or contour listing, because at the time the snow normally melts it may be impossible to have a desirable vegetative cover on erodible areas.

Approved Practices

Any system of terracing, strip cropping, or other conservation practices for a given field must be planned to withstand foreign drainage that runs onto the field from adjacent lands unless such drainage is diverted away from the field by means of a diversion terrace or other structures. It is impractical to plan terraces for a field unless permanent stabilized waterways can be located near the field to handle the excess run-off from the terrace channels. An appropriate water-disposal system is usually of less importance if water is not concentrated in the terrace channels or behind other structures.

Where terraces or other conservation structures already exist on a field, they should be carefully checked to determine their appropriateness for the existing field conditions. Many terraces, soil-saving dams, and other conservation structures have been constructed on fields on which they are inadequate, inappropriate, or of improper structure. If existing terraces or conservation structures can be used with slight change a considerable saving in construction costs will result from their use.

In determining practices or combinations of practices to use, the best guide to follow will be the results actually observed on local demonstration areas of the Soil Conservation Service or the practices successfully used by local farmers on similar land. Experiment station recommendations and recommendations of the State agricultural college and other agencies are also very helpful, if specific enough for use in making final determinations regarding the practices to use on a given tract of land. Some consideration should be given to benefit payments that may accrue from the agricultural conservation program of the Agricultural Adjustment Administration in deciding practices to use on a field.

Only a careful field inspection will normally give the information desired in regard to successful soil conservation practices followed in a community. Careful attention should be paid to the combinations in which practices are used successfully, since the effectiveness of many practices depends to a large extent on their joint use with others. Experience in many sections has shown that terraces alone will not adequately control erosion on most lands; but when used in combination with contour tillage, strip cropping, and cover crops, they prove invaluable and safeguard the other practices.

Temporary cover crops may serve a very useful purpose on a field, but their value as green manures may exceed their value as land cover, especially if grown on a soil that is deficient in organic matter or when the cover is grown during a season when erosion is not severe. Contour strip cropping is usually a valuable practice on sloping lands, but when used in a system of strip rotation it becomes even more valuable, and when the sown strips are plowed under as green manure, the value of the practice is still further increased.

Crop rotation is nearly always a valuable practice in maintaining soil productivity, but it reaches its maximum value in erosion control when a system of contour strip rotation is used that includes a good percentage of erosion-resistant cover crops. Contour farming by itself may be valuable in conserving moisture and controlling erosion during certain seasons but unless it is supported by contour erosion-resistant strips or terraces it usually will not adequately control erosion on land that has any considerable slope. Contour tillage, when used

alone, may, by concentrating water in low places, accentuate gullying on fields that are irregular in slope or dissected by slight draws. In most instances it will be found that no one practice will adequately control erosion and permit continued cultivation of sloping or eroding land. It will practically always be necessary to use a combination of the best adapted practices on erodible fields.

Regardless of the extent to which terraces, diversion terraces, contour tillage, rough tillage, and other mechanical practices are used on erodible lands, erosion can be controlled economically and effectively only by the maximum use of erosion-resistant vegetation. Hence, the cropping system used on a field is of paramount importance in an erosion-control program. It is futile to attempt to plan a conservation program for erodible land in such a way that the use of the entire field is continued for the production of clean cultivated crops.

Crop Adaptations

If the cropping system on a field does not provide for the growing of erosion-resistant crops necessary, then the first step to follow in planning the program is to make a change in the cropping system. Usually the needed changes in the cropping system can be made by growing larger acreages of sown feed crops, small grains, and hay crops, or by growing catch crops for green manure, without greatly decreasing the immediate income to be derived from the field. Sometimes it may be necessary to change the entire farming system in order to change the cropping system so that an adequate erosion-control program can be installed on all fields. Provision must be made in the cropping system not only for erosion-resistant cover crops and strip crops but also for the maintenance of the organic-matter content of the soil. Many farmers in older agricultural areas use a long-time rotation system, whereby each tract of erodible land is maintained in a long-lived perennial meadow or pasture crop for a considerable period before being placed in a rotation of annual crops. In some situations the cropping system may be influenced by regulations of the Agricultural Adjustment Administration, but usually a sound soil-conserving system of cropping will meet the demands for maximum benefit payments under the agricultural conservation program.

A farm operator who is planning the conservation practices for a field should be familiar with the species of erosion-resistant or semi-erosion-resistant plants that will grow on the land. The planner should also know from experience and observation the comparative erosion-resistant qualities of the various crops and the economic uses that can be made of efficient erosion-resistant plants that are adapted to the soil and climate. Most of the legume crops make desirable hay or pasture for livestock and are also valuable as soil-improving crops when plowed under as green manure. Other erosion-resistant plants are usually adapted to use as livestock feed or temporary pasture and for green-manuring purposes although ordinarily not as desirable as legumes for the latter purpose. By proper planning, most erosion-resistant crops can be economically used for feed, pasture, green manure, or other purposes, even though they be planted in narrow strips in connection with a system of contour strip cropping or field stripping.

Acidity of the soil, plant diseases in the soil, or toxic conditions that may exist in the soil must sometimes be given consideration in planning the conservation program. Acidity can be easily corrected by the application of lime, provided the value of the crop justifies the expenditure involved. Many crop diseases can be controlled by a proper system of rotation. Toxic conditions also may often be removed. If such conditions cannot be removed or controlled then they must necessarily influence the cropping system and hence the conservation practices to be used.

Insect pests may be an important factor in determining the practicability of certain conservation measures, especially when vegetative control measures are extensively used. For example, it is usually inadvisable to practice strip cropping with small grains and corn or grain sorghums in chinch-bug areas. The prevalence of other insect infestations may preclude the possibility of using certain crops on which the insects feed. Infestations of noxious weeds may have a direct bearing upon the practicability of vegetative erosion-control measures. The presence of burrowing rodents may be a threat to terraces and other conservation structures. It is important that infestations of insect, weed, and rodent pests be anticipated in planning the conservation program and that effective control methods be developed where necessary before the program is instituted.

Equipment and Cost

Power and equipment available on the farm for the construction of terraces, diversion terraces, or other conservation structures may be a deciding factor in determining whether such structures should be installed. Frequently, the scarcity of seed for certain erosion-resistant crops, or the unusually high cost of seed due to lack of supply, may prevent the use of crops that might otherwise be desirable. The lack of machinery on the farm to plant, cultivate, and harvest certain crops properly may be a limiting factor in their use in the erosion-control program. The need for buying additional equipment to enable the farm operator to grow the desired crops and practice desirable systems of tillage and the expense of obtaining such equipment must be considered in determining the use of some practices.

The construction of terraces and the building of other conservation structures is sometimes expensive unless the work can be done with farm power and home labor. Usually an adequate system of terraces can be constructed with farm power and machinery, but the terrace construction may have to be spread over a period of years. It may be advisable to postpone the installation of practices that are expensive to install on certain fields, thus distributing the cost of installation over a period of years. On some fields strip cropping may be a practical substitute for terracing and usually requires less expense for the initial installation. Likewise, the maximum use of erosion-resistant cover crops which can be grown at little or no additional expense may obviate the necessity for installing terraces or other conservation structures if the cropping system can be so planned as to provide for such cover crops.

Terraces, once constructed, serve as permanent contour guide lines for contour tillage and strip cropping, if properly maintained, and preclude the necessity for new survey work. A system of contour strip cropping or contour farming without terraces may require survey work each year unless proper provisions are made for keeping the contours of the land marked. Maintenance costs that may enter into the decision of planning the practices to use include: Cost of maintaining terraces; cost of buying seeds for erosion-resistant crops that cannot be produced on the farm; cost of additional lime or fertilizer needed for growing erosion-resistant crops; cost of repairing damages to conservation structures caused by floods, rodent burrowing, or other causes; and the cost of maintaining an adequate water-disposal system.

Economic Return

The expense involved in installing conservation measures may often be recovered from immediate increases in crop yields resulting from moisture conservation in arid climates or from a more uniform stand of crops in humid

climates. Properly installed conservation practices will usually pay for themselves over a period of years because of the fact that they increase the productivity of the soil or prevent a decrease in soil productivity.

It is usually impracticable to construct terraces and provide an adequate water-disposal system on land of marginal value. If the value of the land does not justify the cost involved in instituting the conservation practices necessary to protect it from erosion and maintain its productivity under cultivation, it should be retired to permanent vegetation, woodland, or other uses that do not require an expenditure of funds in excess of its value. The installation of proper conservation practices on certain fields may be considered a form of investment, because such practices usually increase the future value of the field and pay good dividends on the original investment.

It may sometimes be advisable to construct terraces or diversion terraces, or to institute other conservation measures on a field for the primary purpose of protecting lower-lying lands or property. The expense involved in the installation and maintenance of conservation practices on a field may be partly chargeable to the protection afforded other lands and property or in some instances to their value in flood control on adjacent streams.

Strip crops, erosion-resistant field borders, and many other vegetative erosion-control practices may prove of value as wildlife food or cover and serve as travel lanes for wildlife between desirable habitats and food patches.

The inconvenience involved in practicing contour tillage, strip cropping, or other conservation practices that are not adapted to the use of large machinery will tend to influence many farm operators against their use. No farm operator should decide against the adoption of a certain practice merely because of the inconvenience it may cause him in his farming operations. These inconveniences are usually temporary. Frequently, also, a farm operator is inclined to look upon a practice which is merely a departure from his usual custom as an inconvenience. In many situations it may be desirable or necessary to replace old machinery with machinery that is adapted to a system of conservation farming.

Thousands of acres of cultivated land in the Southeastern States have been destroyed by erosion even though terraced and contour-farmed for generations. In China and other foreign countries, bench terraces are used on much of the cultivated land as a matter of necessity. Erosion-control practices may become flood-control practices when applied with sufficient intensity over an entire watershed. Erosion control and land reclamation are often closely related but should not be confused because marginal land usually cannot be rebuilt as long as it remains in cultivation.



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Figure 23.—Overgrazing and absence of erosion-control measures are causing serious sheet erosion and gulying on this pasture. Excess run-off from the upper pasture is creating a gullied condition in the field below the fence, although the lower pasture has not been abused.

Figure 24.—An improved pasture on a 10-percent slope. Maintenance of an adequate cover of clovers and Bermuda grass protects this southern pasture from erosion and gives greatly increased grazing capacity.

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Job VIII.—Planning Conservation Practices for Pasture Lands

[This unit deals only with tracts of permanent pasture land on a general farm. The analysis, interpretive science, and related information here presented do not properly cover problems that may arise in planning a program for western range lands.]

ANALYSIS

Decisions to be made	Factors to be considered	Necessary working data
1. What conservation practices to use on each tract.	Physical land conditions and capabilities.	Information regarding the soil type, slope, character, and degree of erosion, and other physical land conditions that might affect conservation practices planned for the tract.
	Vegetative cover----	Facts on the density of vegetative cover on the area; types of vegetation growing on the area; comparative frequency of different vegetative types; erosion-resistant qualities of the different types; economic value of the different types of vegetation for grazing purposes; vigor and health exhibited by various kinds of vegetation at various times during the year; estimated grazing capacity of the area with existing vegetation; brushy, tree, or weed growth on the area.
	Toxic conditions----	Information concerning the presence of toxic substances in the soil; acidity of the soil; presence of undesirable or poisonous plants.
	Pests-----	Information concerning rodent infestations on the tract; heavy insect infestations that may be expected.
	History of the tract..	Information concerning the past use of the pasture; grazing load that has been carried; conservation practices used; past cropping system, if the tract has been in cultivation.
	Climate-----	Information concerning the total annual precipitation; seasonal distribution of precipitation; character of precipitation; expected maximum intensity of rainfall; expected maximum wind velocities; seasonal distribution of high-velocity winds; direction of prevailing winds; expected periods of freezing and thawing of the ground.

Job VIII.—Planning Conservation Practices for Pasture Lands—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
<p>1. What conservation practices to use on each tract—Contd.</p>	Approved practices--	<p>Information concerning the kind of erosion-control practices used on pasture lands on soil conservation demonstration areas and on farms of the locality; apparent effectiveness of various practices in controlling erosion; effectiveness of various practices in preventing run-off; effectiveness of practices in increasing production; practices recommended by the Soil Conservation Service, agricultural experiment stations, and other agencies for use on pasture lands of the locality; benefit payments of the Agricultural Adjustment Administration for various practices; opportunity to observe various practices and gain knowledge about installing and maintaining them.</p>
	Use-----	<p>Information regarding farm demands on the pasture considered; kind and number of head of livestock to be pastured on the area; seasonal demands for pasture.</p> <p>Possibilities of changing demands on the tract by using other available pastures; by increasing or decreasing the acreage of temporary pasture crops; by substituting hay or feed crops for pasture; by substituting pasture for hay or feed; by increasing or decreasing acreage of permanent pasture; or by increasing or decreasing the number of livestock on the farm.</p>
	Vegetative adaptations.	<p>Information regarding the species of pasture plants adapted to the soil and climate; estimated grazing capacity of various adapted plants; erosion-resistant qualities of adapted plants; ability of adapted plants to withstand silting; methods by which desirable plants may be established on the area.</p>
	Cost of practices----	<p>Information on estimated cost of installing and maintaining various practices considered; cost of constructing contour furrows, contour ridges, terraces, diversion terraces, gully checks, or other structures; cost of seeding, sodding, fertilizing, and liming for increased growth of desirable pasture plants; cost of eradicating or controlling weeds and clearing brush or trees from tract; cost of fencing erodible areas and gullies; other costs connected with practices considered.</p>

any pasture that has a slope steep enough to permit run-off, and in some cases it may even be necessary to institute other conservation practices on pastures, even though the land is only slightly erodible.

In planning an erosion-control program for pastures the three important factors determining largely the kind and intensity of conservation practices to use are: (1) The physical land conditions; (2) the climate; and (3) the vegetative cover existing on the land. However, as indicated in the analysis, other factors must also be given consideration.

Land Conditions

In deciding upon the conservation practices to be used on a given pasture, the farm operator may find it necessary to consider the effect of soil type on the type and intensity of the proposed conservation practices. The assumption that unproductive land not suited to cultivation would make a desirable pasture has been all too common. Pasture plants, like field crops, require a fertile soil for maximum growth. If soils of low fertility are to be used for pasture crops, they should be given a light grazing load or steps should be taken to improve their fertility in order to maintain adequate vegetative cover and control erosion.

Highly erodible soils will not stand excessive trampling and grazing from livestock. Sandy soils and other soils of loose structure or coarse texture are especially susceptible to erosion damage caused by trampling. Impermeable soils are usually not adapted to the extensive use of contour furrows, ridges, terraces, or other water-conserving structures.

Steep slopes on pasture lands usually do not suffer severe erosion losses if an adequate vegetative cover is present. On pasture areas of poor vegetative cover long, steep slopes may often need contour furrows, ridges, or terraces to break the length of the slope. Slopes of extreme irregularity may make the use of contour furrows, ridges, or terraces impractical.

Accumulations of silt or sand on a pasture area may destroy the vegetative cover. Gullies frequently occur in pastures that have been overgrazed or improperly protected against water concentration in erodible areas.

Galled spots, alkali spots, and localized erosion conditions caused by stock trampling around watering, feeding, or salting places often present serious erosion hazards. Eroding trails or lanes may become large gullies in a short time if not protected. Unstabilized hummocks or dunes of sand or silt may present a serious erosion problem on many pastures in wind-erosion areas. Where unusual or localized erosion conditions exist, it is important that the cause be determined in order that a preventive program may be planned.

Alkali spots or other toxic substances in the soil that prohibit a proper vegetative cover may present serious erosion hazards and are usually difficult to control unless the toxic substance can be removed. Complete protection from grazing may sometimes be essential for such areas.

Rodents infesting pasture lands may cause acceleration of erosion by their burrowing and by their destruction of vegetative cover. In such cases the control or extermination of such pests may rightfully be considered an erosion-control practice. In cases where an unusually heavy infestation of grasshoppers or other insects eat or destroy a large part of the vegetation on an area the livestock-grazing load should be adjusted to prevent damage to the pasture from a decreased stand of vegetation and accelerated erosion.

It is desirable that the person making a conservation plan for pasture land know the history of the land. Pasture land may be severely eroded due to former cultivation but still not present a serious erosion problem provided it is maintained in pasture. Many pastures are suffering severe erosion because of excessive grazing and trampling that might be easily controlled if the grazing load were regulated.

Climate

In planning a soil and water conservation program for pasture lands it is important to determine whether the water-control measures should be directed toward conservation of moisture or toward orderly drainage of excessive run-off from the land. The total annual precipitation falling on the pasture is usually important only as it affects plant adaptations and the need for moisture conservation or disposal of run-off. Most of the run-off and erosion occurs during heavy rains of high intensity; hence, it is important that maximum intensity of expected rainfall be given consideration in planning conservation structures for the pasture. The failure of contour furrows, ridges, and terraces, caused by overtopping from excessive run-off water, may result in severe damage to the land. Contour furrows, ridges, and pasture terraces often make desirable obstructions to catch drifting snow as well as run-off rainfall.

High-velocity winds seldom do erosion damage to pasture lands that have a good vegetative cover. Wind erosion on pastures usually occurs after the stand of vegetation has been killed or its density impaired by overgrazing, drought, or by deposition of silt or sand from other areas. Wind erosion is often serious on extremely sandy soils which are overgrazed or trampled excessively by livestock.

Pastures heavily infested with weeds often have insufficient grass cover to give the maximum protection to the soil from run-off and erosion. Brushy growth on pastures also lessens their economic value and usually causes a sparser stand of grass, which permits increased run-off and erosion. A large amount of tree cover on a pasture may seriously curtail its grazing capacity. Shaded areas on a wooded pasture are usually sparsely covered or bare of grass and often are exposed to excessive trampling. Accelerated erosion is likely to occur on such areas.

Approved Practices

The most reliable and practical information regarding erosion-control practices adapted to pasture lands of the locality can usually be obtained from nearby demonstration areas of the Soil Conservation Service or from local farmers. The recommendations of experiment stations and State agricultural colleges are also of practical value if specific enough for use in planning the program for a given pasture. Some consideration should be given, also, to benefit payments that might accrue from the agricultural conservation program of the Agricultural Adjustment Administration for various adapted practices.

Controlled grazing is a fundamental basic step in controlling erosion on any pasture. Grazing pasture plants too closely reduces the vitality of the plants and does not permit the storage of the necessary reserve food supplies in the roots. Overgrazed pastures usually make less growth the following season and hence their grazing capacity is decreased. Injudicious grazing may prevent the reproduction of seed by pasture plants. Early spring grazing often results in weakened plant vitality and less growth during the remainder of the growing season. A definite grazing system that provides for deferred spring grazing, rotation grazing, adapting the grazing load to the pasture carrying capacity, protection from grazing when seed production is desirable, and other grazing practices adapted to the conditions existing on the pasture, should be instituted. Proper control of grazing usually results in an increase in the carrying capacity of the pasture over a period of years.

Pasture grasses or plants that are in a weakened and unthrifty condition due to drought, disease, overgrazing, silting, or other cause may need to be protected from grazing for one or more seasons or be used only for light grazing until they have regained sufficient vigor to withstand normal grazing. It may be advisable

to reseed pastures where the stand of desirable vegetation is sparse or unthrifty. Fertilizing or liming pastures may be essential to obtain a good cover on severely eroded, unproductive, or acid soils.

Other commonly used erosion-control measures for pastures include protection from fire during dormant seasons; mowing to control weeds; construction of contour furrows, ridges, or terraces; clearing brushy growth or undesirable trees from the pasture; fencing erodible localized areas to protect them from grazing and trampling; diversion of water from gullied or erodible areas; building temporary or permanent check dams in gullies; constructing water-spreading dams in drainageways; and the moving of feeding, salting, and watering places to eliminate continued trampling of one area. Many other localized practices are adapted to widely scattered areas of the country and are frequently used in conjunction with a program of controlled grazing for soil and water conservation on pasture lands. Most of these practices are designed primarily to stimulate the growth of vegetative cover or to protect existing cover. The adaptability of practices for use on any specific area is very variable.

Economic Returns

In planning the program for any given tract of pasture land, the farm unit as a whole must necessarily be considered. If the farm demands for pasture exceed the carrying capacity of existing pastures, the deficiency may be met either by growing more temporary pastures and hay crops on the cultivated lands or by increasing the size or carrying capacity of permanent pastures. The use of fertilizers and lime and new plantings of grasses or pasture plants may greatly increase the carrying capacity of existing pastures in humid climates. Additional acreage of permanent pasture may be added to the farm by changing land use of some fields or by increasing the size of the farm.

In some instances there may be an excess of pasture land to meet farm demands. In such cases the number of livestock on the farm should be increased or pasture lands changed to woodlands or other productive purposes to which they are adapted. Pasture lands should not be changed to cultivated fields unless they are adapted for such use and erosion can be controlled when they are so used.

Plant Cover

In the more arid sections the acreage and production capacity of many pastures are more or less fixed. Under such conditions the grazing load should be adjusted to the carrying capacity of the pastures as they exist and the pastures supplemented with feed and hay crops or temporary pastures.

The person planning a program should be informed regarding the various species of pasture plants that are adapted to the climate of the locality and the suitability of various soils for these species. It is equally important that knowledge be available concerning the erosion-resistant qualities, grazing capacity, palatability, seasonal growth habits, and ability to withstand silting of the various adapted pasture plants.

Considerable differences may be found in the erosion-resistant qualities of various species of grass. Ordinarily, however, the type of vegetation that affords the densest cover to the soil will also be the most erosion-resistant.

Palatability, succulence, feed value, rankness of growth, and other qualities that affect the economic value of a pasture plant may have small effect on its erosion-control value, but should be considered by the farm operator in deciding whether or not it is a desirable plant to use in the pasture for erosion-control purposes. Assuming that the grazing load on a pasture remains constant, the protection from erosion to the land afforded by any species of pasture plants will vary as the grazing capacity of the species.

The cost of installing and maintaining erosion-control practices should be commensurate with the benefits to be derived. Since most erosion-control practices on pasture lands are directed toward increasing the amount of vegetative cover, they usually result in increasing the grazing capacity of the pasture. The cost of seeding, sodding, liming, fertilizing, mowing, clearing brush and trees, protection from fire, controlled grazing, and other practices directed toward increasing the desirable vegetative growth can usually be justified on the basis of the increased grazing capacity resulting. Nevertheless, practices of this type have a distinct value in controlling erosion and run-off. The expense of constructing contour furrows, ridges, and terraces can often be partially, if not wholly, justified on the basis of the increased grass growth resulting from moisture stored above the furrows or ridges. Mechanical measures for checking run-off may also prevent serious erosion on sparsely vegetated pastures and assist in obtaining a stand of new plantings or they may serve as partial protection to other lands or property which are being damaged by run-off from the pasture.

The cost of gully-control practices and the protection of highly erodible areas from run-off and grazing must be justified on the basis of increased land values, the wildlife crop that may be produced on such areas, and the protection afforded adjacent lands and property.

Some inconveniences may result from various practices. Normally, however, these inconveniences will not play an important part in deciding which practices to use. It is usually necessary to drive all vehicles on the contour in crossing pastures that have been ridged or furrowed. The inconvenience of rotating pastures or practicing deferred grazing may sometimes be objectionable, but should not be of grave importance.

The economic returns from erosion-control practices on pasture or range lands may not materialize immediately. Controlled grazing may temporarily result in a decrease of the grazing load carried by a pasture. Contour furrows or ridges will temporarily destroy some of the grazing area. Increased growth of grass resulting from mowing weeds, clearing brush and trees, protecting from fire, and other practices may not materialize for several years. Hence, it is important that the landowner and farm operator be sold on the program planned and have the right attitude toward carrying it out for the eventual improvement of the pasture and the permanent stabilization of erosion on the land.

The control of erosion and the conservation of water on meadowlands presents a problem very similar to that of permanent pastures on most farms except that in the case of meadows the erosion hazards caused from overgrazing are not encountered, and hence the problem is usually more simple.



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Figure 25.—Burned and cut-over woodlands permit rapid acceleration of erosion and increased run-off. This may seriously damage lower lying adjacent lands as well as reduce productivity and income from the woodland.

Figure 26.—A well-managed woodland provides protection to erodible lands and contributes to a stable, permanent farm income.

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Job IX.—Planning an Erosion-Control Program for Farm Woodlands

ANALYSIS

Decisions to be made	Factors to be considered	Necessary working data
1. What erosion practices to use on each tract.	Land conditions and use capabilities.	Information regarding the texture, structure, depth, permeability, and drainage of the soil; suitability of soil for growing trees; slope of the land; character and degree of erosion on the land; localized erosion problems on the area; special problems of foreign drainage or silting; acid, or alkaline conditions of the soil; land-use capabilities of the tract.
	Climate.....	Information regarding total annual precipitation, seasonal distribution of precipitation, character of precipitation, expected maximum intensity of rainfall; velocity, direction, and seasonal distribution of prevailing winds; periods of freezing and thawing.
	Vegetative cover....	Facts regarding type of cover now on the area, whether fallow, weeds, grass, shrubs, or trees; density of the tree stand; species of trees present; percentage of different species in the stand; whether an all-age stand, old trees, or new plantings; diseased trees, storm damage, insect damage, fungus and parasitic growths, and dead trees; type and density of undergrowth of weeds, grass, shrubs, and vines; thickness and uniformity of leaf litter; decayed and decaying humus in the soil; damaged condition of litter cover from trampling, burning, or other causes.
	History of tract.....	Information regarding past use of the land; forestry practices, grazing or management practices employed in the past.
	Tree adaptations....	Information regarding species of trees that are adapted to the soil and climate; growth habits of adapted species; normal shape of adapted species; economic uses of adapted species.
	Pests and diseases...	Information regarding insect pests, diseases, parasites, and other pests prevalent in the locality that will damage trees; possible control methods for prevalent pests or diseases.

Job IX.—Planning an Erosion-Control Program for Farm Woodlands—Continued
ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
1. What erosion practices to use on each tract—Continued.	<p>Use.....</p> <p>Standard erosion control practices.</p> <p>Economic returns from practices.</p> <p>Cost of installing and maintaining practices.</p>	<p>Facts as to whether woodlands are to be used primarily for erosion control, windbreak, wildlife and recreation area, pasture, or production of wood products; type of wood products to be harvested from the tract; type of erosion that is to be controlled by the woods.</p> <p>Facts on recommendations of the Soil Conservation Service, experiment stations, the United States Forest Service, and other agencies as to various practices adapted for controlling run-off and erosion on woodlands of the locality; apparent effectiveness of various practices in controlling erosion and run-off, as observed on soil-conservation demonstration areas, and farms of the locality; opportunity of observing various practices and gaining information on methods used successfully.</p> <p>Information regarding the increased income that may be expected from the use of various practices; increased production of wood products; stability of production; increased value of the land; value of protection from erosion, silting, and run-off to adjacent lands or property.</p> <p>Information regarding estimated cost of installing and maintaining the practices considered; cost of additional plantings; cost of fire protection; cost of protection from grazing; cost of stand improvement by judicious thinning; cost of installing and maintaining conservation structures; other costs.</p>

INTERPRETIVE SCIENCE AND RELATED INFORMATION

Established woodlands with a uniform tree cover and undisturbed litter cover on the ground permit very little run-off and practically no soil erosion, even from heavy rains. The control of erosion on woodlands usually resolves itself into a problem of obtaining an adequate stand of desirable trees and the use of management practices that permit the building up of a good litter cover on the ground and the maintenance of a uniform tree stand.

Protection from fire and grazing, stand improvement by judicious thinning or planting, the control of insects and diseases, and other good woodland-management practices will usually result in the control of erosion on established woodlands. An

erosion-control program for lands being converted to woods will consist largely of management practices that will obtain and maintain a proper stand of trees and litter cover.

Many times protection from fire and from grazing are all that is required in order to control erosion in woodlands and make them profitable.

The slope of the land, erodibility of the soil, and other physical land conditions will influence the practices needed on established woodlands to a lesser extent than on lands used for cultivation or pasture. The physical land conditions will, however, have considerable effect on the erosion-control practices needed on areas where woodlands are being established or on woodlands with a poor tree stand or disturbed litter cover.

Soil type is usually important in an erosion-control program for woodlands only as it affects the establishment of a good woodland stand. Quite often seriously eroded land is retired from cultivation and planted to trees. The lack of fertility in severely eroded soils may permit a very slow growth of newly-planted trees. In many localities it is desirable to cultivate newly-planted trees in order to eliminate competition in growth from weeds. Since cultivation destroys the ground cover and leaves the soil susceptible to extreme erosion, it may sometimes be desirable to construct contour furrows or contour ridges or to divert water by diversion terraces where new woodlands are being established on erodible lands.

Where erosion is occurring on established woodlands it is important that the history of the land be known in order to determine the cause of erosion. Usually erosion on established woodlands is caused from burning, grazing, or other man-made disturbances.

Gullies, severely eroding areas, or areas exposed to considerable foreign drainage may require diversion terraces or other conservation structures for their protection while a suitable woodland cover is being developed.

Climate and Practices

In planning the erosion-control program for established woodlands, the climate is usually important only as it affects tree growth and tree adaptations. Development of woodlands in semiarid climates may be rather difficult and may call for water-conservation measures. Run-off and erosion may sometimes occur on established woodlands with a good cover where heavy winter snows are melted by spring rains while the ground is frozen and unabsorptive.

The velocity and direction of prevailing winds are usually important in an erosion-control program for woodlands only when the woodlands are being used as a shelter strip to protect adjacent lands.

In thinning woodlands desirable species should be given preference. An all-age stand of trees is desirable for erosion control and for a stable income from the crop. A dense undergrowth of shrubs, weeds, or grass in a woods composed of young trees or in sparsely covered woods will afford immediate protection to the soil but may retard the growth of young trees and result in eventual loss both to the soil and to the farm income. A dense undergrowth is usually not desirable or necessary for erosion control in an established woodland with an all-age stand.

A uniform cover of leaf litter and decaying humus absorbs rainfall, permits water penetration of the soil, and protects the soil from the driving force of falling raindrops. In woodlands where the leaf litter has been burned off or blown away this valuable erosion-resistant cover is lost. Burning also kills young trees and often kills old trees in the stand. In woodlands that have been heavily grazed by livestock the leaf litter is usually disturbed, the soil trampled into a less permeable condition, and young trees killed.

New plantings should consist only of species of trees that have been proved to be adapted to an area. Growth habits affect the adaptability of trees for various purposes. Fast-growing trees usually afford the quickest protection to the land and quicker returns from the crop produced, but often the more rapidly growing trees have less commercial value.

The use to be made of the woodland should largely govern the selection of species for new plantings. It is essential that the person planning a tree-planting program be acquainted not only with the species adapted to the soil and climate but also with the growth, habits, and economic uses of the adapted species.

Wooded areas used primarily for windbreaks should be composed of species varying in height and should be so arranged that a dense windbreak cover is afforded. Woodlands planted primarily to control water erosion on the land should be composed largely of fast-growing species and often should be supported by dense undergrowth cover until the trees have established an erosion-resistant cover. Woodlands that are to be used primarily as wildlife and recreation areas should have a large percentage of species that produce wildlife food and will often be more suitable if interspersed with plantings of shrubs that produce wildlife food and cover.

Erosion-control practices for any tract of woodland should be designed, insofar as possible, to bring about increased economic returns from the land. The maximum income from a woodlands crop can in most cases be obtained by cutting a few of the larger trees each year and disposing of sawlogs, poles, piling, pulpwood, or other salable products. The practice of thinning out only a few large trees from the tract each year should result in minimum disturbance to the erosion-control cover of the land.

The production of naval stores, maple sirup, decorations, and other byproducts of the tree crop will usually not impair the erosion-control value of the woods and may contribute materially toward the farm income and the economic justification of using the area for woodlands.

Woodland-management practices that result in erosion control on critical areas may materially increase the value of the land over a period of years and may also contribute to the protection of adjacent lands from erosion. The maintenance of a good forest cover over large areas of steep or eroding lands may contribute considerably to a flood-control program for the area.

The cost of installing erosion-control practices is usually negligible, since most practices are directed mainly toward increasing the value of the woodland crop. The cost of diversion terraces and other conservation structures that may be necessary on eroding areas can usually be justified on the basis that they afford protection to other lands and assist in establishing the woodland crop. Ordinarily it will not be profitable or necessary to install expensive conservation structures on woodlands because the usefulness of such structures, in most cases, will be only temporary.



Soil Conservation Service, U. S. D. A.

Figure 27.—A severely eroded area on a Kentucky farm. Unchecked erosion may damage lands to such an extent that they have very little economic value and the cost of reclamation becomes excessive.

Figure 28.—The same area as shown in Figure 27 two years later. Inexpensive plantings of trees and shrubs have been made and complete protection from livestock provided. Its economic value is still low but a crop of wildlife may be produced on it. In addition, the conservation measures adopted on this area have resulted in protecting lower lying lands from run-off and erosion.

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Job X.—Planning an Erosion-Control Program for Lands Devoted to Wildlife

ANALYSIS

Decisions to be made	Factors to be considered	Necessary working data
<p>1. What erosion-control practices to use on each tract.</p>	Physical land conditions.	Information in regard to soil type, slope, and character and degree of erosion on the area; special problems of erosion or silting demanding attention; special problems of foreign drainage or protection of other property; galled spots, badlands, or other acute conditions of erosion existing; toxic or diseased conditions of the soil; other physical land conditions that have influenced the decision to use the area for wildlife production.
	Climate-----	Information in regard to total annual precipitation, seasonal distribution of precipitation, character of precipitation, and expected maximum intensity of rainfall; velocity, direction, and seasonal distribution of prevailing winds; periods of freezing and thawing.
	Vegetative cover----	Facts regarding present cover on the land; types of vegetation growing; density of vegetative cover; economic usefulness of vegetation growing; usefulness of plants present for wildlife food or cover.
	Vegetative adaptations of the land.	Information concerning the types and species of vegetation that will grow on the soil; erosion-control qualities of adapted plants; usefulness of adapted plants in providing wildlife food or cover; characteristics of adapted plants with respect to building up the fertility of the soil.
	History of the tract--	Information regarding past use of the area; conservation and management practices used on the area in the past.
	Use of area-----	Information concerning the kind of wildlife that will be produced on the area; other possible uses that may be made of the area.

Job X.—Planning an Erosion-Control Program for Lands Devoted to Wildlife—Continued

ANALYSIS—Continued

Decisions to be made	Factors to be considered	Necessary working data
<p>1. What erosion-control practices to use on each tract—Continued.</p>	<p>Standard practices . . .</p> <p>Economic returns from practices.</p> <p>Cost of practices</p> <p>Convenience</p>	<p>Information regarding the recommendations of the Soil Conservation Service, agricultural experiment stations, and Biological Survey in regard to erosion-control practices adapted for use on wildlife areas of the locality; practices used on soil conservation demonstration areas and on farms of the locality; comparative effectiveness of various practices in controlling erosion; observed success or failure of practices on demonstration areas and local farms, apparent cause of the failure of any practices observed; opportunity to observe methods of instituting various practices.</p> <p>Information concerning the usefulness of various conservation practices considered in providing wildlife food and cover; extent and desirability of wildlife cover provided; kind and amount of wildlife food that conservation practices provide; suitability of food and cover provided for the kind of wildlife to be produced; estimated yield of wildlife products resulting from various practices considered; value of other usable or marketable products that may be produced as a result of various practices; estimated value of wildlife in controlling insect pests; esthetic returns—recreation; extent of protection afforded other lands or property by various practices.</p> <p>Information concerning estimated cost of installing and maintaining various practices considered; cost of constructing diversion terraces, gully checks, and other conservation structures; cost of fencing for segregation of the area from other lands; cost of plantings; cost of protection from fire and management to insure growth of desirable vegetation; cost of stocking with wildlife.</p> <p>Information concerning conveniences or inconveniences that may result from various practices on normal farm operations.</p>

INTERPRETIVE SCIENCE AND RELATED INFORMATION

In planning a program of erosion control and land use that will give the highest economic returns from each tract or parcel of land that it is capable of producing permanently, each area should be used for the production of some crop that will have a value either as marketable produce or for home consumption. A profitable crop of wildlife can usually be produced on those areas that are not adapted to the production of other farm crops. Usually, but not always, the production of wildlife on an area is considered the lowest type of economic use.

Normally only those areas of the farm will be devoted to wildlife that cannot be profitably maintained in cultivation, pasture, meadow, or woodland, due either to the erodibility of the land, or to location, size, or shape of the area. Physical land conditions will often be quite variable on such areas and hence there may be extreme variability in the practices needed to stabilize erosion.

If the problem of land use and erosion control were not unusual or difficult on the area it would probably be devoted to some other use that would bring in greater economic returns than wildlife production. Special problems of foreign drainage, silting, and protection of other lands may frequently be encountered. Extreme erodibility of the soil, serious gulying, galled spots, badlands, or other acute erosion conditions may be encountered. Toxic and diseased conditions or lack of fertility of the soil may have precluded the use of the area for other purposes. Hence it is important that the physical land conditions be given careful study before any attempt is made to plan the erosion-control program for a tract of this type.

The type and density of cover existing on eroded areas is important not only because of its effect on erosion and the needed control measures but also because the existing cover is often an indicator of the plant-production possibilities of the land, particularly if the land has been idle for some time. Where abandoned lands and lands retired from cultivation that are seriously eroded and of low fertility are used as wildlife areas, the plant-production possibilities are usually very limited. If the land has been undisturbed for a few years, the normal trend of plant succession will probably have resulted in covering the area with the highest type of vegetation the land is capable of producing, and the existing vegetation will thus be the best indicator of the plant production possibilities of the tract.

Economic returns from wildlife products cannot be secured from an area unless it is populated with wildlife. A population of desirable wildlife species will not inhabit the area unless suitable food and cover are available. On many areas of this type the natural growth of undisturbed vegetation will control erosion, but plantings of adapted wildlife food and cover plants or other economically useful plants will be needed in order to secure an income from the area. The person developing a wildlife-production plan should be familiar with feeding, nesting, and cruising habits of wildlife that may be produced on the area. Likewise he must be familiar with the characteristics of adapted plants that might be used on the area for wildlife food and cover or for other economic uses. Where food patches are adjacent to the wildlife area, protected travel lanes should be provided. This can often be accomplished by strip cropping and the use of erosion-resistant vegetation as field borders.

Since wildlife areas are likely to be extremely variable, the recommendations of experiment stations and other agencies concerning proper erosion-control practices may be of little value. Soil-conservation demonstration areas or similar areas on local farms may afford examples of treatment that are adapted to the area, but the variability of conditions may be such that the farm planner will need to develop practices with which he is not familiar. If unproved practices

are used, it is all the more important that the planner study carefully the existing conditions on the land and make careful observations of all practices used under similar conditions, wherever such practices may be found.

The value of land and the produce from it will in many instances make impracticable the installation of expensive erosion-control practices on it. It must be remembered, however, that serious erosion conditions on any part of the farm should be corrected regardless of cost. Control measures in most cases will consist largely of protecting the area from livestock, fire, or other disturbance. Water diversion from gullied or erodible areas may be practicable; likewise, temporary gully checks may be required in order to stabilize the area sufficiently to permit the establishment of a vegetative cover.

Plantings of wildlife food and cover plants can be justified to a limited extent. Sometimes plantings may be so designed that an additional income may be derived from the area from wild fruit or other products. Usually wildlife plantings will consist largely of shrubs, but they may include legumes, grasses, trees, or other plants. Contour furrows or ridges may sometimes be justified as measures to conserve moisture and permit the growth of plantings made. Since natural vegetative cover is often as effective in controlling erosion as artificial plantings, it is usually necessary that the cost of new plantings be justified by the income they will afford from wildlife or other products.

Although the land value of the wildlife area may not justify expenditures for control of erosion and run-off, the protection of adjacent lands or property will often justify some expense in controlling the area. Progressive and accelerated erosion on a small area may spread rapidly if not controlled, or the damage to other lands from unproductive silt or sand coming from the area may be considerable.

Usually it will be impossible to stabilize a severely eroded area or to make it a suitable habitat for wildlife unless it is protected from livestock grazing and trampling and from fire damage. The costs of fencing to protect the area from livestock and the cost of fire protection may be justified by the benefit that will be derived from the wildlife crop or by the protection afforded adjacent lands and property.

It is also important that the natural enemies of desirable wildlife species be eliminated insofar as is practicable at least, until the desired species are established. Time devoted to securing a crop of wildlife on an erodible area that has been retired from cultivation may be partly justified on the basis of erosion control; for if no economic returns accrue from the area there will always be a temptation to change the use of the area back to a purpose for which it is not adapted, thereby accelerating erosion.

DEFINITIONS OF SOIL CONSERVATION TERMS

Abney level.—A small hand level suitable for both direct leveling and for measuring the angles of slopes.

Aerial photograph.—A photograph of the earth's surface taken from an airplane. Single-lens photographs, taken with the camera pointed directly downward, are used for most mapping purposes. Oblique photographs can be taken which include more territory, but their usefulness in precise mapping is somewhat more limited. For some purposes multiple-lens cameras are used which take one vertical and several oblique photographs simultaneously, permitting rapid coverage of a wide territory.

Alidade.—A combined sight and straight-edge rule. Two common types are the peep-sight alidade and the telescopic alidade.

1. The peep-sight alidade consists of a peep sight, mounted on a ruler or straight edge. The peep sight is formed by two sight vanes, either fixed or folding. The ruler generally consists of a brass plate 6 to 10 inches long, one edge of which is graduated.
2. The telescopic alidade is designed to give greater accuracy than the peep sight. It consists of a brass ruler about 3 inches wide and 18 inches long. On this ruler is mounted at one end a circular level and at the other end a box compass. In the center of the ruler is a column which supports the telescope.

Base map.—A map having sufficient points of reference, such as State, county, or township lines, and other selected physical and cultural features, to allow the plotting of other special data. The base map for a detailed soil map shows political subdivisions, permanent physical features, such as streams, shore lines, and mountains, and such cultural features as houses and roads, necessary for convenience in plotting the soil data. (See Soil map.)

Cat steps.—Miniature "terraces" on hillsides that result from mass movement of soil. They are most frequent on loess soil.

Compass.—An instrument for determining direction by the pointing of a magnetic needle, free to rotate in a horizontal plane. There are many types of compasses and they are usually named according to usage, such as the mariner's compass, forester's compass, topographer's compass, miner's compass, etc.

1. A pocket compass is a small compass that may readily be carried in the pocket like a watch.
2. A box-trough compass is the type of compass usually found in the traverse-type plane table. The needle has a small arc of movement as limited by the sides of the compass trough.

Conservation survey.—The mapping of physical land factors—soil type, slope, kind and degree of erosion, and present land use—on a suitable base.

Cultivation.—Tillage of the soil such as is practiced with intertilled crops and in preparing the land for grain crops.

Detailed survey.—Detailed surveys are those in which the features studied are examined at close intervals and delineated in detail. They are intended primarily to furnish necessary information for intensive planning on individual farms or other small units.

Distortion in aerial photographs.—Produced either because points of the object which lie in a plane have their images upon a curved surface (lack of flatness of field) or because some portions of the image are magnified more strongly than others.

Engineer's scale.—Divided into 10, 20, 30, 40, 50, 60, 80, and 100 parts to the inch. The 12-inch triangular boxwood rule with 10-, 20-, 30-, 40-, 50-, and 60-foot scales on its 3 faces is most commonly used.

Erosion.—The wearing away of the land surface by running water, wave action, glacial scour, wind, temperature changes, and frost action. These may be supplemented by gravitational processes including soil creep, land slides, and accumulation of talus.

Normal erosion.—The erosion characteristic of the land surface in its natural environment, undisturbed by human activity, as under the protective cover of the native vegetation. This type of erosion is sometimes referred to as geological erosion. It includes (1) normal soil erosion, or the erosion characteristic of the soil type in its natural environment under the native vegetation, undisturbed by human activity; and (2) rock erosion, or erosion of rocks, consolidated or unconsolidated, on which there is little or no true soil, as in stream channels, high mountains, and badlands.

Accelerated erosion.—Erosion of the soil or soil material over and above normal erosion brought about by changes in the natural cover or ground conditions, including changes due to human activity and those caused by lightning or rodent invasion.

1. *Sheet.*—Removal of a more or less uniform layer of material from the land surface. The effects are less conspicuous than those of other types of erosion that produce large channels. Frequently in sheet erosion the eroding surface consists of numerous very small rills.
2. *Rill.*—That type of accelerated erosion by water which produces small channels that can be obliterated by tillage.
3. *Gully.*—That type of accelerated erosion by water which produces definite channels too deep to be obliterated by normal tillage. Ordinarily, these erosion-produced channels carry water only during and immediately after rains, or following the melting of snow. Generally speaking gullies are deeper than rills.

Soil erosion.—Removal of soil material from the solum by wind or running water, including normal soil erosion and accelerated soil erosion. Sometimes used loosely in reference to accelerated erosion only.

Farm level.—A simple, inexpensive type of telescopic level.

Galled spots.—Small areas that are bare because erosion has made them infertile.

Land use capability.—A term used in describing: (1) The suitability of land for cropping or other use, and (2) the degree or intensity of special practices required for such use.

Magnetic bearing.—Direction of any line with respect to a magnetic meridian.

Magnetic interference.—Caused by objects of iron or steel, some kinds of iron ore, and electric wires which alter the direction of the lines of magnetic force in their vicinity and thus are likely to cause the compass needle to deviate from its magnetic meridian.

Magnetic north.—Direction indicated by the magnetic needle; marks the apparent convergence point of magnetic meridians.

Map scale.—Unit of measurement on the map which gives a definite ratio between the map measurements and actual field distances.

Measuring tape.—A narrow strip of cloth, paper, or steel marked with dimensions so as to be used for measuring length. The more common tapes used by engineers are the steel tape and the metallic tape.

Orientation.—Any process by which direction is ascertained.

Orientation of control points.—The process of locating such points with respect to known features of terrain for purposes of determining direction.

Pace counter.—Any device used to record paces. Usually it is either a tally counter which must be pressed for each pace or a passometer which registers mechanically.

Plane table.—Essentially a drawing board that is supported by a tripod and is capable of being rotated about a vertical axis. The complete plane table also includes an alidade for sighting and scaling purposes.

Reconnaissance survey.—Reconnaissance surveys are those in which the features studied are examined at wide intervals and are not delineated in detail. They are intended primarily to furnish information for extensive planning or overall planning in large areas, such as county, State, or large watershed units.

Resection.—The method of locating on a map the position of the ground point over which the map board has been set. It can be accomplished (after the board has been oriented) by drawing rays from two or more visible objects through the corresponding plotted position of the objects on the map. The plotted position of the ground point will be defined by the point where two or more of these rays resect.

Rod (leveling).—Graduated rods of rectangular cross section which are used in measuring difference in elevation. Two general classes of rods are target rods and self-reading rods.

Sharpshooter spade.—A long narrow spade used for tile trenching. It is usually referred to as a tiling spade.

Slips.—Land slides; the result of mass movement of soil material.

Slope.—

1. Length is the distance measured along the slope at right angles to the contour.
2. Percent of slope is the gradient expressed in terms of percent. Mathematically it is the rise, divided by the horizontal projection of the slope length, expressed in percent.

Soil.—A natural body on the surface of the earth, in which plants grow. It is composed of organic and mineral materials and developed by the operation of natural environmental features, such as climate and vegetation on mineral material and plant remains.

Soil auger.—An instrument for boring in and examining soils. A satisfactory soil auger can be made from a 1½-inch carpenter's auger by filing off the screw tip and attaching a shaft with a T-shaped handle. The finished auger should be about 40 inches long. Shaft and handle may be constructed from ¾-inch pipe.

Soil consistence.—The relative mutual attraction of the particles in the whole soil mass or their resistance to separation or deformation (as evidenced in cohesion and plasticity). Consistence is described by such general terms as loose or open; slightly, moderately, or very compact; mellow; friable; crumbly; plastic; sticky; soft; firm; hard; and cemented.

Soil horizon.—A layer of soil approximately parallel to the land surface with more or less well-defined characteristics that have been produced through the operation of soil-building processes. The relative positions of the several soil horizons in the soil profile and their nomenclature are shown below: ¹

A ₀₀	Loose leaves and organic debris, largely undecomposed.
A _n	Organic debris partly decomposed or matted.
A ₁	A dark-colored layer containing a relatively high content of organic matter mixed with the mineral soil. Thin under timber and thick under native grass.
A ₂	A light colored horizon, the zone of maximum leaching. Absent in some soils in semi-arid or arid regions.
A ₃	Transitional to B. Sometimes absent.
B ₁	Also transitional, but more like B than A. Sometimes absent.
B ₂	A usually deeper colored layer. The zone of accumulation in many soils.
B ₃	Transitional to C.
C.....	Weathered parent material.

Soil permeability.—The word permeability as applied to soils usually refers to the rate at which water enters them. Sandy soils are usually highly permeable. Heavy clay soils or those with a clay layer in the subsoil may be very slowly permeable.

Soil profile.—A vertical section of the soil through all its horizons (layers) and extending into the parent material.

Soil series.—A group of soils that resemble each other in all characteristics except texture of the surface soil (see soil type).

Soil structure.—The arrangement of individual soil particles into crumbs, granules, or other aggregates. Following are the principal types of soil structure:

Prismatic.—Blocky structure with the vertical axis of the blocks longer than the horizontal, as in the B horizon of many Chestnut soils.

Nullike.—Blocky structure, angular, as in the B horizon of the Gray-Brown Podzolic soils, or rounded, as in the B horizon of many Chernozems.

Columnar.—Prismatic with rounded tops, as in the B horizon of the solodized Solonetz.

Platy.—Thin horizontal plates, as in the A₂ horizons of the Podzol and the solodized Solonetz.

Crumb.—Generally soft, small, porous aggregates, irregular in shape, as in the A₁ horizons of many soils.

Granular.—Hard or soft but firm small aggregates, angular or rounded, as in the A horizon of many Chernozems.

Fragmental.—Hard or soft but firm irregular aggregates, angular or sub-angular, as in many young soils developed from silty or clayey alluvium.

¹ Adapted from the sketch on page 1160 of *Soils and Men*, United States Department of Agriculture Yearbook, 1938.

Phylliform.—Thin leaflike layers, less distinct and thinner than platy. Where this condition is confined to inherited layers, as in the C horizon of soils developed from thin-bedded sediments, the term laminated is used.

To indicate a lack of definite structure, the following terms are normally used:

Single grain.—Each grain by itself, as in dune sand (structureless).

Massive.—Large uniform masses of cohesive soil, sometimes with irregular cleavage, as in the C horizons of many heavy clay soils (structureless).

Soil texture.—The relative proportion of the various size groups of individual soil grains.

Soil separates.—The individual size groups of soil particles, such as sand, silt, and clay.

Soil class.—Classes of soil based on the relative proportion of soil separates. The principal classes, in increasing order of the content of the finer separates, are as follows: Sand, loamy sand, sandy loam, loam, silt loam, clay loam, and clay. These may be modified according to the relative size of the coarser particles to fine sand, loamy fine sand, fine sandy loam, very fine sandy loam, coarse sandy loam, gravelly sandy loam, gravelly loam, cobbly loam, sandy clay, stony clay, silty clay, stony loam, etc.

Subsoil.—The B horizon or that part of it not included in the topsoil.

Tally counter.—A small instrument used to record units. Counting is accomplished by pressing a lever on the tally.

Terrain.—An extent of ground or territory usually considered in relation to its fitness for some particular purpose.

Soil topography.—Comprises the physical features, collectively, characterizing any region.

1. *Badlands* are minutely dissected topography developed by rill wash on a series of weak sedimentary rocks or deposit of unconsolidated sands, clays, and gravels usually presenting marked differences in the resistance of successive layers; most common in arid or semiarid climates, due to sparse vegetative cover and consequent great exposure of the soil or rock surface.
2. A *hog wallow* is a pool, mudhole, or slough frequented by the hog or other wallowing animals; or it may also be the hollow left in the ground, showing where an animal has wallowed.
3. A *kame* is a conical hill or short ridge of discordantly stratified sand and gravel formed by glacier deposition, and especially by englacial streams, generally in a system transverse to the glacial movement; chiefly occurring as components of terminal moraines.
4. A *mound* is a heap of earth or rock of either artificial or natural formation.
5. A *sinkhole* is a surface depression that has no surface drainage outlet. It depends upon underground drainage and is usually found in a limestone area.

Soil type.—Soils that resemble each other in texture, color, structure, consistency, drainage, origin, and mode of occurrence. Soil type is the unit used in mapping soils. The name of a soil type is a combination of the series name and texture, for example, Miami silt loam.

Solum.—The upper part of the soil profile above the parent material in which the processes of soil formation are taking place.

Talus.—Fragments of rock accumulated at the base of cliffs and steep slopes.

Topsoil.—A general term applied to the surface portion of the soil, including the average plow depth (surface soil) or the A horizon, where this is deeper than plow depth. It cannot be precisely defined as to depth or productivity except in reference to a particular soil type.

Tract of land.—Any area, regardless of size or shape, on which the physical land conditions are similar and its use capabilities are definitely different from adjacent areas.

Traverse type plane table.—A small plane table suitable for reconnaissance sketches and for traversing small-scale maps. The table is attached to a simple tripod. It has no leveling device. A box-trough compass is usually placed in the board near one edge.

Tripod.—A three-legged stand for supporting some instrument. The legs are usually hinged near the top and may also be made adjustable.

REFERENCES ON SOIL CONSERVATION ¹

United States Department of Agriculture Publications ²

Farmers' bulletins:

- 1758. Cover Crops for Soil Conservation.
- 1767. Soil Defense in the Piedmont.
- 1771. Preventing Soil Blowing on the Southern Great Plains.
- 1773. Soil and Water Conservation in the Pacific Northwest.
- 1776. Strip Cropping for Soil Conservation.
- 1788. Wildlife Conservation through Erosion Control in the Piedmont.
- 1789. Terracing for Soil and Water Conservation.
- 1790. The Nichols Terrace: An Improved Channel-Type Terrace for the Southeast.
- 1795. Conserving Corn Belt Soil.
- 1797. Implements and Methods of Tillage to Control Soil Blowing on the Northern Great Plains.
- 1809. Soil Defense in the South.
- 1810. Soil Defense in the Northeast.
- 1812. Native and Adapted Grasses for Conservation of Soil and Moisture in the Great Plains and Western States.
- 1813. Prevention and Control of Gullies.
- 1814. Terrace Outlets and Farm Drainageways.

Circulars:

- 19. Forests and Floods: 5 cents.³
- 33. Soil Erosion a National Menace. 25 cents.³
- 347. Effect of Cover on Surface Run-off and Erosion in the Loessial Uplands of Mississippi.
- 380. Erosion Control on Mountain Roads.
- 402. Blue Grama Grass for Erosion Control and Range Reseeding in the Great Plains and a Method of Obtaining Seed in Large Lots.
- 412. Groups of Plants Valuable for Wildlife Utilization and Erosion Control.
- 430. Emergency Wind-Erosion Control.
- 490. Soil Erosion in the Karst Lands of Kentucky.

Leaflets:

- 114. Vine-Mesquite for Erosion Control on Southwestern Ranges.
- 163. Legumes in Soil Conservation Practices.
- 164. Erosion on Roads and Adjacent Lands.
- 165. Soil-Depleting, Soil-Conserving, and Soil-Building Crops.

¹ Publications on soil conservation are available from many State colleges of agriculture, State agricultural experiment stations, State extension services, and similar sources.

² Publications listed are available to teachers on application to the Office of Information of the United States Department of Agriculture at Washington, D. C., unless otherwise indicated.

³ A available from the Superintendent of Documents, United States Government Printing Office, Washington, D. C., at the price quoted.

Technical bulletins:

- 178. Properties of Soils Which Influence Soil Erosion.
- 528. Conditions Influencing Erosion on the Boise River Watershed.
- 556. Soil Conservation Reconnaissance Survey of the Southern Great Plains Wind-Erosion Area.
- 567. Soil Erosion and Stream Flow on Range and Forest Lands of the Upper Rio Grande Watershed in Relation to Land Resources and Human Welfare.
- 633. Principles of Gully Erosion in the Piedmont of South Carolina.

Miscellaneous publications:

- 221. Soil Blowing and Dust Storms.
- 253. Conservation Farming Practices and Flood Control.
- 256. Early Erosion-Control Practices in Virginia.
- 274. Soil Survey Manual.
- 286. What is Soil Erosion?
- 293. Soil Conservation Districts for Erosion Control.
- 301. Erosion and Its Control in Oklahoma Territory.
- 303. Native Woody Plants of the United States; Their Erosion Control and Wildlife Values. \$1.75.³
- 312. Bibliography on Erosion and Soil and Water Conservation.
- 321. To Hold This Soil.
- 331. The Land in Flood Control.
- 338. Soil Defense of Range and Farm Lands in the Southwest.
- 352. Soil Conservation Survey Handbook.

Yearbook:

Soils and Men. Yearbook of Agriculture, 1938. \$1.75.³

Unnumbered publications, Soil Conservation Service:

- Anchoring Farmlands in the Ohio Valley Region.
- Erosion Control in the Northeast.
- From Ridge to River.
- Soil and Water Conservation in the Northern Great Plains.
- Soil Conservation, official journal of the Soil Conservation Service. 10 cents per copy. \$1.00 yearly.³
- A Standard State Soil Conservation Districts Law. 10 cents.³
- Ten Billion Little Dams. Soil Conservation Service.

(The Soil Conservation Service is conducting surveys on erosion and related land-use conditions in selected areas throughout the country. Information regarding availability of reports on specific areas may be secured from the nearest field office or the Washington office of the Soil Conservation Service.)

Other Publications ⁴*Miscellaneous:*

- Dust Storms and Their Possible Effect on Health. Reprint No. 1707 from Public Health Reports. Public Health Service, Washington, D. C. 5 cents.³
- Future of the Great Plains. Report of the Great Plains Committee. (Also House Document 144, 75th Congress, 1st Session.) 50 cents.³
- Hands to Save the Soil. Civilian Conservation Corps in collaboration with Soil Conservation Service.
- Headwaters: Control and Use. Proceedings of Upstream Engineering Conference, Washington, D. C., September 1936. \$1.00.

³ Available from the Superintendent of Documents, United States Government Printing Office, Washington, D. C., at the price quoted.

⁴ Information on the agricultural conservation and adjustment program of the Agricultural Adjustment Administration is available from the United States Department of Agriculture, Washington, D. C.

- Little Waters: Their Use and Relations to the Land. Soil Conservation Service, Resettlement Administration, and Rural Electrification Administration. 30 cents.³
- Mapping and Measuring Farms. Volume 13, Nos. 5 and 6 of "Agricultural Education." Available at 10 cents per copy from the Department of Agricultural Education, School of Vocational Education, Clemson Agricultural College, Clemson, S. C.
- Results of Erosion. Volume 12, Nos. 6-9 of "Agricultural Education." Available at 10 cents per copy from the Department of Agricultural Education, School of Vocational Education, Clemson Agricultural College, Clemson, S. C.
- Soil Conservation: A Philosopher's Viewpoint. Circular 97. Vermont Agricultural Extension Service, Burlington, Vt.
- Soil Conservation: An Elementary Discussion for Use in Grade Schools. South Dakota Extension Circular 376.
- Soil Conservation in Indiana. Bulletin 228. Extension Service, Purdue University, La Fayette, Ind.
- Soil Erosion: A Critical Problem in American Agriculture. Part V of the Supplementary Report of the Land Planning Committee to the National Resources Board. National Resources Board. 75 cents.³
- Soil Erosion and Its Control. Circular 304. Extension Division, University of Kentucky, Lexington, Ky.
- Soil Erosion by Wind in Kansas. Vol. LVI, No. 224-A, Report of the Kansas State Board of Agriculture, December 1937. Kansas State Board of Agriculture, Topeka, Kans.
- Soil Erosion Control by Engineering Methods. Special Bulletin 171. Agricultural Experiment Station, University Farm, St. Paul, Minn.
- Soil Erosion Control in Farm Operation. Special Bulletin 170. Agricultural Experiment Station, University Farm, St. Paul, Minn.
- Soil Erosion in Michigan Orchards. Circular Bulletin 162. Agricultural Experiment Station, East Lansing, Mich.
- Soil Erosion in Missouri. Bulletin 349. Agricultural Experiment Station, Columbia, Mo.
- Soil Erosion in New York. Bulletin 347. New York State College of Agriculture, Cornell University, Ithaca, N. Y. Out of print.
- Soil Erosion in Ohio. Bulletin 589. Agricultural Experiment Station, Wooster, Ohio.
- Soil Erosion Survey of Pennsylvania. Bulletin 354. Pennsylvania State College, School of Agriculture and Experiment Station, State College, Pa.

MOTION PICTURES ⁵

C. C. C. Fights Erosion (1 reel; sound only):

The Civilian Conservation Corps at work on gully-erosion control.

Muddy Waters (1 reel; sound):

A story of land use and abuse in the Southwest. Shows conditions when the white man came and how his two great industries, grazing and farming, depleted soil-binding vegetation, resulting in destruction of the soil by floods and erosion. It points the way to necessary remedial measures.

³ Available from the Superintendent of Documents, United States Government Printing Office, Washington, D. C., at the price quoted.

⁵ Information regarding these and other motion pictures may be secured from the Division of Motion Pictures, Extension Service, United States Department of Agriculture, Washington, D. C. Motion pictures are available in both 35-mm. and 16-mm. sizes.

Forests and Men (1 reel; sound):

The work of the Civilian Conservation Corps. Portrays representative activities throughout the country. A lecture picture.

Grass Land (1 reel; sound):

Southern Great Plains in their native state, covered with prairie grasses, gradual disappearance of vegetation due to overgrazing and drought, destruction of the land by torrential rains. Soil-saving measures of contour furrowing, revegetation, stock-pond construction, and fencing to bring the land back to grass-covered plains for well-nourished stock.

Rain on the Plains (1 reel; sound):

Texas Dust Bowl. Shows the wind-erosion problem and measures being used to control it.

Film Strips⁶

244. Soil Erosion, a National Menace (96 frames)

Illustrates damage to farm and grazing lands caused by unrestrained soil erosion; with means of control and protection with terraces, trees, and grass.

318. Gully Control and Terracing Experiments, Erosion Experiment Farms, Bethany, Mo. (47 frames)

341. Stop Gullies—Save Your Farm (62 frames)

419. Soil Erosion and Its Control in the Ohio Valley (40 frames)

Illustrates the causes of soil erosion and the practices recommended and employed by the Soil Conservation Service for the control of erosion in the Ohio Valley.

421. Soil Conservation in California (44 frames)

Prepared from photographs taken on the several Soil Conservation Service erosion-control areas in California. Illustrates some of the soil-conservation problems in California and some of the methods that are being used for solution.

425. Erosion Control on the Northern Great Plains (43 frames)

Illustrates damages due to dust blowing and effective measures to control dust blowing in the Dakotas, Wyoming, Montana, etc.

426. Erosion Control in the North Atlantic States (36 frames)

Illustrates the practices recommended and employed by the Soil Conservation Service for the control of erosion in the North Atlantic States.

435. Tillage to Control Wind Erosion (48 frames)

Illustrates specially designed implements used according to type of soil and condition of crops to prevent soil blowing. The necessity for immediate checking of soil blowing is emphasized.

438. Contour Furrows (32 frames)

Illustrates the name *contour furrow* in its correct sense, land where needed, methods of construction, and results obtained.

439. Strip Cropping (35 frames)

National in scope. Illustrates the value of strip cropping and shows how the system may be applied effectively under a wide range of conditions.

442. Farming Practices that Conserve Soil and Water (48 frames)

Depicts many of the more widely used farming practices employed to control soil losses by erosion and to effect water conservation in the various watershed demonstration projects of the Soil Conservation Service.

⁶ Information regarding these and other film strips may be secured from the Extension Service, United States Department of Agriculture, Washington, D. C.

- 455. Control of Water Erosion in the Central Great Plains (48 frames)
Illustrates water erosion control practices for Nebraska, Kansas, and Oklahoma.
- 456. Wind Erosion (45 frames)
Illustrates the soil-erosion problems and methods of conservation in the Panhandle Area of/the Southern Great Plains.
- 458. Soil Erosion and its Control in Arkansas, Louisiana, and Texas (38 frames)
- 463. Soil Erosion and its Control in the Upper Mississippi Valley (48 frames)
- 467. Soil Erosion in the United States (48 frames)
- 468. Controlling Water and Wind Erosion in the Pacific Northwest (46 frames)
- 469. Erosion Control in the Southeast (39 frames)
- 470. Agricultural Conservation for 1938—Why and How (43 frames)
- 476. Keeping Minnesota Soil at Home (48 frames)
- 477. Keeping Wisconsin Soil at Home (48 frames)
- 478. Saving Iowa Soil (48 frames)
- 497. Keeping Illinois Soil at Home (48 frames)
- 504. Gully Prevention and Control (75 frames)
- 520. A Story of Topsoil in the Northeast (48 frames)
- 523. Erosion—Whose Problem? (33 frames)
- 524. Soil and Water Conservation in Arkansas (48 frames)
- 525. Soil Conservation in Ohio Farming (39 frames)
- 550. Saving Soil in Indiana (39 frames)
- 553. Soil and Water Conservation in West Virginia (53 frames)

Conservation Charts ⁷

- 1. Soil Erosion—Cause and Effect
- 2. Contour Farming for Soil and Water Conservation
- 3. Strip Cropping—An Erosion-Control Practice
- 4. Terraces for Erosion Control
- 5. Cover Crops Protect Soil
- 6. Gully Control
- 7. Saving Soil and Water on Pasture Lands
- 8. Trees and Shrubs for Erosion Control
- 9. Wildlife—A Safe Use for Erodible Land
- 10. Farm Ponds

Upper Mississippi Region (Iowa, Illinois, Missouri, Minnesota, and Wisconsin).

- 11. Soil Management Program for Crop Land. 10 cents.
- 12. Effect of Cropping Plan on Soil Losses. 10 cents.
- 13. Story of Three Corn Fields and the Soil They Lost Per Acre Each Year.
- 14. Improve Pastures—Safeguard Soil, Produce More Protein. 10 cents.
- 15. Financial Insecurity Follows Erosion of the Soil. 10 cents.
- 16. Erosion Control Starts With an Inventory of Farm Resources. 10 cents.
- 17. Soil Conservation Calls for Long-Time Planning. 10 cents.

⁷ Available to teachers, schools, extension workers, and other educational groups from the United States Department of Agriculture, Washington, D. C. Others may secure the charts at 5 cents each or 50 cents per set from the Superintendent of Documents, United States Government Printing Office, Washington, D. C.

Ohio Valley Region (Ohio, Michigan, Tennessee, Kentucky, and Indiana).

18. Locust Reclaims Gullied Areas Within Three Growing Seasons. 5 cents.
19. Contour Furrows. 5 cents.
20. Winter Cover Saves Soil. 5 cents.
21. Soil Erosion Destroyed This Community. 5 cents.

Southern Great Plains Region (Kansas, Panhandle Areas of Texas and Oklahoma, and eastern New Mexico and Colorado).

22. Wind Erosion in the Great Plains. 5 cents.
23. Vegetative Cover for Wind Erosion Control. 5 cents.
24. Water Conservation in the Great Plains. 5 cents.
25. Conserving Range Lands of the Great Plains. 5 cents.

