The National Cooperative Soil Survey of the United States

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Cover—Soil Surveyor Wallace Roberts of the Tennessee Experiment Station uses an Abney level to determine slope for the soil survey of Knox County. December 19, 1941. Photograph by Forsyth. December 19, 1941. Negative N-2666. Record Group 16, Records of the Office of the Secretary of Agriculture. National Archives, College Park, Maryland.

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A thesis presented by David Rice Gardner to the Graduate School
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Foreword

David Rice Gardner submitted this thesis, "The National Cooperative Soil Survey of the United States," to the Graduate School in Public Administration of Harvard University as a requirement for his doctoral degree in 1957. As a soil scientist in the Soil Conservation Service, David Gardner had seen the soil survey from the inside while working in scientific and technical positions as well as in administrative ones. Dr. Gardner brought these skills to his historical research and writing on the soil survey program.

David Gardner's doctoral thesis has not been generally available to soil scientists. A few soil scientists in the Service read one of the photographic copies purchased from Harvard University by the Soil Survey Division, but soil scientists in field offices had little access to these scant copies. The purpose of this reprint edition is to make the study available to several audiences. Soil scientists in the Natural Resources Conservation Service will have a better understanding of their heritage through reading it. Since knowledge of historical developments can benefit practitioners in their jobs, this edition will be provided to soil scientists in the agency, to cooperators in the soil survey program, and to government depository libraries.

The author and Harvard University have permitted the Natural Resources Conservation Service to reprint the volume and to distribute it. This version is not a photographic copy of the original. It has been retyped, and the format and pagination have been altered to create a more compact volume. In a few cases capitalization and punctuation have been standardized. Otherwise, the volume remains unchanged from the version presented to Harvard University.

Rebekah Davis, historian in the Resources Economics and Social Sciences Division, prepared this version with proofreading and editorial assistance from Faye Griffin and Klaus Flach.

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Chapter 1 Introduction

From unpretentious beginnings of the last century or so, and earlier, the natural sciences have developed at an exponential rate. During recent decades this development has been particularly accelerated. Whether or not the impact of science is considered in terms of the popular contemporary symbolic form of the mushroom cloud, the progress of modern science is an awesome thing.

Very few Americans have ever seen a mushroom cloud, or wish to. The lives of everyone, however (with the possible exception of certain American Indians of the Southwest who may, indeed, be quite familiar with mushroom clouds), have been profoundly affected by scientific progress. This has come about primarily through the technological application of the principles of fundamental science to the solution of the practical problems of essential human activities. Among these is agriculture.

In the American agricultural economy, the last half century has seen an uneven, but continuous, increase in total production without commensurate expansion in total acreage planted; during the same period, and with a growing population, there has been a reduction, not only relatively but absolutely, in the segment of the population engaged in primary agricultural production. Behind the factors contributing to these explicit increases in the efficiency of production (including, be it noted, the political and economic environment) lies a history, first of trial and error, but more recently, of the increased application of capital inputs and of other innovations of agricultural technology based upon principles of the basic sciences. Among the many basic and applied sciences of importance to agriculture is soil science; and among the basic and applied fields of soil science are those relating to study of the genesis, morphology, classification, behavior, and mapping of soils. Collectively, these several fields may be termed, simply “soil survey”. The scientific and technical evolution of these fields during the nineteenth century is the subject matter of the first portion of the present study, and thus constitutes a history, not of soil science, but of the origins of “soil survey” in the United States.

Parallel to the general growth of basic and applied sciences, has been the expanded role of science in the functions of government. This has been particularly apparent in governmental programs dealing with the problems of agriculture. From the pioneering work in a few states and in the Patent Office of the federal government a century ago, have emerged the many present-day activities of federal and state agencies involving the application of science to agriculture. Publicly supported activities in the collective field of "soil survey", noted above, have been carried on principally through the program of the "National Cooperative Soil Survey," a joint federal and state undertaking begun in 1899. The central portion of the present study traces the development of that program, the Soil Survey, down to about 1952. During that eventful half century, the scientific research of the Soil Survey greatly increased the existing knowledge of the nature, distribution, and extent of deterioration of the soils of the United States; inevitably, sweeping changes in established scientific concepts of the soil resulted. Such purely scientific changes, in turn, directly affected the administration of the program, and resulted in further changes in the internal organizational structure of the federal part of the Soil Survey, in relations between the federal agency and those of the cooperating states, and in the relation of the program of the Soil Survey to individual citizens. Some of the mutual interrelationships between the scientific and technological evolution of the Soil Survey, and the development of appropriate administrative structures and procedures are pointed out in the present study.

During and after the national crises of the early nineteen-thirties, public opinion regarding the nature and extent of the responsibility of government to individual citizens, and particularly to farmers, was reflected in widespread political and administrative changes. As they related to the program of the Soil Survey, an important result of these changes was the tremendous expansion of public agencies engaged in the many and varied phases of "land-use planning"; immediately upon such expansion, the demand for soil survey data throughout the country was suddenly and heavily increased. This intensive use of soil surveys served to reaffirm the importance not only of scientific soundness but of greater accuracy and detail in such data, and of the need for improved means of interpreting soil surveys in terms of predictions for alternative systems of management. The Soil

Survey was further affected by the emergence of another federal agency, the extensive field operations of which involved the making of detailed land surveys: this was the Soil Erosion Service (SES) (later known as the Soil Conservation Service (SCS)).[1] In the vain of the second "conservation movement" under the second Roosevelt, the SCS rapidly achieved permanent status in the Department of Agriculture and launched an auxiliary program of physical land surveys which duplicated, in part, the existing program of the National Cooperative Soil Survey. Until their administrative integration in 1952, the semi-independent operations of the two competing survey programs presented a prolonged and unresolved problem of coordination. The various efforts to effect coordination of the nations soil survey activities, and some of the reasons for their failure, as they involved the Congress, the land grant colleges, and the Department of Agriculture are considered in some detail in the concluding portion of the study.

By limiting the frame of reference to the factors affecting the operations of a single, small, specialized governmental program, the Soil Survey, an attempt has been made to illustrate some of the aspects of public administration that are of especial pertinence to the administration of public programs of scientific investigation and application.

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Even though the discussion be limited to consideration of a single specialized program, the pretense implicit in an attempt to relate the seemingly disparate fields of soil science and of public administration demands, perhaps, more than the usual apologies.

In the course of a short, but varied, career with the Soil Survey, the author has had the good fortune to be associated, in a minor capacity, both with the administrative and organizational aspects of the program, and with the scientific and technical work in field and laboratory. Graduate studies also have been undertaken, both in soil science and in public administration. The mutual interrelations of the two fields in a program such as the National Cooperative Soil Survey, which must necessarily draw upon both, have been increas-

1. In 1994, the Service's name was changed once more from Soil Conservation Service to Natural Resources Conservation Service (NRCS).

ingly apparent and of great personal interest. The nature of these interpretations were further impressed upon the author by the difficulty, indeed, the failure, of attempts to discuss only the scientific and technical phases of the Soil Survey in certain chapters of the present study, without reference to administrative structures, cooperative relations, etc. And vice versa.

Chapter 2 Origins of the Soil Survey

2.1 Scientific Origins of the Soil Survey

The origins of any science, and hence of a scientific agency, may be traced back through the ever more rudimentary work of alchemists, philosophers, priests, etc., almost to the dawn of time. The idea of mapping and classifying soils for a definite purpose seems to have been understood and acted upon by the Chinese under the Yao dynasty as early as the third millennium before Christ (206). Subsequent evidence of interest in, and study of, the soil through the Greek, Hebrew, Roman, medieval, and renaissance cultures has been recorded in detail elsewhere and will not be noted here (150), (72), (277).

Such references constitute the early history of soil science. For the purposes of the present study, the scientific origins of the Soil Survey, the discussion begins, perhaps arbitrarily, with the nineteenth century. The selection of this starting date may not be entirely arbitrary, however, if one would accept Marbut's opinion that

> Probably the most striking fact in all economic history is the almost complete lack of improvements of any kind in agriculture in western continental Europe from the time of the fall of Rome to the close of the eighteenth century (172):8.

The nineteenth century scientific developments which contributed most to the ultimate establishment of the Soil Survey in 1899 were in the fields of geology (particularly geological surveys), and of agricultural chemistry (particularly soil analysis). Developments in these two fields are discussed separately in the two chapters that follow. The subject matter is primarily American, and references to contemporaneous European work in geology or agricultural chemistry are noted only to the extent that they directly influenced scientific progress in this country.

A third field of scientific inquiry might have been included among the scientific origins of the Soil Survey, the development, in the late nineteenth century, of the use of experimental fields for the orderly and regulated field study of the response and behavior of particular crops on particular soils. Such field experimentation was begun at the Rothanstead Experimental Station in England in 1843, but establishment of comparable work in this country was a slow and gradual process. By the time the Soil Survey was initiated, therefore, relatively few American experimental fields had been in operation long enough to have accumulated reliable records of crop yield or response. Nor had there been any means to characterize and classify accurately the soils of such plots. Actually, the full value of field experimental work, and the extension of experimental results, could not be realized until after techniques of soil identification and mapping, in other words, soil survey techniques, were themselves evolved. Thus the work of the Soil Survey and that of experimental field research in soil and crop management have made tremendous mutual contributions, one to the other. Such contributions, however, were made largely after, rather than before, the establishment of the National Cooperative Soil Survey in 1899.

2.11 Geological Surveys

Prior to the start of the National Cooperative Soil Survey in 1899, and to some extent thereafter, questions regarding the origin, nature, and distribution of soils in the United States were considered to be primarily geological problems, and field studies of such matters were largely the work of geologists. The following discussion traces briefly the nineteenth century development of the geological sciences, particularly geological surveys, as they influenced the subsequent emergence of the Soil Survey.

* * *

Until about the end of the first quarter of the nineteenth century, there was little geological work, and no state geological surveys, undertaken at public expense. Nor had the earth sciences advanced to the point where there were available many scientists with geological training adequate for such studies and surveys. In the days when a gifted man could, by the age of twenty-five, acquire a fairly thorough grasp of all science in general, contributions to the body of principles of what was to become the science of geology were made by versatile philosophers of all hues. Physicians, because of superior technical training, were especially well equipped to apply the scientific method, and were among the most observant and prolific of the early "geologists." Schopf, for example, who was perhaps the first student of American geomorphology, had come to this country originally as a surgeon with the Hessian mercenaries of the Revolutionary War (182):208. The Bar and the Clergy also provided men of intellect who observed and theorized about the nature and origin of the earth about them.

These early, essentially freelance, students of geology included within their studies observations on the nature and occurrence of soils. There were understandable differences of opinion among them, particularly as to the origin of soils. One observer, in a paper read before the American Philosophical Society in 1815, attributed the existence of soils to

> ... the decomposition of an immense deposit of vegetables which the ocean had left uncovered by other deposition (182):224.

Perhaps more representative of the general understanding of soils at the time was the statement by Amos Eaton in 1818 that

> ...all soils, excepting what proceeds from decomposed animal and vegetable matter, are composed of the broken fragments of disintegrated rock. From this fact it is natural to infer that the soil of any district might be known by the rocks out of which it is formed (77).

Eaton, a lawyer by training, was among the first Americans to conduct systematic field studies of the relation of geology to agriculture, and his statement of 1818 regarding the coincidence of soil distribution and geological formation was to characterize field studies in soils and geology for nearly a century.

As data from field observations accumulated and as educational institutions began to devote more attention to the earth sciences, the theoretical framework of modern geology took form. By 1828 the significance of the correlation of fossils was recognized and the basic principles of stratigraphy established. In the more important, to soil studies, field of surficial geology, however, theoretical progress was somewhat stultified by the requirement of Scriptural conformity. In such matters, the limits of hypothesis were restricted by a public and professional opinion which was

> ...decidedly against the study of geology or the investigation of any question which might lead to the discovery of supposed inconsistencies in the Mosaic account of creation or to conclusions in any degree out of harmony therewith (182):215.

Thus, surface formations in Duchess County New York, subsequently recognized as glacio-fluvial deposits of late Pleistocene age, were characterized in the early studies as being of an age, “subsequent to the creation, and even the deluge” (183):301. Similarly, evidences of glacial abrasion and the presence of glacial debris on Cape Ann, Massachusetts, ware ascribed to

> ... a deluge of tremendous power...Nothing but a substratum of syenite could have stood before its devastating energy (183):307.

Such philosophical limitations, however, as well as other theoretical misconceptions did not seriously impede the increasingly extensive field studies of geology and, generally as an incidental activity, of soils. Beginning in 1820, geological surveys were made of counties and other small areas. In the years following 1830, surveys of entire states were made and remade.[2/]

As casual geological studies gave way to systematic geological surveys, the pioneering work of lawyer-geologist Amos Eaton was particularly prominent. Under the direction of the Agricultural Society of Albany County, New York, Eaton, (assisted by T. Romeyn Beck), completed a geological survey of the County in 1820. A report of the survey was published the following year (76). In the course of the Albany County survey, field studies were undertaken and chemical and physical analyses made of a few selected soil samples. In the analyses, determinations were made of the amounts of "silex" (sand), "ilalumine" (clay), soluble salts, organic matter, carbonate of lime, oxide of iron, and water, in the classification of the soils of the County, a distinction was made between "geest," described as ",..the proper unmoved soil," and "alluvion," or "...that which has been conveyed from a distance by water and exists in thick beds." The "geest" soils were further subdivided, on the basis of the proportions of "silex," into "granulated soil," "hardpan," "upland loam," "upland clay," and "lowland loam." For each of the different kinds of soil, the survey report listed varying recommendations of practices such as "clovering," "marling," "plastering," "admixing with sand," etc.

From the standpoint of its pertinence to the present study, the significance of the Albany County survey of 1820 lies in the application of geology to agriculture by means of the analysis and classification of soils. The novelty of this type of application was acknowledged by the authors. In the preface to the report they stated,

> The present, so far as it has come to our knowledge, is the first attempt yet made in this country, to collect and arrange geological facts, with a direct view to the improvement of

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2. The literature contains a comprehensive treatment or these early surveys, in addition to the publications of the surveys themselves. The most exhaustive study of nineteenth century state ecological surveys is the work of George P. Merrill, (26), (27), (29); the legislative background of the surveys is covered by C. W. Hayes (104); A. C. True provides an analysis of many of these early surveys as they related to agriculture (30); and George N. Coffey, drawing heavily on the work of Merrill, presents the most thorough review of the surveys in terms of their contributions to knowledge of the distribution and classification of soils (31).

> agriculture. From this circumstance, we were under the necessity of adopting a plan for the regulation of our course of inquiry, without the aid of precedent. Should other counties deem the example worthy of imitation, they may, perhaps, find it of use to be acquainted with the method pursued (78):5.

This claim to priority has been generally accepted by subsequent American students, including Coffey, who referred to the work of Eaton and Beek as

> ...the first attempt at classifying the soils of a definite part of this country (64):136.

The work of Eaton and of others in localized areas stimulated interest in the possibilities of making geological and natural history surveys of individual states. The first state to authorize and to complete such a survey was Massachusetts. Authorization for a general survey of the Commonwealth was granted in 1830, and expanded in 1837 to provide for the appointment of

> ...some suitable and competent person whose duty it shall be, under the direction of his excellency the governor, to make an agricultural survey of the Commonwealth, collect accurate information of the state and condition of its agriculture, and make a detailed report thereof with such exactness as circumstances will admit (184):154.

An acceptably "suitable and competent person" was found in Doctor Edward Hitchcock, Minister of the Gospel, Professor of Geology, and, later, President of Amherst College. As to the relative emphasis to be placed on the solution of practical problems, as distinct from purely scientific aspects of the survey, Hitchcock was informed that

> It is presumed to have been a leading object of the legislature in authorizing the survey to promote the agricultural benefit of the Commonwealth, and you will keep carefully in view the economical relations of every subject of your inquiry, By this, however, it is not intended that scientific order, method or comprehension should be departed from. At the same time, that which is practically useful will receive a proportionally greater share of attention than that which is merely curious; the promotion of comfort and happiness being the great end of all science (184):155.

This was not to be the last time that a watchful legislature would attempt to curtail the "pure science" activities of a publicly supported scientific survey agency.

Published in 1841, Hitchcock's report included, in addition to the geological and biological data, a section on the analysis and classification of soils of Massachusetts. More significantly, the report included a hand-colored map of the geological provinces of the Commonwealth, with the explanatory statement that

> In general, if anyone wishes to know where to find... (the different soils)...let him look at the Geological Map...and he may conclude that the different soils cover those portions of the surface that are represented as occupied by rocks from which they are derived (128):16.

As far as is known, this was the first map to be published in the United States with the intended purpose of showing the character and distribution of soils.

Analyses for a number of chemical soil constituents were made (see chapter 2.12), but the basis for soil classification was almost entirely geological. [3] Accordingly as the geological formations were granite, limestone, alluvium, etc., the soils found in such areas were classified as:

1. Alluvium:
   a. From rivers
   b. Peaty
2. Diluvium:
   a. Sandy & gravely
   b. Argillaceous
3. Tertiary soil:
   a. Argillaceous
   b. Sandy
4. Sandstone soil:
   a. Red
   b. Gray
5. Graywacke soil:
   a. Conglomerate
   b. Slaty, gray
   c. Slaty, red
6. Clay slate soil:
7. Limestone soil:
   a. Magnesium
   b. Common
8. Mica slate soil:
9. Talcose soil:
10. Gneiss soil:
11. Granite soil:
12. Syenite soil:
13. Porphyry soil:
14. Greenstone soil:

(128)

3. It was noted, however, that there was not perfect coincidence between the distribution of rocks and that of soils. Instances of nonconformity were attributed to an unexplained "diluvial" movement of soils from North to South. In a post- script prepared after the text had gone to press, clergyman-geologist Hitchcock identified the "diluvial" action as glacial in origin thereby acknowledging and accepting the conclusions of Agassiz' "Etudes sur les Glaciers," published in 1840.

In a concluding comment upon the migration of young New England farmers to the more fertile lands of the newly opened West, Hitchcock, apparently a Yankee among Yankees, cautioned that

> ...the history of the world leads us to fear that New England character cannot long be preserved except upon New England soil; or upon a soil that requires equal industry for its cultivation. Place New England men where the earth yields spontaneously, and the locks of their strength will soon be shorn (128):120.

The Massachusetts survey was soon followed by others, including that of New York State, published in 1846. The New York survey report, prepared by Doctor (of medicine) Ebenezer Emmons, included a hand-colored map with delineation of six “Agricultural Districts” of the state, primarily on the basis of geology (82).

The steady expansion of state geological and natural history surveys at mid-nineteenth century reflected a general atmosphere of interest and support in the various legislatures. There were occasional instances of legislative opposition, however, such as that involving appropriations for the State Geologist of Arkansas in 1858. While the Arkansas legislature had, in David Dale Owen, one of the most competent state Geologists in the nation, it had also a sharp-witted member who was determined to abolish the state Geological Survey. Unable to defeat the appropriation for Owen, the disgruntled legislator offered the following amendment to the appropriation bill:

> Sec. 12. The same amount which is appropriated to the state geologist shall likewise be appropriated to a phrenologist...and a like amount to an ornithologist and their several assistants, who shall likewise be appointed by the governor, and shall continue in office fifty-four years...and the secretary of state shall forward one copy of each report to the governor of each state in the Union except such as may be known to be black republican governors; also, a copy to the Queen of England, and to the Emperors of France and Russia; also a copy to the Queen of Spain; provided that government will sell Cuba to the United States on reasonable terms.
>
> Sec. 13. It shall be the duty of the phrenologist to examine and report upon the heads of all the free white male and female citizens in the state, and their children, except such as may refuse to have their heads examined (182):483.

Whatever may have been the fate of the state phrenologist of Arkansas, the year 1858 was an historic one for the state Geological Survey of Mississippi and for the subsequent development of soil science and soil surveys in this country. The Mississippi survey, begun in 1858 and published in 1860, was the first important contribution of a young Bavarian-born geologist, Eugene Woldemar Hilgard. Hilgard's survey work in Mississippi marked the beginning of a career of over sixty years of professional work. His contributions to soil science, while never adequately recognized in this country until long after his death, have established his status as the first, and in many ways the greatest, of American soil scientists. His investigations of the South and in the West impressed upon him the potentialities of soil survey work. In his later years, he maintained a continual (if by no means uniformly sympathetic) interest in the conduct of the National Cooperative Soil Survey.

The 1860 Report on the Geology and Agriculture of Mississippi was unique in several ways. While ostensibly a geographical and geological study, the survey report was also a practical handbook for farmers. Fully half the text was devoted to the "Agricultural Report," the first chapter of which was a discussion of the "Principles of Rational Agriculture," In this chapter, and in other parts of the Agricultural Report, Hilgard stated several basic principles of what was later to be known as "soil survey interpretation". One such principle was the maintenance of a clear distinction between objective observations and basic data regarding soils on the one hand, and judgments and interpretations of such data for purposes of agriculture on the other. He demonstrated the great value of such interpretations, however, and readily assumed responsibility for making them: "The agricultural chemist, therefore, ought not only to make the analyses, but also to interpret them to the agriculturist" (119):vi.

In another perceptive statement of principle, Hilgard expressed both his confidence in the then highly questionable value of soil analysis, and his understanding of the means of its application.

> It is often by no means easy to take correctly specimens of soil intended to represent a district of some extent; it is necessary, in the first instance, to study closely all the general characters, and upon that study, to base the selection of representative

> specimens. And I am convinced that by conscientious observance of this method, it is practicable in this state at least, to study the essential features of all the soils... from a limited number of specimens, and 'without an approach to anything as extravagant as the analysis of the soil of every field' as has been thought necessary.
>
> ...attentive study will generally succeed in reducing the mass of soils to a few principal types (and their intermixtures), recognizable by their physical characters or position. In Mississippi, most soils are dependent upon continuous deposits extending over considerable areas, within which they are, to a great extent, of a uniform character, or, at least, vary uniformly (119):205.

As a scientist dependent upon a state legislature for funds with which to pursue his science, Hilgard, like Hitchcock before him, was perhaps not unaware of the appeal of the immediacy and practical applicability of the agricultural portion of his survey report which, as he noted,

> ...appeared to meet the particular approval of the gentlemen constituting the legislative committee, to whose examination the manuscript was submitted. (119):vi.

In the Agricultural Report, Hilgard discussed the everyday problems of soil management in nontechnical terms (to the extent that this was possible for the young Heidelberg trained scientist). Among a number of practical suggestions for better farming practices was his recommendation of circling (i.e. cultivation on the contour), as a "...cure for washes" (control of soil erosion).

Hilgard's understanding of the principles underlying the use of soil surveys and other research was, in 1860, many years in advance of the development of techniques of soil characterization, soil analysis, and field mapping adequate for the full application of such principles. His classification of the soils of Mississippi was not significantly different from the geologically oriented systems in use elsewhere. In the agricultural map which accompanied the report, however, he did introduce the additional criterion of natural vegetation in the delineation of such areas as "Pine upland soil," "Long-Leaf Pine soil," etc.

Following the interruption of the Civil War, Hilgard resumed his work. (Loyal to his adopted Magnolia state, he spent the war years devoting his considerable knowledge of chemistry to the production of munitions for the Confederacy). He joined the faculty of the

University of California in 1875 and continued extensive field and laboratory studies of soils. Working amid the great variety and complexity of California soils, Hilgard recognized an increasing number of soil characteristics and attempted to relate differences in such characteristics both to factors of soil formation, and to differences in soil response and behavior under agricultural use (120).

On the occasion of the tenth U.S. census in 1880, Hilgard was asked to prepare a report on cotton production in the United States. (The census report, although obviously not a geological survey, is noted in the present chapter because of its implications in conservation policy and in the development of soil survey principles and techniques).

In terms of early conservation policy, the 1880 census included a prescient comment on the consequences, good and bad, past and future, of the exploitive expansion of nineteenth century America. In his Introduction to Volume III of the Agricultural Census, Francis A. Walker, a leading American economist, General Officer of the Army, and Director of the Census wrote

> Down to this time our apparently wasteful culture has, as I have sought to show, been the true economy of the national strength; our apparent abuse of the capital fund of the country has, in fact, effected the highest possible improvement of the public patrimony. Thirty eight noble states, in an indissoluble union, are the ample justification of this policy. Their school houses and churches, their shops and factories, their roads and bridges, their railways and warehouses, are the fruits of the characteristic American agriculture of the past.
>
> But from a time not far distant, if indeed it has not already arrived, a continuance in this policy will be, not the improvement of our patrimony, but the impoverishment of our posterity. There will be all the difference between the past and the future, in this respect, morally, economically, and patriotically considered, which there is between the act of the strong, courageous, hopeful young man who puts a mortgage on his new farm that he may stock it and equip it for a higher productiveness and the act of the self-indulgent gentleman of middle life who encumbers his estate for the purpose of personal consumption.

Hilgard's portion of the census report dealt, not with policy, but with the "Agricultural and Physico-Geographical Descriptions of the Several Cotton states and California" (122). This report, like his Mississippi survey of twenty years earlier, included the essentials of an embryonic soil survey report, maps, upon which were delineated "homogeneous" soil areas; data from chemical and physical analyses of soil samples representative of these large areas; descriptions of soil and land conditions in such areas; records of land use patterns and crop yields in the different areas; and reports of current and/or recommended farming practices.

The types and interpretations of soil analyses made for the census survey are noted in chapter 2.12. The "agricultural maps" were lithographed in color for each state at a scale of about fifty miles to the inch. The designations and delineation of certain of the "soil areas" on these maps reflected the increasing weight assigned by Hilgard and his associates to natural vegetation as a soil forming factor. In his general discussion of the work, Hilgard wrote

> Since differences of soil necessarily find their expression in the vegetation covering the ground, the designations of the regions are largely based upon the characteristics in regard to tree growth (122):15.

This use of natural vegetation as a mapping criterion was most prevalent in soil areas of the broad region of the Atlantic Coastal Plains such as "Live Oak Lands," "Southern Wire Grass and Pine Barrens," "Oak and Hickory Uplands with Long Leaf Pine," etc.. In the description of one of these areas, the "Cane Hills" of Mississippi, Hilgard reported

> ...little land susceptible of cultivation has remained untouched; and the cultivated lands, originally highly productive, have by the usual process of exhaustive cultivation, turning out, and washing away of the surface soil, been greatly reduced in fertility, The Bermuda grass has almost throughout taken possession of the slopes, preventing their washing and affording pasturage for cattle (122):45.

As noted in chapter 3.122, erosion conditions in this area of Mississippi were delineated in 1901 in the first instance of erosion mapping by the National Cooperative Soil Survey (85):367.

In the more mountainous regions, with predominantly "residual" soils, geological criteria again were controlling factors in the delineation of such areas as "Magnesian Lime Stone Lands," "Devonian Lands," "Siliceous Lands," etc. In the great unknown that was the State of California, the dearth of accurate field data on geology and vegetation, let alone on soils, resulted in the use of altitude as a mapping criterion in the delineation of "soil areas" in the Sierra Nevada Mountains and foothills (122).

The agricultural maps, therefore, showed the distribution more of general geographic associations than of soils, per se. In this respect, Hilgard's maps were less truly soil maps than were those of his contemporary, T. C. Chamberlin of the Wisconsin Geological Survey (57). In his exacting standards for soil analysis, his recognition and interpretation of soil characteristics, and in his techniques of field study and sampling of soils, however, Hilgard anticipated many of the subsequent achievements of the American Soil Survey. Shortly before the establishment of the Soil Survey in 1899, he wrote:

> Actual field surveys to define the agricultural subdivisions and to study their peculiarities should be made by parties covering ably not only the agricultural, but also the meteorological, geological, and botanical aspects of the several problems. This will be but simple and tardy justice to the fundamental industry upon which the very existence of nations depends (123):59.

While Hilgard's work was the most prominent, there were, as noted above, an increasing number of other state surveys of geology, natural history, and agriculture before 1900. Among these was a survey and report on "The Soils of Tennessee" by C. F. Vanderford in 1897 (298). The Tennessee report is of interest to the present study in that it represented a cooperative effort in which Milton Whitney of the newly formed Division of Soils of the U.S. Department of Agriculture provided "... advice and assistance in the preparation of the soil map and in making the mechanical analyses" (298):2. This cooperative approach was a forerunner of the federal-state structure of the National Cooperative Soil Survey which emerged two years later. The publication of the report and the cooperative agreements involved were the work of Charles W. Dabney, Jr., President of the Tennessee Agricultural Experiment Station. (As noted in chapter 2.2, Dabney, as Assistant Secretary of Agriculture in the second Cleveland Administration, had been instrumental in establishment the federal

Division of Soils under Whitney in 1894). The basis for soil classification used in the survey was purely geological, but in other respects, the report was one of the most advanced of its time. The need for both chemical and physical soil analyses was cited as well as the great importance of careful field observation in the selection of representative soil samples for analysis. In the description of the farm land of Tennessee, extensive soil erosion and deterioration were given as causes for the abandonment of an estimated 1,000,000 acres of formerly cultivated land.

An additional point of interest in the Tennessee report of 1897 was the illustration of a new technique for removing and mounting full-size “prisms” or vertical columns of undisturbed soil to a depth of three or four feet. The idea of preparing and using these “soil monoliths“ apparently reached Tennessee via the Chicago International Exhibition of 1893; among the Russian exhibits at Chicago was a large display of mounted soil monoliths, brought to this country and explained by a Russian pedologist, perhaps V. Williams (Charles E. Kellogg, personal communication). Sixty years after publication of the Tennessee report, such soil monoliths are widely used in this country and in Russia by soil scientists and soil conservationists in teaching and demonstration.

* * *

Before leaving the discussion of geological surveys and their relation to soil surveys, mention should be made of <u>the</u> Geological Survey. While state geological surveys, such as those noted earlier above, were expanding, there was a comparable though belated increase in such activities by the federal government. The earliest national surveys had been primarily explanatory in nature, for the purpose of establishing boundaries and obtaining military and geographical information about the unknown Western domain. By 1879 the field had become crowded by the several federal agencies engaged in various types of surveys. These included

1. The Geological Exploration of the Fortieth Parallel (War Department).
2. Geological and Geographical Survey of the Territories (General Land Office).

3. Geographical and Geological Survey of the Rocky Mountain Region (Smithsonian Institution and Department of Interior).
4. Geographical Survey West of the One Hundredth Meridian (War Department).
5. Coast and Geodetic Survey (Treasury Department).
6. Cadastral Survey (General Land Office) (141).

In what Henry Adams termed "...almost its first modern act of legislation," Congress created a single agency, the Geological Survey, with assigned responsibility for the essential functions of the above surveys (5):312. The Geological Survey of the Department of Interior, significantly a civil, not a military agency, came into being on March 3, 1879 when the organic act was signed by President Hayes (216):4. As noted in chapter 4.1, organic legislation such as the above, which established the Geological Survey, was not enacted for the specific authorization of a national soil survey.

Under its authorizing legislation, the Geological Survey was assigned responsibility for "...classification of the public lands" (257). This authorization did not result in any program of detailed soil examination and mapping by the Geological Survey, but through this, and through other provisions of the organic act of 1879, a national program of topographic and geological mapping was carried forward. Thus were made available controlled planimetric maps which for many years were used as base maps in the program of the National Cooperative Soil Survey.

In the twenty year interim between the birth of the Geological Survey and that of the Soil Survey, the older agency made another contribution to the newer. This was the publication (as a part of the Twelfth Annual Report of the U.S. Geological Survey, 1891) of a monograph on "The Origin and Nature of Soils" by Nathaniel Southgate Shaler. The paper was essentially a scientific treatise on soils, but Shaler noted also the then current "serious debate" revolving around "...the measures of governmental interference with the ownership of the fields and forests" (229):219. He clearly stated the case for an expansion of scientific and technological study of the soil resource so that

> ...this slight and superficial and inconstant covering of the earth should receive a measure of care which is rarely devoted to it (108):219.

Shaler, like George Perkins Marsh, Hilgard, and others before him, described the present and potential hazards of soil erosion, and speculated that

> When in the future a proper sense of the relations of the soil to the necessities of man have been attained and diffused we may be sure that our successors will look back upon our present administration of this great trust with amazement and disgust; they will see that a state of society in which man took no care of the rights which the generations to come have in the earth lacks one of the most essential elements of a true civilization (229):345.

With reference to the relationship between erosion hazard and conditions of soil, slope, and land use,

> it is most important that the conditions of this rapid erosion, which is likely to take place on a large part of the lands of the earth, should be clearly understood and its consequences distinctly apprehended. The prime cause of this danger is due to the reckless effort to win for plow tillage land which is fit only for other and less unnatural forms of culture. Wherever the inclination of the slope exceeds about 50 of declivity (or one in twelve), except where the soils are remarkably permeable to water, it may in general be said that justice to mankind demands that the field be as far as possible exempted from the influence of the plow. Such land should be retained in grass or in orchard, or used as a nursery for timber (229):332.

Shaler did not deal with the problem of soil classification beyond grouping soils, for means of discussion, into general classes based primarily on geological origin. These included "Cliff talus soils," "Glaciated soils," "Volcanic soils," "Swamp soils," etc. and "windblown soils," the extent of which he, even as many later investigators, greatly under-estimated (229).

2.12 Soil Analysis

In the preceding chapter, the development of geological and agricultural surveys during the nineteenth century, and their influence upon soil investigations were discussed. The application of these early geological surveys to practical problems of agriculture was attempted primarily through the medium of chemical and physical analyses of samples of soil taken in the course of the surveys. Some of these types of soil analysis were noted briefly. The following is a more detailed account of the history of soil analysis during the same period, and of the influences, favorable and otherwise, upon the subsequent development of the Soil Survey.

* * *

In the final, violent, decade of the eighteenth century, Lavoisier had lost his head and Priestly had only narrowly escaped with his. Between the two of them, however, they had, by the dawn of the nineteenth century, helped to establish the foundations of modern chemistry.

The application of the new science to agriculture was immediate. In the English-speaking world, this application received its greatest impetus through the work of Sir Humphrey Davy. Agriculture was only one of Davy's many and varied interests, but his "Elements of Agricultural Chemistry," published in 1821, was widely read and accepted in Europe and America. In this book with a confidence rarely found among soil chemists of the Atomic Age, Davy wrote,

> If land be unproductive, and a system of ameliorating it is to be attempted, the sure method of obtaining the object is by determining the cause of its sterility, which must necessarily depend upon some defect in the constitution of the soil, <u>which may be easily discovered by chemical analysis</u> (74):10. (Underlining added)

Almost identical views were published the same year in this country by G. W. Featherstonhaugh of New York state (83):55.

As noted in the preceding chapter, various types of soil analysis were made in connection with most of the early geological surveys. Almost from the first, however, the validity of the results of chemical analysis was under suspicion. As early as 1827, Amos Eaton (cited as the first American to classify the soils of a definite part of the Union), recorded the lack of correlation of chemical soil analysis with crop production, and concluded that

> ...the fertility of the soil does not depend upon ultimate chemical constitution, but rather upon physical properties (64):117.

Another disenchanted practitioner of chemical soil analysis was Edward Hitchcock, also cited. As a part of his geological survey of Massachusetts in 1841, Hitchcock collected soil samples and had analyses made for the determination of organic matter, carbonate of lime, sulphate of lime, water-soluble salts, water of absorption, magnesia, “siliceous” deposits from water, and “aluminous” deposits from water. The “aluminous” deposits (probably clay), were further analyzed for content of silica, alumina, and oxide of iron. Hitchcock carefully followed the analytical procedures recommended by Davy, but was much more fully aware of their deficiencies, as he concluded that

> ...probably some have been led to suppose that the chemist by analyzing their soil, would be able at once to inform them what ingredient might be added to insure fertility. This would imply a degree of perfection in agricultural chemistry to which I think the science cannot yet lay claim (128):66.

At mid-century, the use of chemical soil analysis to determine soil fertility received new support from the work of Baron Justus von Liebig, in Germany. Von Liebig was more restrained in his claims for the wonders of agricultural chemistry than Davy had been, but the improved analytical techniques developed by the leader of the German school and his students actually brought the science much closer to the high state of precision which Davy had described. It was still far from precise (163):74.

English translations of von Liebig’s work were available after 1840, and his reputation attracted students from this country. These included Charles M. Wetherill who was to become the first scientist (title: “Chemist”), to be appointed to the newly established United States Agricultural Commission (precursor of the Department of Agriculture), in 1862, and Samuel W. Johnson., who founded the first State Agricultural Experiment Station at Connecticut in 1875 (21), (239).

Among the state geologists mentioned in the preceding chapter, the value of chemical soil analysis received favorable recognition from Emmons of New York, Owen of Arkansas, and, most significantly, from Hilgard of Mississippi and California. Hilgard wrote knowledgeably of the general failure of chemical to provide a dependable clue to soil fertility, but he recognized that it was the techniques, and not the principle of soil analysis which was at fault. He argued against the then prevalent method of total fusion analysis,

> ... for the agents which the chemist uses in the laboratory are much more powerful than those placed at the command of vegetables by nature (119):217.

and

> ...minerals not sensibly attacked by several days' hot digestion with strong hydrochloric acid are not likely to furnish anything of importance to agriculture within a generation or two (121):187.

Hilgard also argued for improved techniques of soil sample selection, and for recognition of the importance of physical as well as chemical soil characteristics (119), (121), (122), (123).

In spite of Hilgard's perception and the breadth of his views, he had remarkably little influence, and his views, however broad, represented a minority opinion. The practice of total fusion analysis, which he had accurately discredited well before the Civil War, remained in wide use up to and including the era of World War 1 (169):388. Partly because of such inadequate techniques, and partly because no one, nor Hilgard, had yet comprehended the full range of variability and complexity of soils, chemical soil analysis fell into disrepute after von Liebig as it had after Davy (126):313.

During the 1870's and 80's, soil analyses of a desultory and inconclusive nature were made by Wetherill's successors in the office of Chemist of the U.S. Agricultural Commission. Such analyses included both physical and chemical determinations. The methods of chemical analysis employed varied from the use of a simple water extract to the "ultimate" or "total" fusion analysis of all soil constituents including the coarse grains of quartz and of other all, but, inert minerals (46), (47), et seq. Little attempt was made to relate the results of these analyses to specific kinds or areas of soil since in the absence of field surveys by the federal government there was little basis for the delineation of such areas. As a result, the selection of samples was frequently haphazard. In 1872, the laboratories of the Chemist conducted a complete analysis of a single soil sample from Texas which had been submitted with the explanation that

> All our soils for many miles in every direction are of the same character; therefore I suppose one specimen would be sufficient (47).

These and other soils investigations by the Chemist had little value of themselves, but they served to stimulate some interest in the need for more thorough field work. In 1878, the then Chemist Peter Collier suggested that

> It would, perhaps, be advisable that systematic work be done in this direction by selecting for analysis soils from different points along the lines of our western railroads, and thus obtaining results which might indicate, approximately, at least, the comparative value of these lands (66):138.

Collier acknowledged, however, that

> ...for such an extended work, no matter how desirable, there is at present no sufficient force provided, and no room for carrying on a work of such extent and of such possible and probable value (66):138.

As noted in the preceding chapter, this was the same year in which Hilgard had cited the need for more detailed field studies of the soils of California (120):483.

During this period there was increasing activity in soil analytical work at the various state Agricultural Experiment Stations, but no further progress was made in the Department of Agriculture until about 1885. In his Annual Report for that year, Chemist Harvey W. Wiley wrote a scholarly review of what was then known, at least by Americans, about the soil. Obviously heavily influenced by Hilgard, from whose work he quoted liberally, Wiley discussed the weathering of rocks, formation of soil, derivation of chemical nutrients from specific minerals, composition of soils, physical and chemical soil analysis, textural classification of soils, geological classification of soils, distinction between surface soil and subsoil, denudation of soils by erosion, influence of soil temperature, and the need for particular care in the selection of soil samples for analysis. While Wiley discussed objectively both the possibilities and the limitations of chemical soil analysis, he reserved his strongest approval for physical analysis, and concluded that the general productivity level of soils was dependent principally upon their mechanical composition or texture (330).

Meanwhile, in 1884, Hilgard's "Physico-geographical" study of the soils of the cotton-producing states, including, prominently, California, was published as part of the tenth national census. In this survey (noted in chapter 2.11), samples taken as representative of the large areas delineated on the "Agricultural Maps" were analyzed for determination of the following soil constituents:

Chemical Analysis	Mechanical Analysis [4/]
Insoluble matter	Gravel more than 1.2mm in diameter
Soluble silica	Gravel 1.0 - 1.2mm "
Potash	Gravel 0.5 - 1.0mm "
Soda	
Lime	Fine earth 0. - 0.5mm "
Magnesia	Fine earth 0.16 - 0.3mm "
Brown Oxide of manganese	Fine earth 0.12 - 0.16mm "
Peroxide of iron	Fine earth 0.072 - 0.12mm "
Alumina	Fine earth 0.047 - 0.07mm "
Phosphoric acid	Fine earth 0.036 - 0.047mm "
Sulfuric acid	Fine earth 0.025 - 0.036mm "
Water & organic matter	Fine earth 0.016 - 0.025mm "
	Fine earth 0.010 - 0.016mm "
	Fine earth 0.005 - 0.010mm "
	Clay less than 0.005mm "

Many more chemical analyses than physical analyses were made, but Hilgard stressed the importance of physical soil data, particularly determinations of the amount of "true plastic clay", to agriculture (122):59.

* * *

As the nineteenth century drew to a close, the need for extensive and systematic field surveys of soils became increasingly apparent. The strong statements in support of such work by Hilgard, Shaler, and others (cited in the preceding chapter) represented a unanimous opinion among the leading soil investigators. Among these individuals, however, there was no such unanimity regarding the relation of soil analysis to such surveys. In the

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4. Hilgard's data., originally expressed in terms of "hydraulic value" for each fraction, have been converted here to the more familiar size diameter usage (126):94.

half-century after Liebig, the controversy over the value of chemical soil analysis had produced numerous and widely divergent points of view.

Chemical analysis though widely used, was still in a primitive stage of development. The chemical purity of reagents was frequently uncertain, and the influence of “micronutrients” was unrecognized.[5/] Even less was known of the processes of plant nutrition, and it was in the nascent field of plant nutrition that there arose a new school of thought which was to have a profound though, fortunately, impermanent effect upon the development of the Soil Survey.

The leader of this new school was Milton Whitney, of the University of Maryland. Like Hilgard, Whitney was acutely aware of the past failures of chemical soil analysis to correlate with differences in soil productivity. Unlike Hilgard, however, Whitney looked upon this as a deficiency, not of techniques, but of principle. Since knowledge of the chemical characteristics of soils had not provided the information needed in accounting for differences in crop production, Whitney looked for something else. Partly a physicist by training, he turned to physics and to the physical characteristics of soils.

Following some preliminary investigations of soils in Maryland, Whitney developed a theory that related soil fertility, and hence crop adaptability, primarily to physical rather than chemical soil conditions. He later expanded upon this theory to the point of almost completely ignoring chemical soil conditions and the nutritional function of chemical fertilizers. Whitney considered that crop adaptability and production were controlled essentially by moisture relations, that the soil characteristics most significant in moisture relations were those associated with pore space, and that, of those, the most important was soil texture. In publishing the results of his work in 1892, Whitney concluded that

> It is a matter of the available water supply maintained by the soil rather than of the available plant food which determines this local distribution of plants (307):12.

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5. Apropos of the slow progress in soil chemistry, Crowther has pointed out that: “The difficulties facing them in chemistry may perhaps best be appreciated by recalling that Newton devoted much more of his working life to chemistry, in which he appears to have achieved little, than to mathematics and physics, which he transformed” (72):113.

and proposed

... to show that the physical properties of soils very largely determine the local distribution and develop menu of plants, and to suggest methods for the study and expression of the physical properties and conditions of the soil (307):ll.

To account for the familiar phenomena of growth responses to applications of chemical and organic fertilizers, Whitney similarly made his interpretation in terms of soil physics rather than of soil chemistry. He explained the beneficial effects of fertilizers as due to a combination of: a) action of the dissolved fertilizers in increasing surface tension of the soil solution and thereby drawing more water up into the root zone; b) the flocculating effects of dissolved electrolytes in aggregating soil particles and thus increasing water retention; or c) precipitation of dissolved organic matter by the salts in the added fertilizers.

Whitney's thesis was immediately attacked with vigor by Hilgard and, later, and even more vigorously, by Cyril Hopkins of the University of Illinois. In a journal article of 1892, Hilgard aimed particularly at Whitney's discussion of the flocculation effect to explain crop response to chemical fertilizers:

...from Whitney's standpoint, it is difficult to see why lime, the most energetic flocculator of both clay and organic matter, is not a universal and all sufficient fertilizer for all soils for all time; and why the ineffectual fires of superphosphate and kainite should ever be needed (124):327.

Even in the field of soil physics itself, Hilgard (who had previously recognized the unique properties and ultra-microscopic size of colloidal clay particles), took issue with Whitney.

There is one point of the greatest moment in the texture of soils to which Whitney does not even allude. This is the difference between mineral powders, how ever fine, ...and the truly colloidal and plastic clay that remains suspended in water almost indefinitely and escapes microscopic measurement... He places the magnitude of the clay particles at from 0.005 to 0.0001 mm, and his calculations of the surface area in soils are presumably based on this figure, He manifestly regards all particles as being of essentially similar physical, or at least capillary character (124):325.

To such scholarly criticism and to the later violent attacks by Cyril Hopkins, Whitney reacted by publishing numerous and increasingly positive reports in defense of his theory. By the time the National Cooperative Soil Survey was initiated a few years later, strong and articulate adherents had been mustered on both sides of the controversy.

At first glance, the above discussion, dealing as it does with theories of soil fertility and plant nutrition, may seem remote from the subject matter of the present study, the technical and administrative development of the National Cooperative Soil Survey of the United States. The ostensibly scientific controversy of 1892, however, was to leave its mark on both the administrative and the technical aspects of the Soil Survey for many a long year.

On the administrative side, the controversy threatened the very existence of the Soil Survey in its early years. Hilgard threw the weight of his prestige into an effort to remove Whitney from his position as Chief of the Bureau of Soils. The Secretary of Agriculture was publicly and bitterly attacked by Cyril Hopkins for retaining and defending Whitney. Good men left, or were forced to leave, employment in the Soil Survey because of differences in scientific viewpoint. Legislative supporters of Hopkins criticized the work of the Soil Survey on the floor of Congress. Federal-state relations in cooperative soil survey work were rendered *non grata* in California as long as Hilgard lived. In Illinois, a generation was to pass before the successors to Cyril Hopkins would make peace with the federal Bureau. And, forty years after the fact, Whitney's stated position on the causes of soil deterioration was effectively cited, to the discredit of the Soil Survey by Hugh Hammond Bennett, the chief of a new and rival federal agency.

On the technical side, Whitney's preoccupation with the importance of soil texture was implicit in his belief that field soil surveys, based upon the recognition of physical soil conditions, would provide the long-sought touchstone for the proper location of crop production. This emphasis on soil texture, while it led Whitney to grossly overstate his case and to become ensnarled in the administrative and scientific difficulties related, may nonetheless be considered as one of his foremost contributions to the Soil Survey and to soil science. Earlier "soil surveys" had dealt with the distribution, not of soils, but of geologic deposits. Hilgard's maps came closer to the soil, but were drawn essentially on the bases of surface geology and of vegetation. The Soil Survey under Milton Whitney, for all its shortcomings, and these will be examined clinically in the course of the present study, consistently recognized and mapped soils in terms of a soil characteristic. This was soil texture. And the recognition of soil texture by men of the Soil Survey led ultimately to the recognition, the mapping, and the interpretation of the still increasing number of soil characteristics known today.

Amid the welter of criticism by his contemporaries, the overriding fact of history is that Whitney, and Whitney alone, started the National Cooperative Soil Survey of the United States.

2.2 Administrative Origins of the Soil Survey

It has been shown that the scientific and technological aspects of the Soil Survey had their origins in the nineteenth century evolution of field geology and of soil analysis. The administrative steps leading up to the actual establishment of the Soil Survey as a functioning cooperative program followed a related, but somewhat oblique course, beginning, perhaps, at Washington, D. C. in August of 1891.

At that time delegates from the states and territories met for the fifth annual convention of the Association of American Agricultural Colleges and Experiment Stations (24). A matter for lively discussion at these meetings was the prospect for increased college and experiment station participation in the operations of the U.S. Weather Bureau (Transferred to Department of Agriculture from Department of War on July 1, 1891). Bitter criticism was voiced regarding the general inadequacy of Weather Bureau reports for agricultural use, and some delegates urged the establishment of official weather observation stations at each state experiment station. In sympathy with this awakening interest by the college spokesmen, a message was read from Mark W. Harrington, newly appointed Chief of the Bureau, in which he invited further experiment station cooperation in meteorological work. While Harrington discouraged the establishment of weather stations at the colleges because of the latter's

> "...remoteness from telegraph and railroad facilities," he recommended that the colleges

...add some special meteorological investigations such, for example, as the relation of forests to climate, reactions of the soil and climate, the influence of climate upon vegetation, ...and similar topics (24):43.

As the meetings closed, the membership adopted the following resolution regarding the new emphasis to be given the work of the Weather Bureau:

> Resolved: that in the future development and extension of the Weather Bureau in the special interests of agriculture, the Bureau should organize and assist in maintaining a study of climatology in its relations to farming, in cooperation with the colleges and stations and that the sphere of this work should be enlarged to include the physics,

conditions, and changes of agricultural soils (24):60. (Underlining added)

Although both Milton Whitney and E. W. Hilgard were present during these proceedings, and clearly were concerned with any decisions involving soils research, there is little evidence that either took an active part in framing the resolution, which was largely the handiwork of I. P. Roberts, professor of soils and delegate from New York, and of Charles W. Dabney of Tennessee, vice-president of the Association.

Weather Bureau Chief Harrington promptly made good on his commitment to enlarge the agricultural applications of the work of his agency. Already clearly under the influence of the work of Whitney (112), Harrington, in his annual report for 1891, cited the August resolution by the college Association, and reported that

> This new field of investigation thus outlined appears so important and so full of promise of results of great practical value to agriculture, if the work is systematically arranged and carried out that I think it would be well to establish a division in this Bureau devoted to the subject of meteorology in its relations to agricultural soils (111):585.

Legislative authorization for the establishment of a Division of Agricultural Soils was not immediately forthcoming. In the meantime, however, the Weather Bureau published Hilgard's monograph on "Relations of Soil to Climate" and published also the first of a series of reports by Whitney, who had undertaken studies in soil physics as an agent of the Weather Bureau (123), (307).

The necessary legislation, such as it was, was provided by the fifty-second Congress in the Agriculture Appropriation Act for 1894, approved March 3, 1893. This Act, although it lost in conference a Senate amendment to authorize special soils investigations by the Division of Chemistry (67), contained, under the subappropriation for the Weather Bureau, authority for "...investigations on the relations of climate to organic life...."(7).

On February 14, 1894, Assistant Secretary of Agriculture, C. W. Dabney, (who, as vice-president of the college Association, had helped to draft the resolution of August, 1891) recommended to the Secretary that the Division be established. In support of his recommendation, Dabney cited the above legislation for 1894, the 1891 recommendation of the Weather Bureau Chief, and "...resolutions of agricultural societies." The following day

Secretary J. Sterling Morton, in a memorandum to Harrington, formally established the Division. On March 3, 1894, at a salary of $2,000 per annum, Milton Whitney was named Chief of the Division of Agricultural Soils (Archives). [6/]

One of the first assignments of the new Division was to assist Dabney in the preparation of a Department publication on soil erosion. “Washed Soils: How to Prevent and Reclaim Them,” published as Farmers’ Bulletin No. 20 in October of 1894 contained etchings illustrating sheet and gully erosion and descriptions of various chemical, engineering, and vegetative practices for controlling erosion and for the reclamation of eroded soils. This was the first publication of the Department of Agriculture on this subject (272), (275).

The somewhat labored, albeit opportune, association of the soils work with the Weather Bureau was short-lived. In the same annual report in which Secretary Morton announced the formation of the Division of Agricultural Soils, he concluded by recommending that it be taken out of the Weather Bureau and established as an independent division in agriculture (336):27. In making this recommendation (which became effective on July 11 1895), it is likely that the Secretary was acting upon the advice of Division Chief Whitney.

For the first year and a half, the existence of the Division was purely administrative. With authority only for “investigations,” the Secretary had established the Division and named the Division Chief. There was some Congressional grumbling over such independent actions by the Secretary (who, in those pre-Hoover Commission days had much less discretionary authority than his successors) but there was no legislative mention of the Division by name until the Agriculture Appropriation Act for 1896 (68):2374. This act designated the Division of Agricultural Soils as distinct from the Weather Bureau and appropriated for it the sum of $15,000 (8). Under the Appropriation Act for 1897, the unit became the Division of Soils (9).

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6. Throughout the present study, documentation based upon materials available only through the files of the National Archives in Washington D. C. is noted simply as: (Archives).

On May 3, 1899 with an annual appropriation of only $16,000, and with authorization only for the

> ...investigation of the relation of soils to climate and organic life, ... [and] ...investigation of the texture and composition of soils, in the field and in the laboratory... (10).

Whitney began field operations of what was to become the National Cooperative Soil Survey. In a prophetic letter of transmittal to President William McKinley, accompanying the initial publication Field Operations of the Division of Soils, 1899, Secretary James Wilson wrote,

> It covers not only the most important work of this division, but, is, in my opinion, regarded in the light of the possible results of the information which has been secured thereby, the most important work of this character ever undertaken in any country (310).

The area mapped in 1899 totaled 720,000 acres of four separate soil surveys in Cecil County, Maryland, the Connecticut Valley, the Salt Lake Valley of Utah, and the Pecos Valley, New Mexico. All but one of these first surveys were made in cooperation with state agencies and Whitney reported,

> Wherever possible it has been the policy of the division to work in close cooperation with the state experiment stations, the state geological surveys, boards of agriculture, or other local institutions. This cooperation, so far as it has been carried, has proved mutually satisfactory and beneficial to the local institutions and to this division. In a general way it relieves the local institutions of all responsibility of the direction of the work and the preparation of the material, while the expense to them is very much less in every case than if they had to employ competent soil experts, even if such experts could be obtained, which is questionable. On the other hand, this cooperation enables the Division of Soils to very materially widen its sphere of field work, and gives the division a desirable connection with local institutions in touch with the people actually interested in the work (310):l5.

This statement of policy, in spite of periodic strains and a few outright schisms, formed the basis for the cooperative structure of the soil survey program which has been strongly maintained down to the present time. The federal monopoly on competent soil experts implied by Whitney, however, was soon lost, as more and more of the state institutions developed soil scientists able to hold their own easily with men of the federal Division.

By 1901, the yearly output of mapping had reached 6,557,320 acres and the program had aroused considerable popular and Congressional interest. Early that year, at the urging of the Secretary, a proposal was submitted to Congress for the elevation of the Division of Soils to bureau status and for a large increase in appropriations for the field work.

This reorganization, however, was not without opposition. Quite aside from the emerging body of technical criticism from leaders such as Hilgard and Hopkins, there was spirited sniping by economy-minded legislators. In a session concerned with such other incidental problems as Indian treaties and depredations, the fifty-sixth Congress debated the reorganization of Agriculture which would create several new bureaus from divisions, Soils among them. One of the skeptics was Congressman A. J. Hopkins of Illinois (no relation to Cyril G.). Disturbed at the $3,000 salary proposed for the Bureau Chief, Hopkins argued,

> They talk about their being scientists and all that, but they were very glad to get their present positions at the salaries that they have, and it is only by reason of their getting in there and getting the ear of the Secretary and of the gentlemen who have charge of the bill that they have succeeded in creating a sentiment with certain parties in favor of the creation of these bureaus (69):2911.

Another spokesman for the opposition, Congressman Mahon of Pennsylvania, read into the record an editorial from the Philadelphia Enquirer which stated, in part,

> Yet there are those who regard with apprehension the advent of the soil physicist upon the field of our Government's paternal operations. There are those who say that this new Man with the Hoe will turn out to be a Man with the Rake before he gets through physicking the soils of this Republic, and that his rake will not leave much surplus lying around loose in the vaults of the Treasury. The scheme of which the soil physicist is the incarnated representative contemplates a chemical, engineering, and microscopic investigation of the various soils of every state and Territory...with a view to the mapping of the soils so that hereafter no American farmer will waste time and money in trying to

> raise cotton in New Hampshire, or spring wheat in the Mohave Desert, or pineapples on the northern slope of Pikes Peak...
>
> It is the vastness of this undertaking that renders interesting to the country the plans of the soil physicist. The farmers do not care much about them. They know, without his assistance, where to plant their pumpkins and where their cabbages... (69):2912.

Perhaps less witty than the opposition, but more effective, was the sober support given to the reorganization by other legislators, such as Congressman Williams of Mississippi, brushing aside the editorial with the comment that its author perhaps knew as much about agriculture as "...a pig about the Pentecost...," Williams argued:

> ...the object of this reclassification, then, may be said to be threefold, ...It is first of all, to group the various kindred divisions together in given bureaus, so that their work may not be duplicated, but may have a common head, dovetailing together for the common good. It is secondly, to divide the purely scientific parts of the work of the Department from its purely clerical parts. In the third place, and this perhaps is as important as anything else, to establish a law of promotion, so that a man when he gets to be a chief of "division" in a scientific department may look forward after a while to becoming a chief of "bureau." Therefore and thereafter men will not so easily accept larger salaries elsewhere because they will look forward to promotion in their own line of work in the Department in the course of time (69):2915.

Following the debate, the reorganization was approved by both Houses and was signed by President McKinley on March 2, 1901. The newly created Bureau of Soils was granted an appropriation of $109,140.00 for fiscal year 1902 (12).

Chapter 3 History of the Soil Survey

In the chapters above, discussion of the origins of the Soil Survey, scientific and administrative, was carried up to about the turn of the century. The following chapters under the general heading of "History of the Soil Survey" trace the development of the work of the Survey from 1899 to about 1952. An attempt has been made to organize this material both chronologically and topically. To maintain chronological sequence, the major subheadings cover significant periods, i.e., "1899-1912," "1912-1920," etc. Topically, the events and developments during each chronological period are organized in terms of three of the major functions of the Soil Survey, "Soil Classification," "Soil Mapping," and "Soil Survey Interpretation." This general scheme of organization is carried through but, since historical events, like soils, do not lend themselves to ideal and perfect classification, there is a certain amount of overlap both in time and in function. The selection of particular years to separate significant periods of soil survey history is purely arbitrary, and events bringing forth changes and a new era in one function, say, of soil classification may or may not be associated with changes in another function such as soil survey interpretation.

For each of the four chronological periods, a brief introductory chapter describes the general political and administrative environment then prevailing, and a summary of the progress of the Soil Survey achieved under such environment. Subject matter suited better to topical than to chronological organization is discussed in separate chapters following those on "History of the Soil Survey."

* * *

A word or two on the usage of a few terms:

(1) The National Cooperative Soil Survey is, by definition, a cooperative undertaking. The major cooperators are the U.S. Department of Agriculture and the several State Agricultural Experiment Stations. Other federal, state, and local agencies also cooperate locally on a smaller scale. For the purposes of the present study, the entire cooperative program is referred to, simply, as the Soil Survey. To distinguish the total program from the agency responsible only for the national or federal portion of the work, the latter is referred to as

the Department, the Bureau, or, more commonly, the federal Division of Soil Survey. The Soil Survey itself, and the federal portion of it, therefore, are separate, though partially inclusive, entities. Because of the unique responsibilities of the federal agency, and the acknowledged need for national leadership, the Chief of the federal Division of Soil Survey (title since 1953: "Assistant Administrator of the Soil Conservation Service, for Soil Survey"), by general agreement, has been recognized also as the leader of the National Cooperative Soil Survey.

(2) As used throughout the present study, the adjective "federal" refers only to activities and agencies within the executive branch of the national government. This is a more limited connotation of the term than that which refers to a form of decentralized governmental structure.

(3) To avoid confusion in discussions of soil classification, an attempt has been made to conform to the terminology and logic of Marlin G. Cline's "Basic Principles of Soil Classification" (61).

3.1 1899 - 1912

The successive Republican Administrations between those of Grover Cleveland and of Woodrow Wilson brought stability to the Department of Agriculture in the person of Secretary James F. "Tama Jim" Wilson of Iowa (whose sixteen year tenure remains the longest of that of any Cabinet officer in the nation's history). Wilson reorganized the Department and, together with outstanding subordinates including Gifford Pinchot, Seaman Knapp, and Harvey Wiley, greatly strengthened Agriculture's programs of research, demonstration, regulation, and with vigorous support from Theodore Roosevelt, of conservation (102):19.

Secretary Wilson was a strong supporter of the Soil Survey, and defended his sometimes controversial Bureau of Soils Chief, Milton Whitney; in the broad sphere of national agricultural policy however, the influence of and the utilization of the Soil Survey was negligible. The achievements of the first "Conservation Era" under the first Roosevelt were spectacular and largely permanent, but the emphasis was on forests, parks, irrigation, water power, coal, oil, and minerals, rather than on soils (29):124. Roosevelt's notable "National Conservation Commission" of 1909, and the "National Conservation Congresses" of subsequent years dealt almost entirely with the conservation of such other resources, and consideration of the soil as an important natural resource was limited to the relatively brief statements by Van Hise, Hopkins, Condra, McGee, Chamberlin, and a few others (297), et seq.

In the more limited sphere of its own operations, this thirteen-year span saw the birth and rapid development of the Soil Survey under Milton Whitney. Cooperation between the federal Bureau and agencies of the participating states was established from the start, and nearly all soil surveys were carried on cooperatively. As a reflection of the general carryover of geological orientation in the soils work, the designated agencies of the cooperating states were initially state Geological Surveys more often than state Agricultural Experiment Stations. (Important exceptions to the generally accepted pattern of federal-state cooperation were in Illinois, where cooperative relations were terminated in 1903, and in California, where they were not established at all.)

After 1909, procedures were established for organized inspection of soil surveys and for correlation of soil types, and a system of soil classification, later discarded, was evolved. By the end of the period, men of the Soil Survey had developed techniques of soil mapping, many of which remained in use for another twenty years. Many of the basic principles and techniques of soil survey interpretation, including the application of soil survey data to general soil management and to soil erosion control, were worked out and applied. And American experience in making and interpreting soil surveys was carried abroad in the first of what was to be come a continuing though intermittent program of technical assistance in soil surveys beyond the continental limits.

The end of the period marked the transition in direct supervisory control of the federal Soil Survey from Bureau Chief Whitney to Soil Survey Chief Marbut, and the distilled philosophy of the Soil Survey as of 1912 was brought together in the major publication "Soils of the United States," issued in 1913 as Bureau of Soils Bulletin No. 96.

Developments in the separate but related fields of soil classification, soil mapping, and soil survey interpretation, are noted in more detail in the chapters which follow.

3.11 1899 - 1912, Soil Classification

The soil mapping of 1899 was initiated essentially without reference to any systematic framework of soil classification. To a large extent, this was inescapable. Although a few tentative classification systems had been suggested in this country (64), and while the Russians had pioneered far beyond (6), there was not, at the turn of the century a sufficient accumulation of data on the soils of the United States for the derivation of more than the rudiments of a theory of soil genesis, or of a system of soil classification. Whitney unquestionably could have made fuller use than he did of the best thinking then extent in the American and European literature but, in any case, he could not avoid the "chicken and egg" dilemma which might be stated as follows. To be identified and mapped accurately, and to be interpreted properly in terms of use, soils must first be classified. Such a classification, however, must be based upon an understanding of the extent, distribution, characteristics, and relationships one to the other, of soils. But such an understanding can come only from extensive field studies and mapping Ergo, the dilemma. [7/]

Writing of the early work, with the advantage of twenty years of hindsight, Marbut recalled that

> There was no body of accumulated knowledge of field soils in existence. Lacking anything of the kind, and yet finding himself under the necessity of establishing some sort of a classification of the soil units as he identified them, the worker was placed in a difficult situation. Having no scheme of classification of soils based on soil characteristics, he was under the necessity of seeking refuge in those earth sciences which had already attained an advanced stage of development (324):3.

Such "earth sciences" were those of geomorphology and surficial geology, and the classification of soils which evolved in the early years was strongly influenced by the nineteenth-century assumption that differences in soils were simply reflections of differences in the underlying rocks.

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7. This philosophical dilemma applies not to soil classification alone, but to classification, per se, as witness 'The Blind Men and the Elephant" of John Godfrey Saxe.

3.111 Soil Type

In one all-important respect, the soil classification used in the Soil Survey departed from the strictly geological correlations of most of the earlier work. The innovation of 1899 was the recognition of texture, a soil characteristic, in the identification of the lowest, and until 1903 the only, category of soil classification, the soil type.

The soil type was initially thought of as a grouping of the soils of a given locality which had in common the same soil texture at the surface. Soil textures were determined in the field and later verification by physical analysis in the laboratory.[8/] Each recognized soil type was denoted by a binomial term consisting of the particular textural class preceded by a place name from the locality where the type was first identified. Thus the soil types recognized in the first year of mapping Jordan sandy loam and Jordan loam (from Utah), Pecos sand (from New Mexico), Podunk fine sandy loam (from the Connecticut Valley), etc. The use of the textural class and place name in the identification of soil types, however, was not without exception. Geological criteria were retained in the identification of such additional soil types as Triassic stony loam, Pecos conglomerate soil, Gypsum loam, etc. (310). An additional soil condition natural drainage while not explicitly recognized as a criterion for the classification of soil types, was nonetheless reflected in the separation of some wet soils such as Jordan meadows., Connecticut meadows, and Miami black clay loam, "... a black loam soil underlain with blue clay subsoil" (313):53.

This emphasis on the importance of soil texture in the differentiation of significantly dissimilar kinds of soils was a direct expression of the theories of soil productivity and plant nutrition then being developed and promulgated in the Division (Bureau) of Soils. As noted elsewhere in the present study, Whitney led a school of thought residing largely in his own agency which sought to relate crop adaptability and soil productivity primarily to

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8. In the connotation used throughout the present study, the term soil texture refers to the various size groups of individual soil grains in a mass of soil. Specifically, it refers to the proportions of clay, silt, and sand below 2 millimeters in diameter (254):05.

rather than chemical soil conditions. As the most obvious manifestation of physical soil conditions, soil texture thus became the primary soil characteristic recognized in the early soil classification and mapping.

The degree of homogeneity within the mapping units shown as soil types on the maps of the early surveys and the level of accuracy with which they were delineated are discussed in chapter 3.12. Considered either as mapping units or as classification units, the early soil types were broadly and loosely defined. Fifty years after the first mapping was begun, the Assistant Chief of the Soil Survey reflected that

> ...the soil type of 1899 was comparable to a fairly broad soil association as defined in 1949 (237):249a

This appraisal would appear to be equally valid in 1957.

*   *   *

The soil type remained the lowest category of soil classification; significant variations within the soil type areas mapped, however, were recognized and referred to as phases. After 1908, such phases were delineated on the maps and considered as subdivisions of' certain soil types. Phases of soil types did not constitute an additional category of soil classification, and the uses of phase subdivisions are noted under "Soil Mapping" in chapter 3.12.

3.112 Soil Series

At the start, the local place names in the soil type designations had no classification significance other than geographical. Of the work done in 1899, Whitney wrote:

> Having determined the final classification of the soils of a locality, each well defined area is established as a class and given a local name (310):31.

Within two or three seasons, however, the rapid accumulation of a cumbersome number of identified soil types and the recognition by soil surveyors of certain relationships between different soil types led to a redefinition of the place name prefix in the soil type designation. The place name, with the new connotation, was established as a second and higher category of soil classification, the soil series. Criteria for differentiation of soil series were almost entirely geological, since it was still felt that

> ...while a classification founded upon texture and upon local conditions may be satisfactory over limited areas, the general classification must rest upon a basis of geological origin, or method of formation, and of topographic similarity (315):42,

and that, therefore,

> ... while a certain series of geological occurrences has been in progress, soil material has been separated out into a sandy portion, a gravely portion, and others of loamy or clayey character. Whenever there is a general relationship between these different classes of soils, due either to their geologic origin, their method of formation, or their location within an area, a common distinctive locality name is used, and the soils thus grouped together are called a soil series (315):35 (underlining added).

The uses of the word "series" in the first and last sentences of the above quotation may indicate the derivation of the term from the analogous "series" of different textural members of a given sedimentary geological deposit. It is also clear that no distinction was made between origin of "soil" and origin of "soil material," or geologic deposits.

Under this definition of the soil series category, it was considered that, to be "complete", a soil series would include soil types ranging in texture

> ...from stones and gravel on the one hand, through the sands and loams, to a heavy clay on the other (274):19.

Few of the soil series ever became quite so all inclusive, but the Miami series of the glaciated regions embraced, in 1906, sixteen soil types, and the Norfolk series of the coastal plain, twelve; the nine soil types recognized in the Hanford series of the Far West ranged from Hanford gravel to Hanford clay adobe (274). Other important soil series were less inclusive but it was assumed that, in such cases, the missing textural representatives existed, but had not yet been encountered.

Following its introduction in 1903, the soil series be came an increasingly important category in the natural classification of soils. For purposes of interpretive classification, or grouping of soils in terms of agricultural qualities, however, the textural classes represented by the soil types continued to have more significance, Thus in his 1911 bulletin on "The Use of Soils East of the Great Plains Region," Whitney made practically no mention of the various soil series, but grouped the soil types of each province, purely by texture into "the sand group," "the clay loam group," etc. (323). The implication was that, in terms of agricultural use in a broad geographic region, soil types of the same texture, but of different soil series were assumed to have more in common than soil types of different texture within the same soil series. Such a grouping was a logical outgrowth of Whitney's theories, noted above, regarding the relation of soil physical conditions to soil productivity.[9/]

As the mapping expanded and reached into newer areas, the numbers of recognized soil series and soil types in creased rapidly. By 1901, a hundred soil types had been identified and by 1904, nearly four hundred, In spite of Whitney's instructions to field men in 1903 that

> It is very undesirable to increase the number of soil types more than is necessary (273):17.

these had been expanded to seven hundred and fifteen types of eighty-six series by 1909, and to one thousand six hundred and fifty types in five hundred and thirty four series by 1912. The relatively greater increase in the number of soil series as compared with that

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9. While Whitney was the first to apply a textural classification of soils on a national basis, he was anticipated, in the general concept of a textural classification, by T. C. .Chamberlin whose Geological Survey of Wisconsin, in 1882, included a generalized map and classification of soils based upon soil texture independent of geology (57).

of soil types indicates the gradual abandonment of the concept of the complete soil series, and the recognition of a more limited range of textural variability within each series.

The rapid increase in the number of recognized soil types was accompanied by, and largely the result of, progressive refinements in techniques of soil characterization. Then (inevitably, as now), such refinements tended to point up the need for revision of earlier surveys. Well aware of the general reluctance to admit the need for such revisions, Whitney, in 1906, wrote:

> Each additional survey throws new light upon the subject, and sometimes necessitates changes in the soil names used in the earlier reports. The student of soils will doubtless realize that the necessity for such readjustments is an inherent feature of work of this character (274) :3.

While geological criteria still generally determined classification at the series level, additional soil characteristics, color and organic matter content, were used in 1904 to differentiate the Marshall series from the Miami series, and the genetic relationship of these soil characteristics to the influence of differences in natural vegetation was accurately reported (81). In addition to soil texture, color, and organic matter, the Soil Survey Field Book of 1906 listed soil structure, lime content, alkali, drainage, erodibility, physiographic position, nature of subsoil, and lithology, origin and age of parent material among the criteria to be considered in soil characterization (274).

By 1907, the influence of natural drainage conditions upon aeration, oxidation, soil color, mottling, and soil organic matter content was recognized. In a soil survey report of that year, a rudimentary form of what was later to be known as the “soil catena” was used in grouping the various soil types in terms of five general classes of natural drainage conditions (88),136.

3.113 Soil Province

As a means of organizing systematically the increasing numbers of soil types and soil series, a third category of soil classification, the soil province, came into use about 1906. Initially, the soil provinces were simply large physiographic regions, without clearly defined boundaries, which, because of an assumed geological and geomorphological homogeneity, were thought to delimit the extent of the soil series occurring within them.

The Soil Survey Field Book of 1906 grouped the sixty one soil series then recognized into thirteen physiographic provinces with the implication that a particular soil series would not occur in more than one soil province (27). The relationship of the soil provinces to their "constituent" soil series was purely geomorphological and was based more on the circumstances of formation and/or deposition of the parent rocks than on their mineralogical character, Thus,

> ... the soil minerals found in the different soil provinces do not materially differ in character, but, ...soil peculiarities characteristic of the different provinces are the results of the operation of the different agencies ... (of rock formation) (317):27.
>
> Soils may, ...be similar in origin and texture but may occupy so entirely different topographic positions that their relation to crops is entirely changed, and this fact would be recognized by the use of another serial name. An example of this is found in the separation of the soils of the Piedmont Plateau and the Appalachian Mts. into Cecil and Porters series (274):19.

By 1911, the soil provinces were firmly established as a categorical level of soil classification, and recorrelations were referred to as, for example:

> Transfer of the Berks series from the Piedmont Plateau province to the Appalachian Mt. and Plateau province; transfer of the Montalto series from the Appalachian Mt. and Plateau province to the Piedmont Plateau province (323):1.

The soil province of 1911 thus was considered as a category both of soil classification and of soil mapping. The subsequent conceptual and practical difficulties arising from the dual nature of this highest category of soil classification are noted in chapter 3.21.

By 1912 the boundaries of the soil provinces were clearly delineated on a large map of the United States. This soil province map, in color, was widely distributed the following year as a part of the monumental Bureau of Soils Bulletin No. 96, in which it was explained that,

> For the purposes of soil classification, the United States has been divided into 13 subdivisions, seven of which, lying east of the Great Plains, are called soil provinces, and six, including the Great Plains and the country west of them are known as regions.
>
> A soil province is an area having the same general physiographic expression, in which the soils have been produced by the same forces or groups of forces and throughout which each rock or soil material yields to equal forces equal results.
>
> A soil region differs from a soil province in being more inclusive. It embraces an area the several parts of which may on further study resolve them selves into soil provinces. Soil provinces and soil regions are essentially geographic features. They are differentiated on the basis of geographic features rather than on that of soil character (168) :7.

The thirteen provinces and regions listed in Bulletin No. 96 (almost identical to those described in the Field Book of 1906), included,

> Piedmont Plateau, Appalachian Mt. and Plateau, Lime stone Valleys and Uplands, Glacial and Loessial, Glacial Lake and River Terrace, Atlantic and Gulf Coastal Plains, River Flood Plains, Great Plains, Rocky Mountain and Plateau, Northwestern Intermountain, Great Basin, Arid Southwest, and Pacific Coast (168):5.

Despite general assumptions regarding homogeneity, the soil provinces and regions covered tremendous areas and embraced vast ranges in conditions of topography, climate, vegetation, lithology, and, hence, of soils. One of them, the “Glacial and Loessial Province,” extended from Maine to Montana, and from the Canadian border to the delta of the Mississippi (168):109.[10/]

* * *

The above discussion of the development of soil classification up to 1912 relates only to the system officially adopted by the Bureau of Soils and applied, with State cooperation, in the work of the Soil Survey. Concurrent progress in soil classification in foreign countries had little direct influence on the American survey program during this period and so lies beyond the scope of the present study. [11/] Nor can consideration in detail be given here to other, and, with hindsight, better, systems proposed in this country. A few of the latter, however, are noted:

Hilgard, because he did not consider that sufficient morphological data on soils had yet been accumulated, never proposed a comprehensive system of soil classification (127):231. In his extensive studies of soil genesis and morphology, however, brought together in his definitive book, Soils, he anticipated by many years the main principles underlying the subsequent classification system of Marbut (126). From this position of strength he did not hesitate to criticize succinctly and accurately the classification system promulgated by Whitney:

> In this he attempts to indicate hundreds of soil varieties by local names coupled with merely physical designations, with utter disregard of differences of climate in which these soils may have been formed, and also of their conspicuous chemical differences.

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10. The administrative structure, as well as the technical and scientific phases of the early Soil Survey, was affected by the concept of the soil province. Supervision of field work was provided jointly by State and federal men of the Soil Survey, but the major responsibility for correlation and inspection of individual soil surveys was assigned to a small staff of "Soil Survey Inspectors" of the federal Bureau. In designating the specific portions of the country for which each Soil Survey Inspector was to have responsibility, the Bureau Chief utilized the existing boundaries of the soil provinces. Limits of the respective areas of responsibility of the several Inspectors generally coincided with boundaries between soil provinces or groups of soil provinces.

It has been pointed out that, in the light of later developments in soil classification, the above administrative structure was subsequently modified so as to redistribute areas of inspection and correlation responsibility (100):7. The geological bases of the soil provinces were discarded and the inspection areas reapportioned to accord more with the distribution of broad pedological zones characterized by the dominant "Great Soil Groups," Thus a clearcut expression of the influence of purely scientific developments upon administration.

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11. Probably the best American review of the foreign work as of 1911 is Coffey's paper of that year (64).

> We thus have a well leached soil from the humid coast of Texas identified with one from the extremely arid region of the San Joaquin Valley of California, and a poor upland soil from Missouri with a rich lowland soil of Iowa, of many times the cultural value merely because of similar physical composition. This is emphatically a Procrustean process (127):228.

From within the Bureau of Soils itself came another soil classification scheme which also anticipated Marbut, and which also ran counter to the views of Whitney. This was the prophetic but unacclaimed work of George Nelson Coffey, a soil surveyor with the Bureau of Soils since 1900. Reflecting the influence of the work of Hilgard and of the Russians, Coffey criticized, though in restrained terms, the emphasis on textural and geological criteria which, in 1909, still dominated the Bureau system (63). In proposing an improved system of classification, in 1912, Coffey argued that,

> In making such a classification, it would be necessary to recognize inherent differences in the soil itself as the fundamental idea; to consider it as a natural body having a definite genesis and distinct nature of its own... (65):34.

Coffey's proposal was a five category system with a number of classes in each category. His highest category consisted of five classes based upon dominant soil conditions reflecting the influence of broad climatic and vegetative regions; differentiation of classes in the next category was based upon the geology of the soil material; the third category was based upon differences in soil color, and the two lowest categories were the already established soil series and at the bottom—soil type (65).

Coffey's thesis was published by the Bureau of Soils as Bulletin No. 85 in 1912. In approving its publication, however, Whitney, by way of damning with faint praise, stated that the Bureau was doing so

> for the purpose of offering it to the scientific world as a contribution to the subject, without endorsing the scheme of classification proposed and without accepting all the conclusions drawn from the facts cited (65):2.

Not surprisingly, Coffey resigned from the Bureau the following year, and took with him one of the best minds in the Soil Survey.[12]

The classification developed by Hopkins and his successors in Illinois and Hopkins' bitter opposition to the work of the Bureau are discussed elsewhere in the present study. From another State came a proposed "Practical Classification of Soils" by E. 0. Fippin of Cornell University. Fippin, a former soil surveyor with the Bureau of Soils, emphasized the need to refine the definition of the soil type, and proposed a seven-category system which retained the soil province, soil series, and soil type categories, but which introduced additional criteria including temperature and humidity in the differentiation of classes in higher categories (94).

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12. One of the founders of the American Society of Agronomy7, of which he was the second president, Coffey remained professionally active for several years after leaving the Soil Survey and clearly influenced the work of Marbut (23):284, -(169):389.

3.12 1899 - 1912, Soil Mapping

In the preceding chapter, the discussion of the evolution (and convolutions) of soil classification in the Soil Survey was brought up to about 1912. Underlying the seemingly abstract and philosophical arguments implicit in soil classification during the same period was the day-by-day job of men making soil maps. Some of the problems, and some of the achievements, in soil mapping during this period are noted.

Beyond the established techniques of field geology and of topographic surveying, there was little in the way of precedent to guide the early field work of the Soil Survey. And even the best geological survey techniques did not provide the degree of accuracy and detail called for, if not always achieved, by a detailed soil survey. The soil surveyors, therefore, developed their own techniques.

Field mapping was done on base maps of scale 1"/mile. Whenever available, topographic quadrangles of the U.S. Geological Survey were used for base maps, but these varied in quality and scale, and frequently required revision and correction (160):344. In the absence of suitable base maps, soil surveyors constructed their own, with plane table, alidade, and compass (161):33, (87):997. This continual need to construct, or to revise, base maps diverted a considerable portion of the soil surveyors time from their primary functions of examining, identifying, and delineating soils.

Field equipment, in addition to the tools of plane surveying, included augers, picks, shovels, and, in the arid West, instruments for the determination of “alkali”. Transportation was by foot, horse-and-buggy, saddle-horse, chuck-wagon, bicycle, and rowboat (161). Soil surveyors in the field were fair game for bulls, bears, boars, and bees, and for assorted bipeds including quick-triggered deer hunters, quicker-triggered moonshiners, and just plain rugged individuals. It was no bed of roses.

In spite of difficulties of transportation and time spent on base map construction, the early soil surveys were made rapidly and economically. In the soil survey of Cecil County, Maryland, in 1899, field men of the Soil Survey mapped at an average rate of five square miles per day at an average cost (for field work only) of $1.70 per square mile (310):13.

Progress was slower, and costs higher in the mapping of irrigated areas of the West, particularly where “alkali” occurred, but the average daily rate of mapping, nationwide, remained at 3 to k square miles per day by 1912.

Looking over the prospects of mapping Johnson County, Illinois with a six-man party in 1903, Party Chief George N. Coffey wrote to Bureau Chief Whitney,

> ...Johnson County is a small county having only 340 square miles. Unless it proves to be very difficult I think we ought to finish it in one month (Archives).

And later,

> The first three days of this week we did not get to do anything on account of rain. The last three we have put in good time and got in 90 miles (Archives).

As techniques improved and as soil type definitions were refined, costs of field work gradually increased from the 1899 figure quoted above to $1.93 per square mile in 1902, $2.66 in 1905, and $3.29 in 1907 (86), *et seq*.

The degree of detail shown on the soil maps also increased considerably during the first decade of the work. In the instructions of 1899, soil surveyors were directed to delineate all soil separations larger than a quarter of a square mile (310):30. Areas this small, and smaller, were occasionally delineated on the maps of the first few years but, more commonly, much larger areas of non-conforming soils were included in with the broadly defined and broadly mapped soil types. Surveys such as those of the Grand Island and Stanton Areas of Nebraska in 1903 show entire townships of 36 square miles without a single soil boundary (314) and, in the survey of the Jackson Area, Mississippi in 1904, only two soil types were shown on an area of 736 square miles (315).

In 1906, and for many years after, the minimum area to be shown as a soil mapping unit (and the maximum area of “inclusions” which would not be so delineated) was set at 10 acres (274):13. Some soil maps of 1906 and 1907 did show soil separations this small, but for the most part, the 10 acre limit (1/64 of a square inch on the field sheets and published maps), was an unrealistic goal in view of the inaccuracy of the base maps, the wide-ranging definitions of soil types, and the prevailing rates of mapping progress.

In spite of such rapid and generalized techniques of mapping, the early soil survey maps were well received. Some criticism, however, arose from a familiar source. In 1903, E. W. Hilgard, reviewing the work of the Soil Survey, wrote:

> But it may be seriously questioned whether it would not be better to cover less ground more thoroughly and be content with less extended and less hasty mapping. This superficial method of work naturally excites criticism, not only at home, but also abroad (125):119.

Whitney acknowledged the lack of detail in the soil maps, but defended the rapid mapping of the Soil Survey. In a letter to another critic, Cyril Hopkins of Illinois in 1903, Whitney asserted that

> In the work on the scale in which the Bureau is engaged, we cannot recognize differences that might and should be recognized in a more detailed survey of a limited area. It is necessary for us to show only important differences in the soils which will be of value to the people of large areas (138):115[13/]

In addition to the 1:1/mile "detailed" soil surveys described above, which remained the major output of the Soil Survey, two other types of soil surveys were initiated during the first decade. The first of these, beginning about 1906, was the mapping at very large scale, of small areas upon which field experimental work was underway or planned. These special surveys are described under "Soil Survey Interpretation." The second type of soil survey undertaken in this period, the reconnaissance soil survey, went to the opposite extreme in detail and scale. These surveys, designed initially to provide general information on soils and agricultural possibilities over large areas, were made rapidly and published at scales of from 1 1/6 miles to 1 1/2 miles. Following the first work in 1908 (North Dakota, Pennsylvania, and Texas), reconnaissance surveys became a permanent and important part of the Soil Survey (320).

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13. One of the founders of the American Society of Agronomy, of which he was the second president, Coffey remained professionally active for several years after leaving the Soil Survey and clearly influenced the work of Marbut (23):284, -(169):389.

Next to the competence of the soil surveyors themselves, the most important factor in maintaining standards of accuracy and detail in the soil maps was the supervision provided by inspectors from the Bureau of Soils and, later, from the States. This supervision and coordination of the survey .work over large areas was even more important in the maintenance of consistency in identification and mapping of soils by widely scattered field parties. Such supervision was thus at once a technical and an administrative function. In the early years of the Soil Survey, it was also a neglected one. Whitney rarely left Washington, and a regular staff of regional inspectors was not set up until about 1909 (161):80.

> The degree of supervisory control maintained, as it appeared to two anchormen on opposite ends of the chain of command, was described in the two Interesting, and completely contradictory, statements which follow:

Bureau Chief Whitney, reporting to the Secretary of the soil survey work of 1903, stated that

> The work of the different parties has been frequently and carefully inspected throughout the year, in order to make sure that it was correct in detail, to correlate as far as possible the soil types, and to advise with the leaders of parties as to the suggestions and recommendations for agricultural improvements which they might safely make in their reports. This inspection is considered of the greatest importance in maintaining the highest standards of efficiency (314):25.

Writing of the same period, Macy H. Lapham, one of Whitney's leaders of parties recalled:

> In the early years of the Soil Survey, there was little organized field inspection, especially of the far western areas remote from Washington. Periods of two or three years sometimes elapsed during which the field parties were rarely if ever visited by supervising personnel or others of the Soil Survey or associated Departmental activities. Much of the time they were left to make their own way without benefit of close contact with their superiors or of the Washington office. In the early period of organized field inspection, the inspectors probably contributed quite as much in the bolstering of morale of lonely and discouraged field -parties as in the technical duties that they performed (160) :349.

From the first, soil surveyors had found, and occasionally reported, local soil conditions which varied in any of a number of ways from those described for the soil types used. Initially such variations within areas mapped as soil types were not delineated, but were discussed in the soil type descriptions in the reports. On some maps the location of these local areas was shown by the use of additional symbols indicating stoniness, swamp, rock outcrop, etc. The term "phase" to denote such local variations came into use about 1901, when a Georgia survey reported

> The Cecil clay is subjected to very severe denudation from the excessive washing of the spring rains. The micaceous phase suffers most from this cause (85):321 (underlining added).

In addition to the geological variation indicated by recognition of the "micaceous phase," additional criteria for the recognition of phase variations after 1904 were reflected as, "badly eroded phase," "shallow phase," "flat phase," "alkali phase," "fold sand bar phase," "hardpan phase," etc.

The use of the phase of a soil type as a mapping unit, with boundaries delineated on the maps, began in 1908 when three depth phases, "shallow," "medium," and "deep", of Norfolk fine sand were shown separately on the map and described separately in the report of the soil survey of Grady County, Georgia (320):374. By 1910 most of the soil surveys delineated one or more phases of one or more soil types, and for many conditions previously classified as phases of established types, new soil types were set up. Two of the most important criteria for recognizing phases, soil slope and soil erosion, are noted in the two following chapters.

3.121 Soil Slope

In the early definitions of soil series, degree of slope, *per se*, was not a differentiating criterion. Since criteria for soil series classification rested heavily upon geomorphology, however, individual soil series, and the soil types within them, tended to occur with characteristic patterns of topography and ranges of slope. Such ranges, however, were frequently extreme. A description of slope conditions of Susquehanna clay loam, in 1904, stated that

> The surface characteristics of this soil vary considerably. With the exception of the fairly level areas bordering the lakes and streams in the northern and southern parts of the parish, the Susquehanna clay loam, occupies rolling areas. In some parts of the parish the erosion of the numerous small streams has imparted to this type a somewhat rougher surface (315):382.

The location of areas where these various different slope conditions occurred was not shown on the soil map.

The first attempt to delineate differences in slope gradients within the same soil type was the boundary drawn in 1901 between the "Cane Hills" and the "Flat Hills" of Mississippi (85):367. (As noted in the following chapter, this boundary also distinguished between two general classes of soil erosion conditions within the same soil type.) This innovation was not used elsewhere, however, for several years. The refinement of soil type definitions and the introduction of miscellaneous land types such as "rough stony land" tended to reduce the slope range of mapping units somewhat, but not until 1908 were slope variations within soil types again shown on a published map. That year, three general slope classes, "Undulating to rolling," "Sharply rolling to hilly," and "Hilly or broken," were used in the delineation of slope conditions within groups of soil types in the Reconnaissance Soil Survey of Western North Dakota (320):1219. In the following year, slope variations were shown on the soil maps of a few reports by mapping units such as "Norfolk fine sandy loam, broken phase," and "Clarksville sooty loam, flat phase." (121):734, 1-159. Additional slope phases came in use in 1910 and 1911, but they were applied only to a few of the soil types used.

3.122 Soil Erosion

In the reports of the mapping done in 1899 (which were concerned primarily with "alkali" and with tobacco culture), little mention was made of soil erosion (washing) beyond the acknowledgment of its seriousness on Susquehanna clay, and its virtual absence on Windsor sand (310):133, (311):123. In 1900, the report of the survey of St. Mary County, Maryland included a brief discussion of erosion conditions and suggested treatments on Leonardtown loam (311):129. Also in 1900, the survey report for Lancaster Area, Pennsylvania, noted that

> These soils (Hagerstown clay) may be said to be the Hagerstown loam from which the top covering of loam has been removed, exposing the clay subsoil, and yet these soils do not occupy positions where erosion is more pronounced...(311):71.

In 1901, as field operations of the Soil Survey extended further into the badly eroded areas of the Southeast, a number of soil survey reports called attention to the erosion hazard (85). (Some of the erosion control practices recommended in the reports are noted in chapter 3.132.)

The first soil map to show a boundary separating two areas of the same soil type on the basis of differences in the extent of erosion and of erosion hazard was in the soil survey report for the Yazoo Areas Mississippi, in 1901 (85):367. This boundary, which was extended in an adjoining survey the following year, was also a topographic separation (86):339.[14/]

Elsewhere in the South in 1901, soil surveyors made a mapping separation between Cecil clay and Cecil sandy loam. This was, in a very general way, a soil erosion separation, but only two of the party chiefs recognized the relationship (cited above for the Hagerstown series) that much of the area mapped as Cecil clay was actually the severely eroded subsoil of what had been Cecil sandy loam (85):311, 329. This same relationship

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14. As noted in chapter 2.11, the severely eroded soils in this area of Mississippi had bee noted by Higard in his survey of twenty years earlier (122):247.

was subsequently recognized in the mapping of other erodible soils, as in the distinction between Houston clay (uneroded), and Houston chalk (eroded) (320):812.

As soil surveys were improved and reached into new areas in succeeding years, soil erosion conditions, including wind erosion, received increasing attention In the soil mappings In 1909 areas with serious erosion were delineated as “Carrington loam, erosion phase” in a Minnesota report, and “Soils subject to erosion. Best adapted to varying and cover crops” were delineated as part of the land classification for the Reconnaissance Soil Survey of the Puget Sound Basin, Washington (321):1287, (322):1493. “Eroded phases” of established soil types were described and delineated in a number of soil survey reports of 1910, and a comparable unit, “Rough Gullied Land” was used the following year in the survey of Fairfield County, South Carolina (322), (89):505.

3.13 1899 - 1912, Soil Survey Interpretation

In the pages above, the development of the Soil Survey during its first years has been discussed in terms of the conceptual evolution of systems of soil classification, and of technical refinements in soil characterization and soil mapping. These improvements in the technical quality of soil surveys were accompanied by an increasing usefulness of the maps and reports in the solution of a wide range of practical problems in soil and land-use. The applications of basic soil survey information to the solution of such problems are covered by the general field of Soil Survey Interpretation. The following discussion touches upon the development of technical innovations in soil survey interpretation and upon some of the attitudes regarding the extent to which soil scientists of the Soil Survey might make such interpretations of their own basic data:

As initiated in 1899, the Soil Survey was, to a large extent, utilitarian. As has been pointed out, the emphasis on the mapping of soil texture was a direct result of Whitney's views regarding crop adaptability and soil productivity, and the work was generally defended on the basis of its value in guiding agricultural settlement and development (311):19, (96):122. In a speech of 1906, Whitney asserted that

> When the Bureau of Soils began its work on the Soil Survey, we knew that we must study the soil, that we must be able to interpret the soils we mapped or there would be little excuse for the Soil Survey (319):9.

He recognized, however, that the degree of accuracy and detail of such interpretations would be limited by the scale and quality of the soil maps (138):115.

Until about 1909, the interpretive material included in the soil survey reports was, of necessity, of a general and descriptive nature. There were several reasons for this. First, the Soil Survey was a young institution, and the principle of relating soil management research to specific soil types was not well established at the State experiment stations. Second, the Bureau of Soils was under constant pressure for additional surveys and the field work was done rapidly by soil surveyors spread thinly across the country and frequently shifted from area to area. Third, field men, in most cases, had had incomplete training in the developing field of soil management and even the best of them could count on relatively few firm principles relating soil characteristics to soil productivity. Fourth, and most important, the soil types and phases of soil types mapped in the early years were not of sufficient homogeneity to support accurate interpretation in terms of specific recommendations for individual fields.

The difficulty of making such interpretations from the broadly-defined soil types of 1909 (and, incidentally, Whitney's views regarding the then-raging controversy on theories of plant nutrition) are reflected in his statement that,

> The investigations of the Bureau of Soils indicate that the fertilizer requirements do not follow, except in a most general way, the great soil types, but depend more upon the cultivation and previous cropping of the soil (317). 57.

With respect to the making of interpretive groupings of soils on the basis of agricultural value, Whitney maintained that

> The Bureau has never attempted to classify the soils according to their current rank as factors in our agricultural output, but rather to weigh them on the basis of their potentiality, no matter whether they were being used to their full capacity, were lying idle, or were still in their virgin state (317) :45.

Within these limitations, and to a much greater extent than some of Whitney's statements would indicate, soil surveyors had developed, by 1912, the principles and many of the techniques of soil survey interpretation. These could be no more accurate than the maps, which were "detailed" in name only, but they served to establish on a broad base, the practical utility of the work of the Soil Survey.

An important advance during this period was the beginning of highly detailed soil surveying of experimental plots and fields. The principle of extending the results of agronomic research by means of detailed soil surveys had long since been laid down by Hilgard and others, but both the State experiment stations and the Bureau of Soils were slow at first to recognize the primary need to map in detail and, if possible, in advance of the research, those areas devoted to field experimentation in soil and crop management (119). Gradually, however, recognition of the need for such maps spread, and the maps were made. In 1906, at the request of the Alabama Agricultural Experiment Station, a soil survey was made of the Station's experimental farm at a scale of one square inch to the acre in order to provide "...a basis for further experimental studies on the soils of Alabama" (318):24. In Texas, after a new Director of the Station learned, in 1911, that

> ... the ten experimental farms in the Texas system had been located without definite reference to the soil types of the regions to be served, ..., large scale surveys were made of the experimental farms and the usual detailed surveys were made of the counties in which stations were located (331):11.

On the basis of these Texas surveys, several of the farms were found to be on unrepresentative or transitional soils, and were relocated.

Another innovation, which was to have wide application in later years, was the use of soil survey reports and maps in land appraisal for rural tax assessment. Probably the first soil survey to be interpreted for this purpose was that of the Colusa Area, California, in 1907 (88). Upon completion of the Colusa Area soil survey, the Glenn County Board of Supervisors, who were making the tax assessment, requested that the mapping be extended so as to cover all of Glenn County, California (161):69. By 1912, this type of soil survey interpretation received official recognition and support from the National Tax Association (214):2. The use of soil survey data in tax assessment work subsequently provided a source of considerable local support, including financial contributions, from governing bodies of counties and other local areas for which soil surveys were made.

Among other special interpretations developed to meet particular problems were those dealing with soil "alkali" in the arid West. Where salt concentrations were found to be toxic, the soil survey reports generally contained an "alkali" map (or sometimes two, one of "white alkali" and another of "black alkali") and a ground water map, in addition to the conventional soil map (314). To provide interpretation of the soil and "alkali" maps, minimum tolerable salt concentrations were given for important irrigated crops (87):102. The relation of these critical levels to different crops and to different soils was occasionally discussed in detail. Various methods of alkali reclamation, stressing leaching and subdrainage, but including also the use of gypsum, were related in a general way to soil conditions, particularly soil texture and permeability, and to the types and amounts of salts present (314):1141, (321):1514.

Within the Bureau of Soils, soil survey interpretation was carried beyond the pages of the soil survey reports. An organizational unit dealing with "Use of Soils" was set up within the Bureau of Soils in 1910. The following year, Jay A. Bonsteel, in charge of the unit, published the first of what was to be a long series of Bureau of Soils Circulars on "Soils of the Eastern United States and Their Use." Each of the nearly forty circulars in this series dealt with use and management characteristics of a particular soil type (275):19.

In the main, the soil survey reports, though they varied considerably in quality between different parts of the country and particularly between different authors, showed progressive improvement in the quality and detail of their interpretive information, especially after 1909. Some of these developments are noted in more detail in chapters on General Soil Management and on Soil Erosion Control.

3.131 General Soil Management

Interpretive material on soil management in the early soil survey reports was largely descriptive, an unadorned reporting of current practices and results, but gradually more "suggestions" and recommendations were added to the strictly descriptive data. This trend toward more authoritative and advisory interpretations is reflected in the soil survey reports quoted. (Interpretations dealing with the specific problem of soil erosion control are noted separately in the next chapter.)

Typical of the early descriptive discussions of soil management was a soil survey report of 1901, which included the following (re: Cecil clay):

> ...it is comparatively well drained and does not suffer in excessively wet seasons more than the more sandy soils. If the underdrainage were more complete, however, it is probable that the soil would suffer less from washing. Crops on this soil are very susceptible to injury by drought, for just at the time when the crops need cultivation most the surface is apt to be dried and baked so hard that it is nearly impossible to work it. But it is a strong, productive soil, recognized as excellent land for the production of cotton, wheat, and corn. The average yield of cotton is about one-half bale per acre, while corn (in the ear) and wheat will yield from 8 to 10 bushels per acre. With careful cultivation, however, and under favorable conditions, 1 bale of cotton per acre or 15 to 20 bushels of wheat can be produced. There are a few peaches grown on this soil and when proper care and cultivation are employed good results are obtained,... (85):333.

Within a few years, as soil surveyors became more experienced, the reports, such as one of 1906 quotes, dealt more in recommendations. In the limited reference to chemical fertilizers, this report, and others of the period, perhaps reflected the opposition, on the part of the more thoughtful field men, toward Whitney's theories.

> Corn yields from 10 to 50 bushels, with an average of 22 bushels; oats, 10 to 30 bushels, averaging 18 bushels; wheat, 5 to 20 bushels, averaging 10 bushels; potatoes, 50 to 100 bushels, averaging 75 bushels; and hay, one-half to 1 ton, averaging two-thirds of a ton per acre. A few tomatoes are also grown, yielding the same as potatoes. Mixed hay yields from 500 pounds to 3,000 pounds per acre, averaging a little less than 1 ton.

...The fertilizer practice followed on most of the type (Upshur fine sandy loam) is conspicuous only by its absence ...

... the following suggestions for improvement in the agriculture of the area are offered:

1. Methods of cultivation are very inadequate. Good turning plows should be used and the land plowed to sufficient depth to cover completely all crops or weeds growing on the surface, and to afford a good seed bed. Then the clods should be thoroughly crushed by spring-tooth, disk, or cutaway harrows, followed where necessary by a plank drag or roller and smoothing harrow.

2. Tilled crops should be cultivated sufficiently to keep down all weed growth and to regulate and conserve moisture for the crops' needs.

3. Crops should be harvested at the proper stage of ripeness. Less than 10 per cent of the hay crop was cut the present season before it was far advanced in the woody stage, although the rainfall at that period was only slightly above normal. The corn crop in an autumn of very favorable weather was not cut until nearly all its forage value had been wasted, and, in fact, no attempt was made to save a considerable part of it. Straw stacks are left in the fields where thrashed., those of as many as three seasons often standing side by side. If not wanted for feed, these should be hauled to the stable, mixed with the manure as rapidly as possible, and then returned to the land to increase its productiveness.

4. Manure, both solid and liquid, should be scrupulously saved and applied to the land as soon as possible, and covered at once to prevent loss. The time has passed when crops can be grown on many of the upland types with a reasonable rate of profit without paying attention to increasing the productivity of the soil. This can be cheaply accomplished by carefully saving all animal manures, and by growing and plowing under crops of cowpeas, clover, or hairy vetch, accompanied by an application of lime; or even more profitably by harvesting and feeding these crops and returning the manure to the soil. When lime is used in connection with the green crops, it should be so applied as to be mixed with the soil as thoroughly as possible, thus coming into contact with the greatest possible amount of vegetable matter being turned under. In view of the very limited present supply of stable manure, and the fact that leguminous crops increase only the

> humus and nitrogen of soils. It seems probable that the use also of commercial fertilizers, composed principally of potash or phosphoric acid, or both, will be an essential aid to increasing the productivity of the soil (318):596-603.

The principle of interpreting soil survey data as a means of classifying land in terms of land-use capability or suitability was developed and applied in a few areas. In 1909 this principle was stated, as part of a lengthy discussion on "Suggestions for Soil Improvement," in the report of the Reconnaissance Survey of Southwestern Pennsylvania:

> these farms often include land so steep that the farm should be managed first from a topographic viewpoint, and then by adaptation of soils to crops. Such farms should be divided into (1) tillable land, (2) pasture lands, and (3) forest lands. Then the plans of management adapted for each of these three conditions should not be permitted to encroach one upon the other. If more tillable land is wanted, some suitable for such purpose should be bought instead of bringing land suited only to pasture or forestry into tillage. If necessary, some woodland or pasture can be sold to obtain funds for this purpose, but these three plans of management should be kept distinct, and balanced in the farm economy (321):266.

Such a classification of areas in terms of land-use capability or suitability, only suggested in the above Pennsylvania soil survey, was first applied on an extensive scale that same year (1909-1910) in the Reconnaissance Soil Survey of Puget Sound Basin, Washington. This survey was also the first to include extensive and systematic mapping of current land-use. In the Puget Sound survey, the two distinct types of basic data—soils, and current land-use were mapped separately but simultaneously. Then, as an interpretation from the former, a separate land classification map was constructed showing, in eight classes, the land-use capability or potential regardless of the actual current land-use.

Current land-use was mapped in five classes, defined as:

> (1) Cultivated lands; (2) logged off, but undeveloped land; (3) woodlands or areas covered by a non-uniform or inferior growth of timber, classed by timber cruisers as unsuitable for lumber; (4) areas covered by the original forest growth of valuable timber; and (5) treeless or very sparsely timbered gravely prairies (322):1492.

The interpretive classification of areas in terms of land-use capability was based upon the following criteria:

> This classification is based principally on the texture, topography, natural drainage, erosion, and general characteristics of the soils and gives in a general way the relative agricultural value of the land... Under this system of grouping, several types of soil often fall into the same general class. This does not necessarily mean that these types are equally productive, but that they are adapted to the same general type of agriculture.
>
> Class I — land adapted to general farming and justifying immediate agricultural development.
>
> Class II — lands which are capable of being developed agriculturally and are adapted to intensive farming, fruit growing, and pasturage.
>
> Class III — areas where the soil and moisture conditions are well adapted to farming, but where, owing to the steep topography and to the fact that the soil erodes rapidly, the land is better adapted to sowed crops than to those requiring constant cultivation.
>
> Class IV — lands which can be utilized for orchards and pastures, but are not well adapted to farming.
>
> Class V — mixed lands or areas where small tracts of agricultural land are scattered throughout more extensive areas of nonagricultural land.
>
> Class VI — nonagricultural lands, suitable for reforestation only.
>
> Class VII — sparsely timbered, gravely prairies.
>
> Class VIII
>
> Class VIII — virgin forests, unclassified (322):1493.

As noted in the above quotation, the land class boundaries did not necessarily coincide with soil boundaries. The number of land classes in which most soils occurred, however, was restricted by the limits of the range of topography normal for the soils. In this way the various land classes were each characterized by particular soils as well as by particular topography and other conditions. For example, Class III was described as

> ... the more rolling and hilly section of some of the residual soils such as the Hoquiam clay loam and Melbourne silty clay loam. In these hilly sections the steep topography causes the soil to erode or slide during the rainy season. When cleared of the natural

forest growth the erosion of the land in this class is so severe that both the soil and subsoil are rapidly washed down from the steeper slopes, leaving the underlying rocks exposed on the surface (322):1493.

The three types of aerial classification, soils, land-use, and land-use capability, were shown in the published report of the Puget Sound survey by means of two maps at the same scale. One was a conventional soil map while the other, without soil boundaries, showed the various classes of current land-use in color, and the land-use capability classification by superimposed hachures.

The principle behind this method of organization of data, a principle which was to be sometimes ignored in the application of capability classifications thirty years later, was the clear distinction between the basic data (soil survey) and an interpretation from the basic data (land-use capability classification). With this distinction maintained, the basic data could be interpreted for a variety of other purposes, and remained available for later reinterpretation, unaffected by subsequent changes in economic conditions or other external factors influencing the interpretive uses to which such data might be put.

The Puget Sound soil survey (followed, in 1911, by a similar survey of Southwestern Washington State), demonstrated the application of sound principles of soil survey interpretation, and employed advanced interpretive techniques. The innovations in these surveys, however, were by no means typical of the interpretive materials included in the detailed soil survey reports of the same period. The land-use capability maps and current land-use maps described above, which were made at the reconnaissance scale of 1/2"/mile, would have been costly additions to the regular detailed soil surveys published at scales of 1"/mile and, very occasionally, 2"/mile (321):1511. Such interpretive maps were not made as a part of the detailed soil surveys. Nor did the detailed surveys, with a few exceptions, include the mapping of current land-use as a part of the published reports (322):1267.

As noted, interpretive materials dealing with crop yields, suggested soil treatments, etc., varied considerably in form and content between the individual soil survey reports. There was little variability, however, in the requirement that each survey report should include data on the results of mechanical analyses (i.e. relative percentages of fine gravel, coarse sand, medium sand, fine sand, very fine sand, silt, and clay), for the “soil” and “subsoil” of the more important soil types. From the standpoint of interpretation in terms of agricultural use, such detailed physical data had limited usefulness, but Bureau Chief Whitney had not yet abandoned his original hypotheses regarding the importance of soil texture. Bureau policy required that such data be included in the reports.

3.132 Soil Erosion Control

As noted in chapter 2.2, the then Division of Soils, in 1894, contributed to the Department publication on Washed Soils: How to Prevent and Reclaim Them (272). With the advent of the Soil Survey in 1899, the nature and extent of soil erosion came under the closer scrutiny of soil surveyors, and soil erosion control became an important topic in the soil survey reports. Erosion damage was sometimes underestimated, and, particularly in the first few years, the control measures recommended were not closely related to specific soil and slope conditions (85):294. (But then, neither were the soil types.) In general, however, the discussions of soil erosion control represented the best thinking then available on the subject and the recommendations became less generalized as the differences in erodibility between different soil types became better understood.

In a report of 1900, “permanent sod” for eroded areas, and “brush dams” for gullies were recommended (311):129. In 1901, and frequently thereafter, “terracing and contour cultivation,” “sidehill ditches” (i.e. diversion ditches), “permanent forestation,” “permanent pasture,” and “permanent sod of Bermuda or Lespedezal were among the erosion control measures recommended (85):35, 257, 369. To these were added, in 1902, “deeper plowing,” “increasing legumes in the rotation,” “Plowing under stubble of clover and cowpeas,” etc (86):245. Also in 1902, a separate section on “Washing and Gullying” was included in the report of the soil survey of Abbeville Area, South Carolina. This report, with reference in a general way to “the red clay soils of the Piedmont region,” presented the following specific guides for terraces and diversion ditches:

> The most common practice is that of terracing the land on the steeper slopes and running horizontal ditches on the slopes of less declivity. These terraces and ditches can be laid off with an ordinary carpenter’s level and straight edge, but more rapidly and accurately with a surveyor’s level. One man with the instrument, another with the rod, and a third with a hoe to mark the course of the ditch, can lay off from 15 to 20 acres a day. A team with a ditching plow can throw up the ditches on 8 or 10 acres a day, the number of ditches, of courses depending upon the steepness of the slope. The average cost of ditching should not exceed 50 cents per acre. The ditches should have a slight fall toward

> both ends, and should always be kept in good repair. Intelligently made, the ditches have been very successful, but unskillfully made, they often do more harm than good. The hillside terrace or ditch system, with the introduction of grasses whose roots have a tendency to mat and bind together the soil particles will ultimately prove the salvation of much land that would otherwise be wasted (86):285.

The planting of "cover crops between rows" was recommended in 1903 (314):728, and in 1905, contour strip cropping, and construction of terraces at 1 percent gradient with protected outlets (87):57, 487. Damages resulting from terraces built at such a gradient, however, were described in a report of 1909, and the use of "perfectly level" terraces was strongly urged in the report of the soil survey of Hancock County, Georgia (321):556. Vegetative measures for the control of wind erosion, previously reported in 1902 and 1906, were recommended in the report for the Fallon Area, Nevada, in 1909 (86):470, (318):572. These included crosswind strip planting, and the establishment of windbreaks with four suggested tree species (321):1486. (Some of the recommended erosion control measures involving broad changes in land-use are noted above under "General soil management".)

In 1907, Whitney set up "Soil Erosion Investigations" as a separate organizational unit within the Bureau of Soils, under the direction of W J McGee (88). The following year, McGee, alone among man of the Soil Survey, was selected to serve as a member of Theodore Roosevelt's National Conservation Commission (297). McGee ("W J" was his name, not initials), helped to organize the combined soil survey-land-use capability classification in the Puget Sound Basin Report, and, in 1911, he published the results of his work in his monograph Soil Erosion (161):81, (180). In this paper (issued as Bureau of Soils Bulletin No. 71, McGee warned of "... destructive soil erosion, one of the greatest evils confronting the American farmer." (180)4.24 and quoted, from the National Conservation Commission

> Soil wash should be considered a public nuisance, and the holder of the land on which it is permitted to occur should be held liable for resulting damages to neighboring lands and streams (297):79.

On the control of soil erosion, McGee described a large number of recommended practices under the four general means, "Treatment of the Soil," "Treatment of Cover," “Treatment of Slopes,” and “Treatment of Water Supply” (180).

In 1911, the same year that the above paper by McGee was published, the Bureau of Soils issued its Bulletin No. 68, The Movement of Soil Material by the Wind by E. E. Free (97). Unlike McGee’s study, which dealt with the immediate problem of controlling soil erosion, Free’s paper was a scholarly treatment of soil blowing primarily as a geological phenomenon. Free acknowledged, however, that

> ...when excessive, “wind erosion” is one of the most baneful of the farmers’ troubles. Its prevention and control is, therefore, one of the great practical problems of agriculture, one easily met in the majority of cases, but sadly neglected, nevertheless (97):7.

The position of the Bureau of Soils and, less directly, that of the Soil Survey with respect to the nature and extent of soil erosion as a national problem was compromised to a considerable extent by the ambiguity of Milton Whitney’s views on soils and soil fertility. As Chief of the Bureau of Soils, he had authorized all the various Soil Survey publications noted above, and had established the “Soil Erosion Investigations” unit within his bureau which had led to the work of McGee and of Free. In an earlier address on “Exhaustion and Abandonment of Soils,” he pointed out the great loss and destruction of soil resulting from overgrazing in the West (312):9. At the time of the National Conservation Commission meetings, he wrote:

> It is certainly clear that the general principles of the movement for conserving and making better use of our natural resources are sufficiently strong in themselves to make it unnecessary to resort to extreme arguments (Archives).

Whitney thus recognized the damages associated with physical removal of the soil. In his preoccupation with gaining acceptance of his theories of soil fertility and plant nutrition, however, he tended to sweep aside evidences of chemical or nutritive deterioration of soils, and this preoccupation led him to take the extreme position that, “the Bureau of Soils believes the direful predictions of the exhaustion of soils are unfounded...” (317):67. And that, “As a national asset the soil is safe as a means of feeding mankind for untold ages to come.” (317):80. “The soil is the one indestructible, immutable asset that the Nation possesses. It is the one resource that can not be exhausted; that can not be used up.” (317):66.

3.133 Local Reaction to Soil Surveys

General acceptance of the Soil Survey by local communities in the early days was implicit in the increasing volume of local requests for surveys, and in the gradual expansion of the program. There were isolated instances, however, where unpredictable and sometimes intense local opposition to the work of the Soil Survey was encountered. In most cases, this opposition arose because of real or imagined influences on land values resulting from publication of the soil maps and reports. The possibility of such influences was well known and was, in fact, a point of pride with Milton Whitney when he wrote (with reference to the field work of 1899):

> As an illustration of the monetary value of the Bureau's work ... it may be stated that the soils of the Connecticut Valley, which the Bureau declared were adapted to the growing of a superior wrapper tobacco, increased in value more than threefold (316):10.

Such findings were not likely to enrage most citizens owning or selling such land. The disinterested objectivity of the Soil Survey in mapping and describing soils, however, proved to be a two-edged sword with a well-honed blade for the neck of the soil surveyor who might discover and report the occurrence of "alkali," "hardpan," "blow sand," etc., in the midst of some ambitious local land development or promotion. A few instances of this sort are noted. In 1901 and 1903, soil surveys were made in the Imperial Valley of Southern California (314):1210. The report of the second survey was frankly optimistic about the eventual reclamation and tremendous fertility of the soils, but both reports described accurately the extensive areas of heavy-textured impervious soils of high salt content, and the difficulties of drainage and reclamation under such conditions. Publication of these soil survey reports coincided with the promotion of a large-scale irrigation project by an influential stock company incorporated in Mexico and in California. The immediate reaction to the publication of the soil survey findings, according to a soil surveyor who was on the spot, was such that

> These reports were construed as condemning the larger part of the Valley as unfit for cultivation, and put the financial stability of the project in question. They brought forth a storm of protest, and threat of political activity adverse to the Bureau and the future of the Soil Survey (161):75.

A few years later, following completion of the survey of the Crookston Area, Minnesota, the Northwest Farmstead, a local newspaper, printed the following quotation and editorial comment,

> "There will be no more land classification or soil surveys in Minnesota if that map is published!" The gentleman had seen an advance copy of a soil map lately completed by the Bureau of Soils for the southeastern part of Beltrami county. He is a land agent. He owns some land. Some of it on the map is marked Sandy, of low value for agriculture (Archives).

The news article went on to describe threats by the "shark" to use his influence in cutting off appropriations for such work. The "sandy" soil referred to was the Mcleod sand, described in comparatively mild terms in the report (318):866.

Another seemingly inoffensive soil survey report that stirred up a tempest was that of Richland County, North Dakota, in 1908 (320):1121. Distribution of this report was opposed by real estate interests and, although the events took place fifty years ago, reports still persist of destruction of many copies of the survey report and map in one or more public bonfires. Whatever may have become of them, copies of the Richland County Soil Survey have been unavailable in quantity ever since. [15/] Long after the reports had been virtually eliminated because of their factual descriptions of some of the poorer soils of Richland County, local citizens were requesting federal assistance for submarginal land purchase and reforestation of the very soils which the early soil survey report had indicated as unsuitable for cultivation (Charles E. Kellogg, personal communication).

The violent allergy of real estate promoters to the mapping and reporting of "alkali" conditions became epidemic in the San Joaquin Valley of California following publication of the soil survey report of the Modesto-Turlock Area in 1909. The original request for this survey had been strongly urged by local groups, but opposition immediately developed when the report appeared, accompanied by a map which indicated the presence of "alkali'

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15. With a comment on "the Irony of history," a recent letter from the North Dakota Agricultural College reports that a Richland County banker was offering to pay up to $10.00 to obtain a copy of the report which, long before, had disappeared in wholesale lots (H.L. Walster, personal communication).

in certain parts of the area. The report contained recommendations for the reclamation of the salty soils and concluded that

> ...if the causes that lead to the concentration of alkali are clearly understood, and available means taken to prevent its accumulation near the surface, the damage done may be confined to small areas (320):1265.

This was still too bitter a pill, however, for local interests, led by a real estate project known as the Stevenson Colony which was interested in promoting the development of some of the areas mapped as poorly-drained “alkali” soils. Distribution of the maps and reports was suppressed by the local Chamber of Commerce and it was reported that

> ...the entire quota of soil survey reports for Congressional distribution was obtained and for some years kept safely under lock and key and withheld from the public for which they were intended (160):346.

A recent letter from the former Soil Survey Inspector quoted above notes that the worst of the areas shown as “alkali” soils in 1909 have never “shown any evidence of prosperity” (Macy H. Lapham, personal communication).

A few years later, a soil survey field party found itself in the midst of a booming land promotion scheme for the Florida Everglades. The report of their survey, while it described the predominantly poorly-drained brown fibrous peat soils accurately, added the warning comment that

> It is such land as this, untried for agriculture and a large proportion of it under water, that... is being sold for twenty to sixty-five dollars an acre (25).

Local reaction, as recorded by a Florida historian, was such that

> ...the report of the soil survey was quite unpopular and was soon hushed into disappearance. John Newhouse wrote that he was never able to obtain a copy and Mr. Lawrence Will of Belle Glade Informed the writer that all available copies were destroyed in a public fire in Ft. Lauderdale soon after it appeared (76):151.

On the basis of surveys such as that of the Everglades, various land agents were prosecuted and convicted of fraud in Florida and elsewhere, sometimes with expert testimony provided by men of the Soil Survey (116):73. Not surprisingly, soil surveyors were occasionally emphatically discouraged from visiting areas earmarked for such dubious promotional operations (Wm. J. Latimer, personal communication).[16]

It should not be inferred from the above that expressions of local resentment arose solely from the avarice of real estate sharks. Their hostility was generally discounted by the public, but, on occasion,

> local pride and mistaken self interest of the community were...turned against what was represented as a disparagement of their community. In some cases, local and state officials have considered it their duty to defend a soil type and encourage an influx of settlers regardless of the facts (221):131.

Nor should it be assumed that in all such controversies the soil surveyors were right and the local citizens wrong. In the development of a program which was overwhelmingly beneficial in its general application, there doubtless were instances where publication of the soil survey reports worked injury and perhaps injustice on individuals (221):131. In less than fifteen years after publication of the above report of the Everglades soil survey, a portion of the peat soils so caustically disparaged in the report were brought to unprecedented levels of production. This transformation was effected by improved methods of drainage and by the discovery and correction of ameliorable soil deficiencies in the micronutrients, copper, manganese, zinc, and boron, techniques not known at the time of the earlier soil survey (R.V. Allison, personal communication).

The interpretations included in the Everglades report were valid in terms of the technology available at the time, and for some years thereafter, but, like all such interpretations, they were based upon judgment and could not anticipate subsequent technological innovations nor changes in economic conditions. Hence the importance, noted elsewhere in the present study, of the distinction between basic data and interpretations from them.

* * *

16. In the Proceedings of the Fourth National Conservation Congress, in 1912, the use of soil surveys was specifically suggested as a means of protecting individuals and communities from “Land Frauds and Get-Rich-Quick Schemes” (214):129.

In spite of occasional complaints such as those noted above, and in spite of other, more disinterested criticism from professionals like Hilgard and Hopkins, the practical value of the Soil Survey was established and the demand for surveys increased steadily. By 1908, the Bureau of Soils had on file requests, over and above its capacity to meet, for soil surveys of six hundred and fifty-four additional areas, covering nearly three-quarters of a million square miles. This aggregate area for which soil surveys were requested amounted to almost four times the total area covered by the Soil Survey In the nine years of its operations up to that time (320):33.

The increased demand for copies of the reports and maps of individual areas brought about a change in the publication procedure. In the first few years, the entire work of the Soil Survey, reports, maps, and summaries, was bound together and published each year as an annual volume entitled “Field Operations of the Bureau of Soils.” After 1903, although the complete bound volume continued to appear each year, separates of the individual maps and reports were issued as “advance sheets” and distributed through Members of Congress and the Bureau (315):1153.

The heavy demand for surveys brought increased federal appropriations for the work. From an initial appropriation of $16,300 for the Bureau (then Division) of Soils for fiscal year, 1899, the Bureau appropriation, most of which was allocated to soil survey work, increased to $31,960 by 1901, $169,680 by 1903, and $231,020 by 1911 (10), *et seq*. Financial support from many of the States was also increased, although as noted elsewhere, with monolithic lack of cooperation in Illinois and California. In 1907 the Legislature of the State of Alabama enacted a law providing an appropriation for completing the soil survey of the entire State, with Bureau of Soils cooperation (88):28.

3.2 1912-1920

On the national scene, although only coincidentally, this period of Soil Survey history fell within the two administrations of Woodrow Wilson and of his Secretary of Agriculture, David F. Houston. Public interest in the development and conservation of natural resources, stimulated originally by Roosevelt, had been dimmed and confused somewhat by the Ballinger-Pinchot dispute under Taft, but it remained as a permanent and important phase of national policy and administration. [17/] While the earlier natural resource polities and programs had dealt primarily with forests, water power, minerals, etc., rather than with soils, it seems clear that both Woodrow Wilson and Secretary Houston were concerned with the state of the nation's soil resources, and that Wilson, at least, recognized the need for long-range planning for soil inventory and protection. (20):316, (102):33. Any such long-range concern for the state of the soil, however, was hastily shelved in favor of the all-out drive to increase food production, for the Allied Powers after 1914, and for American forces and others after 1917.

During this period, the Soil Survey, still too small and too thinly spread to merit consideration as a factor in national policy, made a small start in that direction. In 1912, strong political pressure was brought to bear upon the President to exclude from the National Forests tracts of land suitable for agricultural use (and hence available for entry under the Homestead and related acts) (161):101. For the making of any such decisions, a classification of the National Forest lands was clearly a prime requisite. As the only operating agency with a staff adequately experienced and competent for such work, the Soil Survey, between 1913 and 1917, was called upon to undertake the physically demanding and politically hazardous job of making the classification, in cooperation with field personnel of the Forest Service (Archives), (161):101.

17. The importance of inventory and conservation of natural resources seemingly received a setback in the Taft administration when, as a matter of administrative discipline, Taft was forced to dismiss the popular and influential Forest Service Chief, Gifford Pinchot, and to defend Pichot's opponent, Secretary of Interior Ballinger. Elected to carry out Roosevelt's conservation policies, Taft, in the words of Pinchot, had carried them out "...on a stretcher." (117) 427.

In the federal-state corporate structure of the National Cooperative Soil Survey, this period saw the growth of relatively greater power than before in the position of the states. The states, with the obvious exceptions of California and Illinois, had been largely dominated by the federal bureau in cooperative soil survey work under Milton Whitney. In the Soil Survey under Marbut, however, the States attained more status. In a positive sense, this was the inevitable result of the professional development and increasing tenure of state representatives in the Soil Survey; in addition, however, in a negative sense, the increased influence of some of the state spokesmen was the result of their closing ranks in opposition to Marbut’s actions in de-emphasizing soil survey interpretation and, ultimately, in discarding the established system of soil classification in favor of his own completely new and different system. This opposition was at least one factor in the organization of the American Association of Soil Survey Workers in 1920 (22):3.

In the general field of soil classification, the early part of the period was dominated by the long shadow of Bureau of Soils Bulletin no. 96 of 1913. After about 1917, however, the earlier system came in for increasing criticism by Marbut who, having learned of the pioneering work of the Russian soil scientists, sought to emulate their achievements in soil classification and in studies of soil morphology and genesis.

In the field of soil mapping, techniques became somewhat more accurate and detailed, but, by 1920, such improvements were largely in degree, rather than in kind, over the techniques of 1912.

There were no important improvements in soil survey interpretation within the soil survey, although the reports and maps were widely used for interpretive purposes by others. Soil Survey Chief Marbut sought to eliminate much of the “recommendations,” “land-use capability classifications,” and other interpretive materials which had been included in soil survey reports before 1912.

3.21 1912-1920, Soil Classification

The development of soil classification in the Soil Survey during this period was manifest not so much in changes in the established system, as in the recognition of entirely new principles and criteria which were to lead to a total revision of the established system after 1920. The recognition and application of the new concepts in America were the work of Curtis Marbut alone (Hilgard and Coffey, as noted , excepted) and the circumstances of his background and influence might be noted briefly at this point.

No adequate biography of Marbut is available. The nature of his work and the scope of his influence may be seen in his original publications and in the far-reaching changes in the philosophy of soil science which he inspired. Some measure of his professional standing and the power of his personality is reflected in the personal appraisals by his colleagues, from all continents, brought together and published in memorial volumes by the Presidium of the Soviet Section of the International Soil Science Society in 1936, and by the Soil Science Society of America in 1942 (331), (252).

Curtis Fletcher Marbut was born in a Missouri log cabin in 1863. Following graduation from the University of Missouri in 1889, he enrolled as a graduate student at Harvard University. Marbut's teachers at Harvard included the geomorphologist Davis, and the geologist Shaler (who had himself been a student of the elder Agassiz), and it was in these two fields that he attained eminence as Professor of Geology and Physiography back again at the University of Missouri from 1895 to 1910. He held a concurrent appointment as Geologist with the Missouri Geological Survey until 1905 when he was named the first Director of the Missouri Soil Survey. In spite of considerable soils work with the Missouri Soil Survey, Marbut was known, and well known, primarily as a geologist when, after three years of "temporary" assignments as soil scientist with the National Soil Survey, he became its chief in 1913 (252):14-20.

The reception accorded this "geologist," and a relative newcomer at that, by the senior soil scientists of the soil survey was something less than enthusiastic (331):484, 612, (252):19. The tables were resoundingly turned within a very few years when Marbut became seemingly an arch anti-geologist, but he was at first still the geologist.

As senior author of Bureau of Soils Bulletin No. 96 in 1913, he had firmly established the "soil provinces" on the basis of geomorphology. In his report of the Soil Reconnaissance of the Ozark Region of Missouri and Arkansas in 1914, the soils were "very closely related to the rocks therefore, and vary with them,..." and the rocks were described in great detail (89):1730.

The subsequent changes in Marbut's thinking came about as a result of his rediscovery of Hilgard, his new discovery of Glinka, and his association with the far-flung field operations of the Soil Survey which provided factual support for the theories of both.

In Russia, Dokuchaiev, together with Sibirtsev and their followers, and in America, Hilgard (by himself) had independently demonstrated a basic principle of pedology before the turn of the century. Based upon the study of soils over a wide range of physical and climatic conditions, Dokuchaiev and Hilgard had shown that soil differences, on a continental scale, were closely related to broad variations in climate (123):11, (6):9, (107):4.

Konstantine Dimitriev Glinka, a student of the Dokuchaiev school, but acquainted also with the work of John Stuart Mill, and of Eugene Waldemar Hilgard, synthesized much of the earlier work, including his own, and in 1914, published a monograph entitled "*Die Typen der Bodenbildung*." Glinka here established the unique nature of soil science (or "pedology") as a distinct discipline separate from geology or any other, which dealt with the scientific study of soils as natural phenomena. The morphology of soils was described in terms of the characteristics of the various horizons of the soil profile, or vertical section. These characteristics, in turn, were functionally related, through a theory of soil genesis, to the influences, primarily of climate, but also of lithology of parent rock, topography, natural drainage conditions, plants and animals, and time. Glinka showed that different combinations of these influences gave rise to different kinds of soils. On these bases of soil genesis and soil morphology, and drawing heavily upon the work of his predecessors, Glinka classified the known soils of the world in terms of several broad groups, having in common similarities in profile characteristics. Some of these groups, such as the "Techernozems," the "Podzola," and others, were shown to occupy broad geographic zones, closely coincident with climatic zones, and such soil groups were termed "zonal" (106).

During World War I, Marbut obtained and read a copy of the German publication of Glinka's work, and his conversion from geologist to pedologist began. Perhaps the first vows in his conversion were taken in 1916. As Chairman of the Soil Classification Committee of the American Society of Agronomy for that year, Marbut reported (with a strong assist from two earlier investigators cited), that his committee was unanimous in its agreement with

> (1)...Dr. Coffey's recommendation that the systematic definition of soil units should not be based on climatic environment, but on the soil characteristics produced by the environment,
>
> and
>
> (2)...Prof. Fippin that while a field soil man should be able to recognize geological features and changes in such in the field, yet the soils he identifies should be defined in terms of soil characteristics instead of those of the parent rock (169):389.

Thereafter, Marbut became increasingly concerned with the identification and description of such "soil characteristics." In accord with the Russian methodology, he argued for much more thorough characterization of soils in terms of the horizons of the soil profile. (A term incidentally, which had been used, off and on, in soil survey reports since 1900) (311):260.

These new and (to most American soil surveyors) revolutionary concepts placed Marbut in direct opposition to the advocates of the geological criteria implicit in the Soil Province-Soil Series-Soil Type system promulgated in Bureau of Soils Bulletin no. 96. This system, largely the handiwork of geologist Marbut only a few years before, still represented official Bureau policy in 1916 (54). Soon after, however, because of Marbut's criticism, the use of the soil province as a category of soil classification was discontinued in most Bureau of Soils publications. [18] Although he did not seriously propose an alternative system

18. Bulletin no. 96 had been distributed and accepted far and wide, however, and, over Marbut's objections, the soil province map remained in use for many years. Soils of the United States were described in terms of the soil provinces by Milton Whitney himself in 1925 (325); an Iowa State publication of 1936 located the soils of Iowa in the "glacial and loessial soil province," defined precisely as that of 1913 (45):6; an adaptation of the original soil province concept was reported still in use in 1945 in some training work of the U.S. Army (160):348.

until some years later, Marbut pointed out the difficulties arising from

> ...the practice...of regarding the subdivisions of this early soil province map as 'water-tight' boxes and that no soil occurring in one 'box' should be permitted to occur in any other, regardless of the characteristics of the soil itself (177):222.

The wide acceptance of the simple and systematic soil classification of Bulletin no. 96 led to firm opposition, particularly from the state soil survey leaders, to Marbut's efforts, begun about 1917, to revise the earlier system. The probability exists that organization of the American Association of Soil Survey Workers (American Soil Survey Association after 1923; Soil Science Society of America after 1936) in 1920 was inspired, in part, by a small coalition of state men as a pressure group in opposition to the spread of Marbut's new ideas. Although he came ultimately to dominate the Association, and lived to see his ideas accepted in the main, Marbut initially evoked strong negative reaction to his new soil classification, particularly as it involved elimination of both the geological and agricultural criteria.

In a discussion of "The Contribution of Soil Surveys to Soil Science" in 1920, Marbut placed the American Soil Survey on a higher position of professional and scientific standing than it ever before had warranted,

> The soil itself must by the object of observation and experiment and the facts obtained must be soil facts before they can be incorporated into soil science. The science of zoology was developed through the study of animals, that of botany through the study of plants, and soil science must be developed through the study of the soil (170):116.

The formulation of principles and the collection of the data of soil science, according to Marbut, were made possible in America almost entirely through the work of the Soil Survey. While he differed strongly with the earlier concepts and classification systems such as those noted, he defended the older soil surveys as indispensable stages in the development of the science (170):123.

In dealing with the practical problem of criteria to be used in differentiation between soil types, Marbut listed:

(1) Number of horizons in the soil profile

(2) Color of the various horizons, with special emphasis on the surface one or two

(3) Texture of the horizons

(4) Structure of the horizons

(5) Relative arrangement of the horizons

(6) Chemical composition of the horizons

(7) Thickness of the horizons

(8) Geology of the soil material (170):124.

And hopefully predicted the subsequent discovery of additional criteria.[19/]

The last place position accorded geological criteria in this list may be taken as a measure of the change in viewpoint attained by 1920. It may also be considered as a demonstration of Marbut's tendency to overstate his case.

19. Marbut's prediction of subsequent addition and correction was all too true. His original criteria were well enough selected however, that in the judgement of a distinguished soil scientist thirty years later, "No one has yet improved appreciably upon [Marbut's] list." (61):89.

3.22 1912-1920, Soil Mapping

The soil mapping of this period was carried on largely through the extension and refinement of field techniques worked out by 1912. The maps became much more detailed and more accurate, however, and as noted , the emphasis on soil characterization as a part of the field mapping resulted in greater homogeneity within the mapping units delineated.

Field data for soil characterization, which contributed to improved soil classification and interpretation as well as soil mapping, were recorded on a standard tabular form (Bureau of Soils form #79) for each soil type. As used in 1916, this form provided for the following data in the description of new soil types discovered in the course of a survey: (Archives)

1. Soil Province (Geological)
2. Modification (i.e. aeolian, weathering, leaching, organic or chemical precipitation, etc.)
3. Regional Topography
4. Surface soil characteristics (color, texture, depth, structure, organic matter content, etc.)
5. Subsoil characteristics (same as for surface soil)
6. Other underlying material (substratum, hardpan, etc.)
7. Gravel and Boulders
8. Rock Outcrop
9. Concretions, volcanic ejecta, iron crusts, lime, or other recognizable materials
10. Surface configuration (relation to erosion or drainage; adaptability to irrigation)
11. Natural vegetation
12. Present use
13. Crop yields
14. Special crop adaptations

In the field work, the basic mapping unit remained the soil type, but increasing use was made of the subdivision, a phase of a soil type, to indicate significant variations in depth, color, erosion, slope, natural drainage conditions, etc., within the soil types. Nearly all soil maps showed phase separations for some soils but such separations were generally made only for the more important soils, while those of lesser extent or importance were mapped simple as soils types without further subdivision. In a New York survey of 1914, four phases of Volusia silt loam were mapped and, in a 1919 report, five phases of Ontario loam (90):288, (92):297. While typically fewer phase subdivisions were used, in a Florida survey of 1915, eight of the ten soil types were phased, and one type of the brown fibrous peat had seven such subdivisions (91):764.

An important innovation, though a decidedly mixed blessing at first, was the introduction, about 1913, of automobiles for field parties of the Soil Survey (160):348. Base maps, both for field use and for publication, were also improved through establishment of the "Map Section" which became an important adjunct to the Soil Survey (160):348.

Model T transportation tended to speed up survey progress somewhat, but not nearly enough to offset other developments which were continually adding to the time required for mapping and publication. The increased detail and accuracy of the mapping, the field observations needed for soil description and characterization, the application of higher standards in cartography, and the development of closer inspection, correlation, and other means of technical control, resulted in a doubling of the man-hour inputs per acre of soil surveys mapped and published (92):xiii.

3.23 1912-1920, Soil Survey Interpretation

With the improvements in detail and accuracy noted , the soil maps of this period reached an increasing number and diversity of users and uses. In the reports themselves, however, there was little improvement and no important innovations in form or content of the interpretive material. Indeed, in view of the achievements of the pioneering work reached by 1912, there was a retrograde tendency in soil survey interpretation <u>in the reports</u>. New uses for soil survey data were discovered and the need for such data in agronomic research was increasingly felt. But the Soil Survey itself tended to de-emphasize interpretation and assumed the role more of a fact-finding agency which functioned primarily

> ...to get the facts about soils, to classify them, and to map them in ways that would furnish a sound basis for interpretation by other people (152):4.

This de-emphasis was in line with a specific change in policy. In a letter of January 28, 1914 (to a soil survey party chief who had bitterly objected to the deletion of certain interpretive parts of his soil survey report manuscript), Bureau Chief Whitney cited

> ...a recently adopted policy of the Department to restrict the substance of the soil survey reports to a description of the soils and a statement of the agricultural conditions and farm practices actually existing or being followed in the area surveyed. To state another way, this means the omission from future reports of all advice to the farmers in regard to drainage or other engineering matters, in regard to methods of cropping, the substitution of crops, of rotation or of fertilization, which matters come normally within the field of farm management, and in regard to seed selection, plant breeding, or varietal adaptation, which are subjects within the domain of other offices in the Department. The result will be to make the chief duty of the Soil Survey the gathering of fundamental soil information to be used as a basis for experimental work by the other bureaus or offices of the Department which in due time will be in a position to give more specific and reliable advice to the farmers, each along the lines of its special work. (Archives)

There was considerable support for this policy shift. It came not only from the state experiment stations and from other federal agencies which regarded the field of soil management as their own, but also from other, more altruistic critics who recognized that, while compilations of fundamental soils data were comparatively permanent, interpretations dealing with soil and crop management would inevitably become outdated as technologies improved, new materials and varieties became available, and economic conditions changed. It was felt that if soil survey reports dealt heavily with interpretation, the changes and progress in agriculture would compromise the value of the reports as basic data and would shorten the period of their usefulness. Similarly, it was argued that built-in interpretations for one particular purpose (i.e. agriculture), would obscure the basic data needed in interpretation for other purposes (i.e. engineering).

While he differed with Bureau Chief Whitney on most matters, Soil Survey Chief Marbut strongly supported the policy cited. Marbut recognized the importance of utilitarian interpretations of soil survey data, but he saw that as a function necessarily quite distinct from that of making soil surveys. As noted in chapter 3.21, Marbut was, during this period, formulating the concepts of what was to become a new system of soil classification. In the development of this system, he felt that overemphasis on the interpretive aspects of soil survey work would tend to inject a strong agricultural bias into the criteria applied in the classification. By way of emphasis, he later wrote

> The soil scientist must be concerned primarily with the accumulation or assimilation of knowledge concerning the soil without reference to the use to be made of that knowledge. Probably more harm has been done to the science by the almost universal attempt to look upon the soil merely as a producer of crops rather than as a natural body worth in and for itself of all the study that can be devoted to it, than most men realize. The science has undoubtedly been retarded in its development by this attitude (170):117.

The reports continued to provide interpretive material on erosion control methods and crop suitability for the various soil types described. The preparation of special maps of land-use and of land-use capability (such as the Washington State surveys noted in chapter 3.131) was discontinued, however, and the discussions of agricultural use of the soils tended to deal more with the descriptions of current practices than with specific recommendations for improvement. The following excerpts might be considered typical:

> 1915. Van Buren County, Iowa (re Memphis silt loam, eroded phase): ...the eroded phase occupies the more or less steep slopes bordering stream courses and is especially well

developed along the south valley slopes of eastward or westward flowing streams.... Ordinarily crop yields are lower on the eroded phase than on the typical Memphis loam because of the shallowness of the surface soils and the lack of uniformity in the soil on the eroded slopes. The pastures on the eroded phase, consisting largely of bluegrass, are excellent and the quality of the growth is considered superior to that on the Grundy silt loam. In order to maintain the productiveness of the soil and prevent serious erosion much care is necessary. Deep plowing is advisable and in addition fields should be kept in some cover crop or vegetative growth as much of the time as possible. When once started the extension of ditches and gullies is difficult to control. All the steeper and rougher areas can best be used as permanent pasture or forest land (91):1798.

1917. San Francisco Bay Area, California (re Yolo clay adobe): Nearly all the type is dry-farmed to grain and grain hay, of which good yields are obtained. Very little attempt has been made to grow the more intensively cultivated crops such as fruits and grapes. Irrigation, deep tillage, and the incorporation of organic matter will widen the crop range (134):92

1915. Fairfax and Alexandria Counties, Virginia (re Manor loam): A majority of the farmers on this type apply some lime to the soil, the usual application ranging from 500 to 1000 pounds per acre. Lime is applied at intervals of 3 to 6 years or more. Most farmers use commercial fertilizers at the rate of 200 to 400 pounds per acre for wheat and some use about 100 pounds per acre of corn.... Judging from the effect of lime on this soils, it would seem that the use of larger quantities, say 20 to 30 bushels per acre would be advisable. With liberal applications of lime, in conjunction with manuring and the growing and plowing under of leguminous crops such as crimson clover and cowpeas, it seems that the only fertilizing element required for corn, wheat, and rye, and timothy and other hay crops would be phosphoric acid (55):113.

The comparative de-emphasis on interpretive material in the soil survey reports did not go unnoticed in Congress. In the course of Congressional debate on the Bureau of Soils appropriation for fiscal year 1913, the question was raised by Congressman Foster of Illinois. Clearly inspired by his compatriot, Cyril Hopkins, but with considerably more restraint, Foster asserted:

Not that I am opposed to the Soil Survey nor the head of this work, for I have confidence in his ability and honesty of purpose,... But I believe, and it has been so stated by

> Members in former Congresses, that this Bureau of Soils ought to be by all means in the Bureau of Plant Industry. It has been stated that we have men who go out and make investigations of the soil. They issue beautiful maps of certain sections of the country. They show what these soils may contain or may not contain, and yet when that is over, that is about all there is to it (71):3165.

Such sentiments, however, together with occasional Congressional motions that the entire Soil Survey be turned over to the states, constituted a minor opinion (71):3170. Congressional and popular requests for soil surveys continued to exceed the capacity of the Soil Survey to supply them, and federal and state appropriations for the work were regularly increased. Federal appropriations for the Bureau of Soils (the bulk of which was devoted to the Soil Survey), amounted to $231,020 for fiscal year 1911, $360,635 for 1915, and $491,235 for 1920 (14) et seq. Appropriations from the States increased more rapidly, and, in total, approached the federal contribution to the Soil Survey. In 1916, the Secretary of Agriculture wrote to Congressman Kahn of California (where cooperation with the Bureau of Soils had finally been accepted, following Hilgard's death), that

> ...we have on file nearly one thousand requests for soil surveys, and, with our present resources are only able to survey between fifty or sixty areas each year. (Archives)

While the Soil Survey was thus far from able to meet the number of requests, the soil maps and reports which were issued during this period were applies to a growing number of different uses. The files of the Bureau of Soils accumulated a mass of testimonial letters (more than few, no doubt, intended to bolster written requests for additional copies of the soil survey reports), from soil survey users including the following diversity of individuals and organizations:

Individual farms and other private citizens
State Experiment states and Extension Service workers
Federal and other legislators
Land banks, life insurance companies, and real estate companies
Large-scale commercial agricultural producers
Local chambers of commerce
State and local highway agencies

Educational institutions of all kinds

State forestry agencies and private timber companies

State and local boards of health

Private and public engineering services

Courts of law, and public and private attorneys

State, University, and private geologists

Light and power companies

Newspapers and libraries

Individuals and organizations in foreign nations

Federal agencies, including:

Forest Service, Geological Survey, Bureau of Public Roads, Interstate Commerce Commission, Department of War, Post Office, Bureau of Internal Revenue, Veterans' Bureau, Bureau of Reclamation, Customs Service, etc. (Archives)

The variety of interests represented on the list reflected the diversity of uses to which soil survey data were applied; in 1914 and 1915, soil surveyors of the Bureau of Soils, in cooperation with the Forest Service, made extensive reconnaissance surveys in the National Forests to delineate the broad separation between "agricultural" and "nonagricultural" areas (Archives); in 1915, Governor Hiram Johnson of California asked for a special soil survey in an area where the State was being charged exorbitant prices for land purchases in a flood control project (Archives); use of soil surveys by the War Department resulted in saving and estimated half million dollars on the purchase of land for an artillery range in North Carolina (116):73; field work by men of the Soil Survey was instrumental in the settlement of a boundary dispute between Texas and Oklahoma, which had reached the U.S. Supreme Court (116):74; military interpretations, which were later to occupy a special section within the soil survey, were described in the following letter from the Office of the Army Chief of Staff:

> ...geology and soil characteristics are receiving increasing attention as one result of the world war, in the study of terrain from a military point of view, and the maps and literature issued by your bureau are beyond any question the best basis for studies of this nature (Archives).

An additional, and doubtless vital, phase of soil survey interpretation, which possible had not been anticipated by any one in the Soil Survey, was discovered by an official of the United States Customs Service, who wrote that the soil map of Chatham County, Georgia,

> ...would be of great value to the Customs Service in its effort to apprehend those illegally bringing into the country intoxicating liquors. (Archives)

In addition to such expressions of general approval, the Soil Survey continued to receive occasional brickbats arising from errors in mapping, or from outbreaks of local opposition such as those noted in chapter 3.133.

* * *

While not directly involved, either with principles or techniques of soil survey interpretation, a very real problem affecting the usefulness of soil surveys appeared during this period. This problem, the increasing time lag between completion of soil survey field work, and its availability through publication, was to become a source of frequent and effective criticism of the Soil Survey in later years. With the early soil surveys, the publication lag was insignificant, and the work was generally published and distributed the same year it was completed, or within the following year. Prompt publication was expected. In 1911, a Southern Congressman complained on the floor of the house that

> ...a soil survey was made several months back in...my district, and the report has not yet been printed (70):2301.

Between 1912 and 1920, however, as the field work became more and more detailed and cartographic costs rose, the delay in publication became a matter, not of “several months,” but of several years. Of the seventy soil surveys made in 1918, only forty-five had been published by 1924 (324):7. These forty-five survey reports had been issued earlier as “advance sheets,” but for the remaining twenty-five, the publication lag was six years or more.

3.3 1920-1933

This period of Soil Survey history, like the first, coincided with a succession of Republican administrations. Under Harding, the popular demand for a return to “normalcy” led to a relaxation of public responsibilities in policy and administration relating to natural resources. Perhaps the low point in this reaction from the conservation policies of Theodore Roosevelt and Woodrow Wilson was the conviction of Harding’s Secretary of the Interior for accepting a bribe in connection with oil concessions (117):549, (29):316.

At the same time, the national agricultural economy was beset by an extended depression. Because of the demands of World War I, the price of wheat had more than trebled between 1916 and 1917. With characteristic lag and inelastic supply response, however, major increases in wheat production came largely after the armistice, and carried over into the immediate postwar years. (29):159. The above is an oversimplification of a situation involving also other commodities, weather conditions, nonfarm price levels, etc., but the net result was a sharp and prolonged break in farm priced when worldwide demand diminished after 1920.

The relaxation of national conservation policy under Harding, and the concurrent agricultural depression (which was interpreted as a sign of overproduction) are significant to the present study in that they created a political atmosphere undistinguished by any considerable concern for the nation’s soil resources (29):317. Federal appropriations for the Soil Survey were cut in fiscal year 1921 and cut further the following year (16), et seq.

The complacent national attitude regarding soils and soil erosion began to change in the late nineteen-twenties and early thirties, largely as a result of the work of Hugh Hammond Bennett, originally of the Soil Survey. After heading up a cooperative program of soil erosion experiment stations, begun in 1929, Bennett was transferred to the Department of the Interior in 1933 to administer relief funds allocated by the National Industrial Recovery Administration (270). As Chief of the resulting Soil Erosion Service and its successor in the Department of Agriculture, the Soil Conservation Service, Bennett subsequently became one of the leaders in the second “Conservation Era” under the second Roosevelt.

In addition to the specific programs for soil erosion control, the deepening political and economic crises after 1929 brought forth and unprecedented demand for soil survey data. The emergence of the Soil Survey (and of the ultimately much larger Soil Conservation Service) as significant factors in policy and planning, however, occurred after 1933 and will be noted in later chapters.

Within the structure of the National Cooperative Soil Survey, representatives of cooperating states demonstrated a healthy unwillingness to submit unconditionally to the federal Bureau. Coordination was maintained, however, and Marbut continued to dominate the scientific work of the Soil Survey through the strength of his personality and his towering scientific stature.

In the straight-line administration of the strictly federal part of the Soil Survey, Marbut had available something more the “personality” and “scientific stature” after 1927. In a reorganization of July 1, 1927, the Bureau of Soils and the Bureau of Chemistry were combined (17). In the new Bureau of Chemistry and Soils, the work of the Soil Survey was given full division status and, as Division Chief, Marbut exercised much freer administrative autonomy under the new Bureau Chief, Henry G. Knight (Charles E. Kellogg, personal communication).

Overseas activities of men of the Soil Survey during this period included soil surveys and other soil research in Central America, China, the Virgin Islands, Cuba, Alaska, and the Amazon Basin. In addition, Marbut participated in a number of European conferences and brought tremendous scientific prestige to the American Soil Survey as host of the First International Congress of Soil Science in Washington, DC in 1927.

On the technical level, progress within the Soil Survey was unbalanced in favor of soil classification (which was transformed) at the expense of comparable interest in soil mapping and soil interpretation. A new classification system was developed by Marbut which completely replaced the earlier systems.

In the field of soil mapping, the great innovation of airphoto base maps was developed, but used in only a few states before 1933. In addition, mapping detail was increased through enlargement of field mapping scale, and through greater recognition of soil slope, erosion, etc., in mapping separations.

Soil survey interpretation received no further support from Marbut (until 1933), but continuing use was made of soil maps and mapping techniques in the solution of problems of land-use planning, irrigation and reclamation, tax assessment, etc.

The end of this period was marked by the emergence of a vastly new and different political atmosphere with respect to the extent and nature of the responsibility of the federal government to individual land owners. It was also marked by the establishment of a competing, though ostensibly cooperating, mapping program in the Soil Erosion Service. Within two years the Soil Erosion Service had become the Soil Conservation Service, a permanent bureau in the Department of Agriculture; Chris Marbut had died in the remoteness of Manchuria; and the Soil Survey was delivered up to Marbut's handpicked successor, Charles E. Kellogg, thirty-two years old.

3.31 1920-1933, Soil Classification

Developments in soil classification during this period, like those of the latter part of the preceding decade, were dominated by the philosophy of Curtis Marbut. Within the Soil Survey itself, Marbut's comparatively much greater interest in soil classification rather than in the mapping and interpretation phases of the work imparted something of an unbalance to the program, but in the development of the narrower field of pedology, he "...achieved for soil science what Darwin achieved for biology, he made a ration whole from scattered, seemingly unrelated facts." (331):605

From 1920 until his death fifteen years later, Marbut devoted himself to the elaboration of a comprehensive natural system for classification of all known soils. Such a system was to consist of a series of categories with a number of mutually exclusive classes within each category, comparable to the system, kingdom, subkingdom, phylum, subphylum, class, subclass, order, suborder, family, genus, species, used in biological taxonomy. In 1922, Marbut laid down the basic principles to be applied in the new natural system. These included:

> The soil is a natural body, developed by natural forces acting through natural processes on natural materials. Its true nature cannot be determined except through a study of the natural or virgin soil...
>
> Soil classification must be scientific and on a basis comparable with that employed or used in the classification of natural bodies. No deviation from the strict scientific considerations for the sake of the so-called practical use of the soil can safely be permitted...
>
> Every soil, in the course of its development, and as a result of the forces under the influence of which the development takes place, develops a series of horizons or what might be called a soil section or profile...
>
> ...the basis of grouping should be the characteristics of the objects grouped. They should be tangible, determinable by a study of the objects themselves and by direct observation and experiment...
>
> For the major grouping, we should select that characteristic that will gather all the objects to be grouped into the smallest number of groups possible, so that each group

will contain the largest number of objects possible...

A little study of the various profiles will show that they may be grouped into two large groups, one of them including all soils having a zone, somewhere in the soil profile, of carbonate accumulation, the other without such a zone...(171).[20]

At various times, in this country and abroad, Marbut published his successive systems for soil classification in which he defined all categories, and the differentiating criteria applicable at each categorical level. The most important of these were published in 1922, 1927, and 1935, only the last of which will be discussed here (171), (173), (175). (Although the last stage in the development of Marbut's classification system was not published until 1935, its principal features had been worked out by the late nineteen-twenties, and therefore it is noted at this point rather than in a later chapter.)

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20. Subdivision of soil types which had been delineated on soil maps for many years as phases were not considered to constitute a categorical level in this system.

Category	Pedalfers (VI-1)	Pedocals (VI-2)
VI Solum Composition Groups	Soils from mechanically comminuted materials	Soils from mechanically comminuted materials
V Inorganic Colloid Composition Groups	Soils from siallitic decomposition products	
	Soils from allitic decomposition products	
	Tundra	Chernozems
	Pozols	Dark-brown soils
	Gray-brown podzolic soils	Brown soils
IV Broad Environmental Groups (Great Soil Groups)	Red Soils	Gray soils
	Yellow soils	
	Prairie soils	Pedocalic soils of Arctic and tropical regions
	Lateritic soils	
	Laterite soils	
	Groups of mature but related soil series	Groups of mature but related soil series
	Swamp soils	Swamp soils
	Glei soils	Glei soils
III. Local Environmental Groups (Family Groups)	Rendzinas	Rendzinas
	Alluvial soils	Alluvial soils
	Immature soils on slopes	Immature soils on slopes
	Salty soils	Salty soils
	Alkali soils	Alkali soils
	Peat soils	Peat soils
II. Soil Series Groups	Soil series	Soil series
I. Soil Units	Soil units, or types	Soil units, or types

Essentially, the system consisted of a number of groupings at six categorical levels. Category I, the lowest level, included not groups, but the total of all soil units, or soil types. Category II was made up of soil series, "...soils whose characteristics, other than texture of the surface layer, are uniform in all respects," each of which was a grouping of soil types. At Category III, soil series which had in common "...some feature developed by local rather than general environmental conditions" were grouped into soil families.

This orderly pyramidal sequence was not carried through into the higher categories. The constituent classes of Category IV were groups, not of soil families, but of related soil series which had in common "...a similarity of true soil or solum features but not similarity of parent materials." (As noted in more detail, the great soil groups of Category IV included only soils with "mature" or "normal" profiles.) Category V consisted of three broad classes of great soil groups differentiated in a general way on the basis of the chemical composition of the parent material, particularly of the colloidal fraction thereof. At the top level, Category VI, Marbut applied his criterion of 1922 in grouping all "normal" soils into only two classes, "pedalfers" and "pedocals," differentiated on the basis of the horizon of lime accumulation (175).

In the development of this system of soil classification, as in his earlier ones, Marbut maintained his strong emphasis on the importance of the soil profile as the only expression of soil characteristics to be used in soil classification. This emphasis on significance of the horizons of the soil profile served to eliminate most of the purely geological criteria from soil classification, but it led to some initial confusion in its application to soil mapping. In addition to establishing the importance of the soil profile, Marbut's systems embodied his concept of the soil as a dynamic natural body and strongly reflected his and strongly reflected his geographic orientation in soil classification:

Marbut's recognition of the dynamics of soil formation, changes in soil characteristics over time, was incorporated into his soil classification through the concept of soil maturity and the differentiation of soils considered to be at different stages of maturation. He rejected (as had Glinka before him) Sibirtsev's terminology of "zonal" soils, but he came very close to the Russian concept of his definition of "mature" or "normal" soils (106):29. Marbut's "normal" soils were those with profile characteristics which reflected the full influence of environmental conditions over broad areas. They were defined in terms of

> ....characteristics common to the soils of a large area of the country in which those conditions known to produce local variations in soils, such as rapid changes in slope, in drainage conditions, in geological character, and texture of the soil materials, have been reduced to a minimum, or in which those conditions are at least not the dominant ones...(175):13.

They were, therefore,

> ...well drained soils, developed on relatively smooth land surfaces, from materials free from large amounts of those few compounds known to have strong influence on the characteristics of soils in the early stages of their development (175):13,

which had

> ...developed free from these inhibiting influences or have reached the stage of development in which features produced by them in an earlier stage of soil development have been eliminated (175):13.

In the application of this concept of "normal" soils to his system of soil classification, Marbut emphasized that

> The categories of the higher orders...must be based wholly on the features of the soils with mature or fully developed profiles (173):13.

Soils other than those considered to be "normal" were grouped as "Incompletely, but otherwise normally developed..." or "Temporarily abnormally developed (173):10."

This criteria based upon soil characteristics or soil morphology were applied in the differentiation of classes in the higher categories, as they were in the lower categories of soil type and soil series. This was particularly true in the differentiation of "great soil groups," the classes of Category IV. The higher categories, however, included only "normal" or "mature" soils; soils which were "immature" other otherwise not "normal" were not classified above Category III. In the all-important distinction between soils which were "normal" and those which were otherwise, therefore, while soil profile characteristics were considered, the differentiating criteria were based heavily on inferences regarding soil development or soil genesis. Thus, while Marbut rejected the strong genetic bias implicit in the Russian emphasis on climate in soil classification, he nonetheless built a genetic bias into his own systems by the requirement that the genesis or stage of development of any soil had first to be inferred if that soil were to be classified.

As noted, Marbut's work also reflected what might be called a geographical orientation in soil classification. He rejected both the soil zones of the Russians based on climate, and his own earlier soil province map based on geology (173):5, (171):32, and asserted that,

> The field man makes no inquiry, for the purpose of soil differentiation, concerning the

> vegetation, climate, or geology (except such inquiry concerning the latter as is necessary for the determination of the features of all horizons of the soil profile (177):28.

His soil classification was strongly influenced by soil geography, however, and he considered that morphologically similar soils grouped together in classes of the higher categories were sufficiently closely associated geographically so that the location and distribution of such classes could be plotted on a map for each categorical level. (With the possible exception of Category III) (173):26. He plotted such maps for several of the higher categories. The highest category, that of the “soil order,” or “soil composition groups” contained only two classes which, as noted, were differentiated on the basis of the occurrence of an horizon of lime accumulation; the distribution of these two classes (“pedalfers” and “pedocals”) in the United States was shown with a single boundary bisecting the country from Northwestern Minnesota to Corpus Christi, Texas, running approximately along the Western boundary of the American prairies (173):19, (175):14. Marbut clearly acknowledged the occurrence of “islands” of pedalfers in the pedocal region and vice versa, and of similar nonconformitities in the maps showing the distribution of classes in other categories, but he concluded, under “Geographic Relationship of the Categories,” that

> It is possible that when knowledge concerning the groups has become much fuller than at present, their relationship may be shown in all their gradations on a single complex, large-scale map. At the present time this is not possible (175):14.

Marbut thus considered that classes of the higher categories could be considered as mapping units as well as classification units. This same idea had been embodied in the earlier soil province map of 1913 (of which we was highly critical), but Marbut drew a sharp distinction between the new and the old:

> The classification here outlined is based on soil character, only the soil character being expressed in the features of the soil profile... The term soil <u>province</u> does not enter into the system as an essential part. The latter term merely designates the general region in which a given profile predominates, but the soils within this area are differentiated not on the basis of their occurrence within such areas but on the basis of soil profile. It is conceivable that an area of one soil family may occur in the midst of a large area of a

totally different family. The word province is merely a geographic term and not a term to be used in soil classification pure and simple (171):32.

As noted, Marbut's emphasis on the importance of the soil profile was instrumental in the development of soil classification. This emphasis on profile also greatly improved the quality of soil mapping ultimately, but at first there was some confusion. At the lowest category of soil classification, the population to be classified, were the soil types. As Marbut defined this population,

> ...the ultimate soil unit, the soil type, the species, includes all areas having a uniform profile, uniform in all respects, ...also...the soil series, or soil genus, includes all areas of soil having profiles that are uniform in all respects except that of the texture of the surface horizon... (171):29. (Underlining added)

By definition, therefore, Marbut's soil type occupied an area. To a soil surveyor dealing with the natural variability of soils in the course of soil mapping however, and are within which soil profile characteristics were "uniform in all respects" approached the dimensions of a point. Commenting on this difficulty in 1928, a senior Soil Survey Inspector reported the

> ...constant conflict between the soil series as an ideal or concept, and the soil series as actually represented by the soils in the field, which may not be typical and which may merge by indefinite transitions into soils of related or associated series (159):59.

As noted in chapter 3.42, this conflict was ultimately resolved through the recognition of "modal profiles," "range of characteristics," etc., but the common tendency to think of soil units only in terms of Marbut's profiles, which had the soil dimension of depth, persisted for years.

Throughout this period, Marbut maintained close contact with the leading pedologists in Europe and Russia.[21] His high standing among world soil scientists, particularly after the 1927 meeting of the First International Congress of Soil Scientists in Washington, DC, greatly enhanced the prestige of the American Soil Survey. At the time, most of Marbut's foreign colleagues were, like himself, scholars of high order, but few if any of them were faced with the political, administrative and practical problems concomitant with his position as leader of the National Cooperative Soil Survey. Perhaps because he himself had much less interest in such mundane problems than in pedology, he sometimes received stronger support for his ideas on soil classification from abroad than from among his American associates. On his part, he was strongly oriented toward the thinking of the Europeans and Russians, whom he considered his peers, and made relatively little use of the work of other Americans. His work on the soil classification system of 1935, was largely a "one man job" which was published without thorough prior review, testing, and criticism by his staff of Soil Survey Inspectors or by more than a very few others in the Soil Survey.

* * *

Partly because of Marbut's dictum that soil classification was to be based on soil characteristics, but, more importantly, because of the evolution of soil science itself, the decade-and-a-half following his publication of "The Contribution of Soil Survey to Soil Science" in 1920 was a period of accelerated development of techniques of soil character-

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21. During the summer of 1922, in Prague, Marbut attended the Third International Conference of Pedologists. This was a postwar renewal of earlier meetings such as the "II Internationale Agrogeologenkonferenz" held in Stockholm in 1910 (at which Hilgard had read a paper succinctly critical of the American Soil Survey (127):228. At the Prague conference and two years later in Rome at the Fourth International Conference of Pedologists, Marbut established personal acquaintance with Glinka, Remann, von Sigmund, Hissink, Murgosi, Stremme, and other European pedologists. While in Rome he helped to organize the new International Society of Soil Science and to initiate plans for the First International Congress of Soil Science, held in Washington D.C. in 1927. As a part of the First Congress, a transcontinental field trip, organized by Marbut and his associates, provided an opportunity for the visiting scientists to study the soils of the United States and to observe the work of the Soil Survey at first hand. In 1929, Marbut was elected president of the International Commission on Genesis, Classification, Morphology, and Mapping of Soils, which met in Danzig. He actively participated in meetings of the Second International Congress of Soil Science at Moscow and Leningrad in 1930 and, shortly before his death in Harbin, Manchuria, at the Third International Congress, held at Oxford in 1935 (252).

ization, and of discovery and interpretation of additional soil characteristics and combinations of characteristics. Within the Soil Survey, and particularly in the forum of the American Soil Survey Association, techniques, definitions, and terminology were developed and standardized for the description and interpretation of soil characteristics including soil color, soil texture, soil structure, soil consistence, etc., and for the designation of soil horizons. From the growing volume of basic research in soil science throughout the world came such portentous discoveries as that of the crystalline structure and mineral composition of soil colloids and of the existence of the base exchange complex.

As Marbut freely acknowledged, the validity of any system of classification, including his own, was dependent upon the state of knowledge of the objects classified. Increases in knowledge about soils, therefore, logically necessitated a subsequent critical reappraisal of Marbut's last system of soil classification just as Marbut's intensive and fruitful studies of soil morphology and genesis fifteen years earlier had led to revision (in fact, rejection), of the geologically-oriented soil classification systems of the preceding era. The most searching criticism of Marbut's classification occurred after, rather than during, his lifetime, and is noted in chapter 3.41. Such criticism is the flesh and sinew of progress in any scientific field; Marbut's legacy was a scientific tradition which stimulated the interest of a new generation of scientifically trained, and scientifically curious, soil scientists.

3. 32 1920-1933, Soil Mapping

The nineteen-twenties, in the field of soil mapping, saw the emergence of the tremendous innovation of the use of aerial photographs for base maps in field mapping. The development of the airphoto technique for this purpose is noted in chapter 3.321.

Although the practicability of mapping on airphotos was well established by 1929, the technique did not come into general use in the Soil Survey until several years later. There were other technical advances in mapping during the twenties, however, but not nearly on par with the progress in soil characterization and classification during the same period (see chapter 3.31). Significantly, much of the support for improvements in soil mapping came from State soil survey leaders who had shown little initial enthusiasm for Marbut's ivory tower of Pedology (326).

In protest as the growing unbalance between the interest in soil classification and that in the more work-a-day matter of soil mapping, a member of the American Soil Survey Association commented, in 1928:

> We are not so much a Survey Association, as a Soil Association, or a Soil Science Society, or Society of Pedologie, or Edaphology...(51):23.

Despite the lure of pedology, edaphology, etc., sufficient soil surveyors remained soil surveyors so that some improvements were made:

Soil slope was mapped in more detail. In 1921, slope variations within soil types were mapped in a Wisconsin survey according to the following slope classes:

"A"	"Level to gently undulating"	"0 - 5% slope"
"B"	"Undulating to gently rolling"	"5 - 15% slope"
"C"	"Rolling to steep and hilly"	"15 - 30% slope"
"D"	"Rough and broken"	"Above 30% slope"

A similar slope legend was recommended by another Wisconsin soil surveyor in 1925, with the comment that

> ...it increases the value of the map considerable to show the portions of a type which are level and those which are steep or subject to erosion, as distinct from the average topography for that type. Many level terraces include undulating or eroded areas, and

undulating types include level and steep areas which in detail mapping should be separated, their value being different than the average because of this variation in topography (104):99.

A recommendation from Michigan, also in 1925, concluded:

There should always be as much as detailed topography as is practicable. If contours are not available, at least a set of color or other symbols to break topography into a minimum of five classes from level to mountains (104).

Slope legends even more detailed than the above were used during the nineteen-twenties in Illinois surveys conducted at that time completely independently of the federal Division of Soil Survey. More typically, however, slope variations in the soil surveys of the twenties were shown as phase separations only where considerable differences in agricultural use were influenced by the lay of the land.

In addition to soil slope, other features such as erosion, wetness, stoniness, etc., were delineated as phases of soil types. Until about 1930, however, the soil type was the most common mapping unit and the phase was considered as

A subdivision of the soil type covering departures from the typical soil characteristics insufficient to justify the establishment of a new type, yet worthy of recognition. (232):72.

In many cases, soil surveyors recognized and mapped detailed soil and land features which were later generalized or deleted upon publication and thus did not appear on the finished maps. This was true of the soil survey of McKenzie County, North Dakota, one of the most highly detailed soil surveys made without the use of airphotos. In the McKenzie Country, survey, begun in 1930, four slope classes were recognized and mapped, stoniness was shown in four classes, and on rough areas suitable only for grazing, the quality of the grass cover was mapped in four classes (302). This detailed information, in addition to the soil types, was needed and used in land appraisal for tax assessment, but many of the mapping separations which resulted were generalized and combined into broader mapping units on the published map (146), (80).

Another important improvement during this period was an increase in the scale of field maps. The limit of detail to be delineated in field mapping in the early nineteen-twenties was still supposed to be 10 acres, as it had since 1906 (274):13. The fallacy of assuming that such detail could be mapped consistently and accurately at the prevailing field scale of 1”/mile, however, was pointed out in 1922 by M.W. Senstius, a trained geographer from the University of Chicago:

> The present scale of approximately 1 inch to the mile is claimed to enable one to map differences in soils within an area of 10 acres. Last summer I had the privilege of working under men with considerable and varied experience, but in no case could their work convince me of the validity of the claim mentioned (228):88.

Senstius was only saying what most soil surveyors already knew to be true; while publication scale of soil surveys remained at 1”/mile, the scale of base maps used in field mapping on many, but by no means on all, soil surveys was increased to 2”/mile (177):216. This doubling of the linear scale, or course meant a quadrupling of mapping area and hence of mapping detail possible. Where airphoto base maps were used, field scales ranged up to 4”/mile (52):74.

Although field scale was increased, a higher degree of cartographic accuracy was required of base maps prepared by soil surveyors, following creation of the Federal Board of Surveys and Maps in 1919, since their work was used by other agencies such as the U.S. Geological Survey in the preparation of topographical quadrangles (181), (205). As a result, many men of the Soil Survey, of necessity or by inclination, became highly skilled field cartographers and draftsmen. Published soil survey maps were, in most cases, also the most accurate and up-to-date county road maps available, and were widely used as such (205):41. Amid the efforts toward achieving precision in cartographic techniques, progress in the more difficult job of accurate and detailed identification and delineation of soils did not always keep pace.

In the mid-nineteen-twenties soil surveyors were covering the ground by hiking transects one-half to one-quarter of a mile apart, and the average coverage per man per day was about two square miles (205):41, 82. The cost of field mapping varied considerable across the country, but the average was estimated roughly at about one cent per acre in 1929 (337).

3.321 Airphoto Base Maps

The most significant development in the techniques of soil mapping during the nineteen-twenties, and probably the greatest innovation in such techniques in the history of the Soil Survey, was the introduction of the use of aerial photographs as base maps for field mapping. The application of aerial photography to the construction of maps emerged as an offshoot of military intelligence operations in World War I. Among the wartime officer corps in the U.S. Army Air Service engaged in such operations were a few young men of the Soil Survey, and the airphoto idea returned with them.

One of these men was William Battle Cobb, formerly of the Bureau of Soils and later of North Carolina State College. Encouraged by the experiences of 1918, Cobb made some experimental flights over Alabama and North Carolina around 1922 and recommended to his Soil Survey colleagues the use of the airplane both for direct observation and mapping of soils, and to provide airphoto maps for use in mapping on the ground. In discussing the latter, Cobb cited the advantages of airphotos in showing the configuration of streams, towns, swamps, etc., and the relative proportions of land under cultivation, in forest, etc.. Venturing upon the thin ice of airphoto interpretation, Cobb reported:

> In the south you can determine the topography fairly well from aerial photographs. Square fields and straight rows indicate level or nearly level land. Contour plowing indicates slopes. Terraces indicate steeper slopes and terraces close together indicate still steeper slopes (62):78.

Elsewhere, tentative beginnings were made and, about 1923, an airphoto map of an entire county was used in a soil survey in the Southeast. Reporting on the results of using this map, S.W. Phillips of the Bureau of Soils was less enthusiastic than Cobb, but he noted the advantages of airphotos in locating roads, buildings, and wooded areas and recommended the continued use of airphoto maps for soil survey work “...in connection with our own plane table maps...(205):43”

Phillips looked upon the airphoto map primarily as an adjunct or auxiliary to the conventional base map laboriously prepared by planetable and alidade. Meanwhile, however, a complete departure from such conventional methods, the direct use of airphotos as primary base maps, was being developed elsewhere. Between 1925 and 1928, Thomas W. Bushnell of the Indiana Agricultural Experiment Station conducted some experimental mapping on airphotos, and compared the results with soil maps made on the conventional base. The contrast was so marked that, in 1928, Bushnell suggested a two year suspension of all soil survey field work pending the availability of airphotos, and concluded:

> Personally, I am unwilling to map another square mile without the aid of aerial photos. (51):28.

In 1929 and 1930, the first county soil survey in the United States made entirely on large scale airphoto base maps was completed for Jennings County, Indiana under the direction of Bushnell and other state and bureau soil surveyors (158). By 1932, soil surveys on airphotos at field scales of 3.5" to 4" per mile, with use of stereoscopes, had been completed for six additional Indiana counties (52).

In 1930, the American Soil Survey Association went on record with the resolution to the effect that:

> WHEREAS: aerial photography has proved very useful as an aid in soil mapping, Be It Resolved that this Association urge the cooperation of the Federal and State Soil Surveys with other organizations interested in the use of aerial photographs, with the view of affording mutual assistance and of reducing the cost of such work (223):197.

By 1931, soil surveyors in Michigan were mapping soil slopes by use of the mirror stereoscopes (with ground check by hand level), and reported that the shift from plane table to airphoto base had resulted in nearly doubling the daily rate of mapping progress (186).

Strong support for the adoption of airphotos came also from Mark Baldwin of the federal Division of Soil Survey, another of the Army Air Service fledglings of 1918, and, as the Bureau's Inspector of soil surveys for Indiana, a long associate of Bushnell. In 1931, shortly before becoming Chief Inspector for the Division of Soil Survey, Baldwin paid a tribute to Bushnell's contribution, and reminded his colleagues that the conventional plan table methods were

> ...a source of irritation and bloodshed in tangled regions of logs, dense brush and windfalls. These methods date back to the year 1900, or earlier. About the only marked

> change in methods for 25 years or more was the substitution of the automobile for 'Dobbin and the one-horse shay,' which was forced upon us by Henry Ford, et al (26):94.

The efforts of Bushnell, Baldwin, et al., to emulate the example of Henry Ford in effecting adoption of the new techniques were not everywhere successful. Airphotos were widely used for soil surveys in the areas noted, and in some others, but elsewhere much of the work in the early nineteen-thirties was done by the old methods. This was due primarily to the lack of available airphoto coverage and the lack of sufficient funds for State and federal soil survey agencies to assume the cost of providing the needed coverage. In addition, however, there was a considerable among of inertia on the part of some of the senior Soil Survey personnel in both the Bureau and the States, and a stiff tendency on the part of the Bureau's cartographic section to resist changes in the highly developed procedures for preparing finished maps from the soil survey field sheets. This interim was minor in comparison to that which had faced Marbut in the field of soil classification fifteen years earlier. In the early thirties, however, Marbut was devoting his energies much more to refinements in soil classification and soil geography on a broad scale, than to the opportunities for increasingly accurate and detailed soil mapping made possible by the innovation of the aerial photograph.

3.33 1920-1933 Soil Survey Interpretation

In an earlier chapter, the years between 1912 and 1920 were described as a sort of "incubation period" for the elaboration of the principles, theories, and systems of soil classification which subsequently emerged with sudden impact. Similarly, in the field of soil survey interpretation, the decade-and-a-half after 1920 saw the gradual development of new techniques and, finally, changes in basic policy, which led to the great improvements in the usefulness of soil surveys during and after the nineteen-thirties. But not during the 'twenties:

As noted, Soil Survey Chief Marbut's interest in soil survey interpretation was secondary, although his understanding of it was clear. In 1924 he wrote,

> There is a constant tendency to limit more and more the amount of agricultural advice given. This is being done partly because the soil survey report is being regarded more and more as a scientific publication and should not attempt to give practical advice. The soil surveyor is being regarded more and more as primarily a scientific man concerned with the scientific investigation of the soil, and one who is not primarily concerned with the use or the treatment of the soil, except in so far as his wide experience may suggest. The limitation of the amount of agricultural advice is due partly also to the realization that the identification of a soil, the determination of its physical, chemical, and morphological characteristics does not at once determine its agricultural capabilities. These must be determined by experimental work carried out on the fields whose soil characteristics have carefully been determined, it being assumed and confidently believed that the experimental results obtained at one or two places on a given soil will be applicable to all areas of the same soil wherever it may be found. The soil survey report and map will enable the experimenter properly to locate his experimental fields so that this results may apply to a definite soil and enable him also to determine the area over which his results may be applied. The soil survey, in other words, is the fundamental scientific basis of fact and principle on which experiments may be based and through which and only through which the results of the experiments may be interpreted. Without the soil survey experiments have little practical value because they cannot be correlated with actual soil conditions except on the spot where the experiments were performed (177):221.

Because of Marbut's position and influence, the statement represented the Soil Survey policy (at least from the standpoint of the federal Bureau), regarding soil survey interpretation until the late nineteen-twenties. Soil management information was included in all the soil survey reports, but the form and content of such information were not standardized and management recommendations continued to deal in general terms. In the two examples, the recommendations were only slightly more specific than those in the soil survey reports of ten or fifteen years earlier:

1926. Kent County, Michigan:

> Miami loam readily responds to good cultural methods and with proper management retains its natural productiveness. On account of its rolling relief, some care must be exercised to prevent erosion. Clover crops turned under assist in maintaining the supply of organic matter. Finely ground limestone, applied at the rate of one to two tons per acre has proved beneficial on this soil because of the slight to strong acidity of the surface soil. Applications of superphosphate have increased the yields of grain crops (329):17.

In another area, a year later, soil management information was limited essentially to descriptions of current practices:

1927. Worcester County, Massachusetts:

> The crop yields from Charlton loam are fairly good. Hay yields from 1 to 2 1/2 tons per acre and as high as 3 tons in some cases. Corn and oats make good yields, corn being grown almost entirely for silage and producing from 10 to 12 tons per acre. Oats are used as a nurse crop for grass, principally timothy and clover, and the oat crop is harvested in bundles or cured as hay. Potatoes yield from 100 to 250 bushels per acre. Apples do well upon this land, the trees being healthy and the fruit of good flavor and quality. Most of the plowing is done in fall. Manure is spread in the winter (162):1563.

At the time, the rather generalized soil management information in the soil survey reports, such as that cited, was about all that could be reliably correlated with the comparatively loosely defined (by modern standards) soil types, or accurately applied with the 1"/mile soil maps. Nonetheless, Soil Survey policy regarding the type and amount of interpretive material to be included in the soil survey reports became an increasingly controversial issue. In the arena provided by the newly-founded American Soil Survey

Association, the Soil Survey was criticized both for attempting too much of its own interpretation, and for attempting too little (165), (241), (326). In the latter category was the statement by Charles F. Shaw of California in 1922 that

> The value of the soil survey depends on the extent to which it can be used by the people. As a historican [*sic*] document, an inventory of soil resources and conditions, to be filed away in libraries, it has little justification; the basic reason for supporting the work is the anticipation that the survey will have a definite utilitarian value, will be of positive use in solving the problems of today (231):40.

In the general controversy, soil scientists of the cooperating State agencies largely favored the inclusion of more interpretive material in the reports than did the federal staff of the Soil Survey. The State men, with greater stability and with more limited areal responsibility, were in closer contact with Extension Service agents and other users of the soil survey reports, and were in a better position to observe both the value and the limitations of the reports and maps. Also, the State agencies were dependent for funds upon State legislatures which, as Hilgard had recognized a half-century before, were prone more to the support of agricultural programs of immediate practical applicability than to the maintenance of longer-run scientific studies. An additional source of difference (noted) was the opposition to Marbut's progressive elimination of most agricultural criteria from his systems of soil classification.

Efforts to increase the practical utility of soil surveys through revision of the form and content of the reports resulted in a series of moves by the Soil Survey Association. For four straight years after 1926, the Association adopted resolutions calling for a major policy change in the publication of soil survey reports. The recommended policy provided for the publication of two types of reports for each survey. One was to be a popularized, nontechnical report with an emphasis on soil management information, while the other was to deal with the technical and scientific aspects of the work; State personnel were to have a large share in the preparation of the popular reports, and the Bureau would assume major responsibility for publication of the others. The various resolutions did not bring about the changes intended, except in a few states, but agreement was reached with the Bureau to separate the "technical" from the "practical" material in the reports (44), et seq.

Other programs while not related directly to the makeup of the soil survey reports, demonstrated some of the broad land-use applications of soil survey interpretation. One of these was the "Land and Economic Survey" in Michigan, organized in 1922 as a cooperative survey program involving several Michigan State agencies, the U.S. Geological Survey, and the Bureau of Soils. The program combined a basic inventory of resources with an economic analysis. In the field work, teams of foresters, geologists, soil surveyors, and others prepared maps showing soils, topography, water, geology, cover and land-use, including man-made structures and improvements. In the interpretation of the basic inventory, the field men cooperated with economists and other specialists in a broad study of problems and potentialities relating to agricultural and industrial development, community organization, taxation, recreational land-use, etc. (227). Similar but less extensive programs were organized in Wisconsin and in a few other States.

In the West, after a number of large-scale irrigation and reclamation projects had failed for lack of adequate data on soils, some of the senior men of the Soil Survey were assigned to assist and advise the U.S. Bureau of Reclamation in the interpretation of soil surveys as a basis for classification of land in proposed reclamation projects. This work, started in 1925 led to the establishment of a program of soil and land mapping within the Bureau of Reclamation (161):149.

At scattered locations across the country, a start was made on correlative studies on the relation of specific soil types to the occurrence of various plant and animal diseases and infestations. These included "alkali disease," corn borer, phylloxera, diseases of livestock, and quality of human teeth (161), (22), et seq.

Thus, although the standard soil survey reports changed relatively little, interpretation of the data by others for specific purposes continued. The use of soil survey data in the engineering problems of highway and road construction was recognized in 1926, when the Soil Survey commenced cooperative studies with the U.S. Bureau of Public Roads (303):157. By 1928, the "engineering characteristics" of some of the more extensive soil types had been tentatively determined, particularly in Michigan, where the State Highway Department made use of special soil surveys at a scale of 25"/mile in the design and construction of highways (144). (Such “highway soil science,” begun originally in this country by civil engineers about 1914 was one field in which Russian soil scientists acknowledged an American priority.) (215):10. In another phase of engineering interpretations, the Soil Survey cooperated with the U.S. Bureau of Standards about 1930 in studies on the correlation of different soil types with the extent of pipe line corrosion (Archives).

With the stimulus of programs such as the Michigan Land and Economic Survey (noted), in the early ‘twenties, the application of soil survey data to forestry and silviculture was tentatively tried in the Lake States and in New England (299). In 1931, a forest soils investigator in Wisconsin reported that

> Not only does the planting of a forest depend on the data of soil survey, but the soil survey is often the only way of securing a satisfactory classification of the forest cover, particularly of young, natural reproduction of ‘second growth’ stands...Commonly the soil types recognized by a soil survey are correlated with typical floral associations and sometimes even with the rate of growth of forest lands (328):27.

The results of other attempts to soil survey interpretation for forestry were less successful, particularly where older maps were used, but the possibilities suggested by the work in Michigan, Wisconsin, and elsewhere, brought together foresters and soil scientists and encouraged the wider use of soil surveys in forest planting and management (99).

In another field of growing national importance, the need for soil surveys was reappraised in the latter nineteen-twenties. This was the increasing concern about the extent of soil erosion and the recognition of the need for more effective erosion control measures. The Bureau of Soils had long since discontinued the earlier work on soil erosion investigations begun by McGee in 1907; in the report for fiscal year 1927, however, the Bureau Chief noted.

> Another matter of immediate practical importance has forced itself to the front during the past year. The tremendous loss from soil waste by erosion has been recognized in a rather hazy way for many years. The progress of soil survey work in certain parts of the country has shown in increasingly definite form the magnitude of this loss. The loss through erosion has finally been recognized as a national menace, and a strong demand has been made for an investigation of the causes of the loss and for the working out of

the practical methods for its control (179):2.

In the American Soil Survey Association, the problem of soil erosion received increasing, if belated, attention, and the membership repeatedly pointed out the need for soil surveys in both research and operations in soil erosion control (187), (188), (31), et seq.

A small number of soil erosion experiments were already underway at some of the State Agricultural Experiment Stations. In 1928, M. F. Miller of the Missouri Station, reporting on "Ten Years of Erosion Measurements," noted:

> ...an increase of approximately 25 percent in erosion under continuous corn, for each percent increase in slope (188):32.

More significantly, Miller further pointed out that,

> The land on which these measurements are being made is a poor phase of Shelby loam having a slope of 3.68 percent and the results are, of course, applicable to this soil and slope only (188):29.

Also in 1928, Hugh Hammond Bennett of the Bureau of Chemistry and Soils, in the influential bulletin, "Soil Erosion as a National Menace," wrote,

> This kind of information that is most needed about erosion is that which will apply to the definite kinds of land, to soil types that vary from place to place, not only in their crop adaptations and requisite methods of cultivation, but in their resistance to erosion and in the means necessary for checking erosion. Any other method of procedure in studying the problem will be, in no small degrees, wasted effort, as methods that may apply to one soil map injure a soil of different character (30):19.

To his colleagues in the Soil Survey Association, Bennett declared,

"We are taking very little interest in this momentous problem in a national way. We have been quite inarticulate about it and still more inactive" (31):73.[22/]

There was nothing "inarticulate" about Hugh Bennett, and he became increasingly

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22. At the request of the American Organizing Committee of the First International Congress of Soil Science, held at Washington DC in June of 1927, the Library of the U.S. Department of Agriculture compiled a "Classified List of Soil Publications." Of the thousands of bulletins and journal articles on soils published as of the end of 1926, the Library compilation listed about seventy that dealt specifically with soil erosion by water and wind and with methods of erosion control. None of these was by Bennett (275):479-483.

outspoken in the cause of soil conservation. In 1928 he was assigned to head up the Bureau's reactivated unit, "Soil Erosion Investigations," briefly under Soil Survey chief Marbut and subsequently on a coordinate level with Marbut within the Bureau (Archives). The later evolution of this work into the Soil Erosion Service of the Department of Interior and, in 1935, the Soil Conservation Service of the Department of Agriculture is noted in chapter 3.44.

As the nation evinced a growing interest in, and support of, soil conservation in the early 'thirties, specific programs of research and demonstration in soil erosion control were developed on a large scale. The popularity of the conservation movement, however, attracted support from various diverse sources which tended to confuse the issue and to overstate the case for conservation by resort to emotional and quasi-religious evocations (29):317, (110):98. To the overstatement of such "neo-malthusians," Curtis Marbut countered with understatement. In a short article for the Encyclopedia of Social Sciences, published in 1934, Marbut wrote,

> Soils are subject to erosion by the action of both environmental and human forces. Erosion is, however, essentially a local problem; its main importance is in relation to floods and flood control. For the world as a whole erosion is unimportant. The key to the agricultural crisis is the surplus created by the productivity of modern farming and the social relations which condition it (176):254.

* * *

In 1933, with the nation entering the period of its greatest demand for modern, detailed soil surveys, a major unsolved problem of the Soil Survey, time lag between completion of field surveys and publication of the results, had become, if anything, worse. This time lag for most surveys was five years or more. Of the two surveys noted in chapter 3.32, that of Jennings Country, Indiana, completed in 1930, was not published until 1940, and the McKenzie County, North Dakota survey, completed in 1933, was published in 1942 (158), (80). In some other instances, the lag was more than fifteen years.

3.4 1933 - 1952

In the preceding discussion of Soil Survey history up to 1933, three significant periods were recognized. These were 1899-1912, 1912-1920, and 1920-1933. The selection of these particular dates, admittedly somewhat arbitrary, was based primarily upon technical and scientific development within the Soil Survey itself. It was also pointed out that the dates selected happened to coincide with political development resulting in changes in partisan control, Republican or Democratic, of the national administration. Until 1933, the Soil Survey was little influenced by such political changes and the coincidences were purely coincidental.

In the two decades of the New Deal and Fair Deal, however, the Soil Survey (although very nearly lost in the shuffle at first), was profoundly affected by the public attitudes, the political philosophy, and the federal administrative structures which emerged from the national election of 1932. As it happened, the end of this period of Soil Survey history coincided with yet another change of Administration, and the program has since been affected by some of the Republican policies, particularly as they involved federal-state relations; the decisive administrative action of October 14, 1952, however, that resulted in a thorough shake-up of federal activities in the Soil Survey and the integration of such activities within the Soil Conservation Service was the work of Democratic Secretary of Agriculture, Charles F. Brannan in the final weeks before the Eisenhower victory (279).

* * *

Among the vase political changes wrought, and/or recognized, by the New Deal were those involving public attitudes toward the nature and extent of the federal government's responsibility to individual farmers. The earlier "Conservation Movement" and the national land policies which developed before 1933 dealt primarily with nonagricultural lands, and emphasized public ownership as the remedy for misuse of land (102):142. The crisis conditions of the 'thirties, however, and the political and administrative response to such conditions, brought forth programs of direct federal assistance to millions of <u>individual</u> farmers on hundreds of millions of acres of <u>private</u> land. To provide this individual assistance on problems of production adjustment, price support, soil conservation, agricultural credit, etc., the Congress and the Administration created a complex of new, or greatly expanded, federal agencies including the Agricultural Adjustment Administration, Soil Conservation Service, Tennessee Valley Authority, Resettlement Administration, Commodity Credit Corporation, Farm Security Administration, and others. In the operations of these various agencies, and particularly in the programs of the Soil Conservation Service and the Tennessee Valley Authority, an unprecedented need for up-to-date, large-scale soil surveys became almost immediately apparent.

More generalized soil survey data were also in demand. The proliferation of committees, commissions, boards, etc., dealing with various phases of land-use planning at all levels of government pointed up the need for broad surveys of soil resources of the nation, the States, counties, local communities and watersheds.

At the national level, the National Resources Planning Board stimulated efforts to obtain generalized inventories and appraisals of the nation's soil resources. Among such early efforts were the hastily-completed national survey of "Soil Productivity" under Marbut of the Soil Survey, and of "Soil Erosion" under Bennett of the Soil Erosion Service, both in 1934 (196). The growing recognition of the importance of basic soils data for use in national planning served to release funds for the long-delayed publication of Marbut's monograph and map, "Soils of the United States," published in 1935 as a part of the "Atlas of American Agriculture" (175). Also in 1935, generalized surveys utilizing soils information were undertaken by Agriculture's Bureau of Agricultural Economics in cooperation with many of the States to provide for "...a more equitable operation of the Agricultural Adjustment Administration" (194):48.

In land-use planning activities at the state level, federal-state relations were strained as some of the new federal "action agencies" tended to bypass existing State programs in dealing directly with individual farmers. To resolve some of the friction which had developed, and, at the same time, to foster the adoption of land-use planning procedures at all levels, the Department and the State Colleges ratified the "Mount Weather Agreement" in July of 1938 (27), (39). The coordinated scheme of community, county, State, and national land-use planning committees envisioned by the Mount Weather Agreement was never realized in total, but the activities of the many such committees that were set up further demonstrated the need for, and the lack of, adequate soil surveys at all levels of generalization.

Any further discussion of the many agencies notes, except as they affected, or were affected by, the National Cooperative Soil Survey, is clearly beyond the scope of the present study. Suffice it to say that soil surveys were needed, and badly.

After thirty-five years of operating in relative obscurity and on a scale and budget that, by New Deal standards, amounted to an undersized shoestring, the Soil Survey, it would seem, had come into its own. Soil surveys were being put to use as never before and urgent requests for additional soil survey coverage were submitted by local committees, professional societies, federal and state agencies, Members of Congress, and, repeatedly, from the Land Grant Colleges, individually and through their Association. (Archives), (207), et seq. Within the organization of the American Soil Survey Association, the challenge and opportunity presented by the rapid turn of events were readily recognized and accepted (219), et seq. In this general atmosphere of expansion and of sudden demands for soil survey coverage, the position of the Soil Survey was something akin to that of a peacetime military service at the onset of war. In the early and middle thirties, the men of the Soil Survey had something in common with Rudyard Kipling's Tommy Atkins, who wryly observed (approximately):

> O, it's "Tommy this" an' "Tommy that," an' "Tommy go away"; but it's "A thin red line of 'eroes" when the bands begin to play...

The simile is inapt. In "muddling through" even the worst of his campaigns, Tommy Atkins was generally provided with some means of accomplishing what was demanded of him. The Soil Survey was not. An analysis of the political and administrative causes of this logistical failure, and of its consequences, political, administrative, scientific, and technical, is the subject matter for the concluding chapters of the present study. (Clearly, the events described and, indeed, the entire twenty-year span, are much too recent to be viewed with the historical perspective comparable to that of the earlier periods of Soil Survey history.

Also, the present author, having had some slight participation in these events, cannot pretend to the degree of personal disinterest with which, it is hoped, he discussed such subjects as Amos Eaton's geological surveys of 1820.)

In place of the expanded mapping program so urgently needed, the Bureau's Division of Soil Survey was caught at the outset in the conflicting national legislation of 1933 which imposed reductions on budgets of existing agencies while simultaneously providing billions of dollars to new agencies for emergency relief and public works. Federal appropriations for the Soil Survey received successive cuts in 1933, '34, and '35 (19), et seq. Meanwhile, the new Soil Erosion Service of the Department of the Interior, with allotments of emergency public works funds, launched a vigorous program of soil erosion control projects. As an integral part of this program, highly detailed "soil erosion surveys" were made for each project. (Factors affecting federal appropriations for the two separate mapping programs are noted in chapter 4.2.)

By the time the initial budget cuts were restored to the Division of Soil Survey, the Soil Conservation Service, with its own mapping program, had become an extremely popular and politically potent permanent agency in the Department of Agriculture. (The mapping program of the Service is noted in chapter 3.44.) The "soil conservation surveys" of the Service, while nominally coordinate with the program of the Soil Survey, were initially intended only to serve the immediate farm planning needs in the field operations of the Service and did not constitute a part of the basic Soil Survey of the United States. The coverage of soil conservation surveys, however, rapidly outstripped that of the Soil Survey and, after 1945, the two mapping programs became practically independent. About 1949, the Service proposed the recognition of its soil conservation surveys as a "National Land Capability Inventory" which seemingly would absorb or replace the program of the National Cooperative Soil Survey. (The repeated efforts from within the Department of Agriculture to coordinate the work of the two competing survey programs are discussed in detail in chapter 4.)

In the more complex politics of federal-state relations, the Land-Grant Colleges were deeply involved from the first in the problem of obtaining adequate soil surveys throughout the country. In the long controversy between the mapping program of the Service and that of the federal Division of Soil Survey, the Colleges (collectively) strongly favored cooperation with the latter. (The position of the Land-Grant College Association, and the reasons, technical and otherwise, for its support for the Soil Survey are noted in chapter 4.3.) State participation in the work of the Soil Survey was strengthened through the establishment of the "Annual Technical Work Planning Conference of the National Cooperative Soil Survey" which included both federal and state representation.

Administratively within the federal division of Soil Survey itself, the organizational structure was shaken up soon after Acting Chief Charles E. Kellogg became Chief of the Division in 1935. While retaining full responsibility for the entire Division program, Kellogg delegated authority to a degree unknown under Marbut. The field staff of Soil Survey Inspectors was assigned an increased role in decisionmaking, and their views were brought to bear on broad technical and administrative problems by means of regular staff meetings, also unknown under Marbut. The Inspectors' positions were upgraded professionally and salary-wise (the title "Soil Survey Inspector" was changed to "Soil Correlator"), and an increasing portion of the slim federal budget was devoted to soil investigation and correlation costs, including travel. The functions of "Chief Soil Correlator," formerly the province of the Division Chief were assigned to a senior staff member reporting directly to Kellogg. A similar position was set up at the national level (and later at the field headquarters of the correlation staff), to provide technical leadership in soil survey interpretation. The emphasis on high standards of professional competence encouraged advanced studies and individual research by soil scientists at all levels, and opened up more rapid and more varied advancement opportunities for field men of the Soil Survey, both federal and state.

On the technical and scientific level, the Soil Survey under Kellogg and his staff developed along a middle course somewhere between the old-school scientific aloofness of Marbut and the flamboyant pragmatism of Bennett (155). The scientific gains of thirty-five years of soil survey work were consolidated, and some of the errors of thirty-five years of soil survey work were corrected, through the continued application of basic soils research to soil characterization and classification. On the basis of new knowledge available, Marbut's soil classification of 1935 was twice revised and, after 1950, work was begun on a cooperative international project of soil classification.

Technical progress in soil mapping was equally marked, but only after an initial lag, and with some stimulation from the competing program of the Soil Conservation Service.[23/] The use of airphoto base maps, a Soil Survey innovation of the late 'twenties, was adopted almost universally for detailed mapping after the late 'thirties; field mapping scale was increased to 4"/mile, and phases of soil types (representing variations in slope, erosion, depth, etc., within soil type areas where such variations were significant in soil use and management), replaced the soil types themselves as the most common mapping units on detailed soil surveys.

Soil survey interpretation, after a lapse of twenty years, again became recognized as an essential and integral function of the Soil Survey. Progress in soil survey interpretation was dependent upon a specific policy change and a reappraisal of the purposes and functions of the total program. The result was a greatly increased emphasis on the practical application of scientifically sound soil surveys. In 1949, Kellogg wrote:

> No choice can be made between a utilitarian soil survey and a scientific soil survey. Of course, soil surveys made for predictions about land-use and management, and most of them are, must be practical. <u>But they will not be practical unless they are also scientifically sound</u> (155):9. (Underlining added).

Two years later, in the Soil Survey Manual of 1951, the primary functions of the Soil Survey <u>in relation to purpose</u> were specified as follows:

> The Soil Survey includes those researches necessary (1) to determine the important characteristics of soils, (2) to classify soils into defined types and other classificational units, (3) to establish and to plot on maps the boundaries among kinds of soil, and (4) to correlate and to predict the adaptability of soils to various crops, grasses and trees, their behavior and productivity under different management systems, and the yields of

23. Apropos of the mutually corrective influences of the two competing programs, one upon the other, in the field of soil mapping, is Hardin's observation that :
In the welter of criticism of 'bureaucratic duplication and overlapping,' it is well to note that the administrative competition may have its uses. (110):33. Of course, the mutual influences were not, in all instances, mutually corrective.

adapted crops under defined sets of management practices.

The fundamental purpose of a soil survey, like that of any other research, is to make predictions. Although the results of soil research are being applied increasingly to engineering problems, such as the design and maintenance of highways, airports, and pipelines, applications are chiefly in the agricultural field, including forestry and grazing. It is a purposeful research (254):23.

Many specific systems of soil survey interpretation were developed for as many different specific purposes. For the recognized major purpose of application to soil surveys to agriculture, the most important interpretive system involved the development of yield estimates of particular crops on particular soils under defined levels of management. With such "inputs" and "outputs" thus quantitatively defined, these yield data for individual soils provided the first approximation of "production functions" for soils. When used in combination with broad land classification expressing "land-use capability," such soil production functions defined both the physical and the economic land-use alternatives needed for comprehensive land-use planning. As with earlier portions of the present study, developments in the separate fields of soil classification, soil mapping, and soil survey interpretation are noted in the three chapters that follow.

* * *

The administrative changes and the increase in scientific activities of the Soil Survey, most of which involved increasing expenditures per acre mapped, were carried out under an environment of precariously low appropriations, steadily rising costs, and continuing demand for more and more soil survey coverage. The decision taken by Kellogg and his staff under the circumstances was to sacrifice quantity for quality. With a few exceptions, such as the program in the Tennessee Valley, where TVA funds were available, the scope of field operations of the Soil Survey in terms of acreage mapped annually was significantly reduced.

This decision to curtail the coverage of field mapping while, at the same time, expanding and diversifying the supporting scientific investigations, did little to strengthen the position of the federal Division of Soil Survey vis-à-vis the mapping program of the SCS in the already unequal contest for Congressional recognition and support. By the late ‘forties, the SCS, in the purely quantitatively measure of acreage mapped, was overwhelmingly out-producing the Soil Survey, and was fully prepared to eliminate the remaining competition by absorbing the older program, lock, stock, and barrel auger. It very nearly did.

The course taken by the Soil Survey, however, was supported by the scientific community, by other research agencies in the Department, by most of the land-grant colleges, and by the not inconsiderable determination of Soil Survey Chief Kellogg himself. This combination served to forestall this seemingly inevitable dissolution of the National Cooperative Soil Survey. Thus a continuity was maintained in the scientific tradition of soil science dating back to Marbut and, beyond Marbut, to Hilgard.

The result was a gradual, but accelerating increase in national recognition of the Soil Survey, even by the Congress. By 1950, federal appropriations for the program were about a million dollars, with an additional estimated $750,000 contributed by the states (190):4.

More significantly, upon final integration of the federal activities within the SCS in 1952, the professional standing of the Soil Survey was such that top-level leadership of the integrated program within the Department was assigned to the Chief and the senior staff of the numerically smaller former Division of Soil Survey. The total cooperative program which has since emerged has drawn upon the best elements of both the former programs, but the policies and standards prevailing are essentially those previously established by, and carried over from, the Soil Survey.

3.41 1933-1952, Soil Classification

During the latter years of Marbut's administration of the Soil Survey, work in the field of soil classification was strongly dominated by this individual philosophy and, as noted, the soil classification system of 1935 was essentially a "one-man job." Marbut's successor as Soil Survey Chief, Charles E. Kellogg, also maintained a unique position of professional leadership in the American Soil Survey, and strengthened contacts with foreign soil scientists and soil surveys established by Marbut. The Soil Survey under Kellogg, however, became organized on a much broader cooperative base, and contributions in the field of soil classification came from an increasing number of soil scientists, including notably several from cooperating state soil survey agencies. These were unawed critics, who spoke frankly.

This scientifically healthy state of affairs was described, with a pinch of salt, by a visiting foreign soil scientist in 1938. After a lengthy tour of this country, G. Milne, a British soil scientist well known for his work in East Africa, tried his hand as a de Tocqueville:

> The liveliness of the subject [of soil classification] is manifested to the visitor in the variety of soils he is shown which 'do not fit' into somebody else's categories of classification or system of description. The pedological papacy in Washington lays down a body of canon law for its priesthood, but speculative thought is rife even amongst the College of Cardinals. In Indiana I was witness to one of its inquisitors in dalliance with advanced doctrine, and in Berkeley, California, it positively has a prophet on its payroll. Amongst the minor clergy, heresy is freely talked, and on the Pacific Seaboard, there is a dissident church whose unorthodoxy almost amounts to a schism. An approved liturgy is prefaced by admission of 'possible present errors and certain future development,' and will no doubt prove to be as valuable in provoking that development as in codifying established belief (192):35.

The "heresy" to which Milne referred (and to which he was apparently converted) arose from the rapidly accumulating body of evidence showing defects in Marbut's classification of 1935, the "canon law". As a result, major efforts to improve the soil classification on a nationwide basis were made in 1938, 1949, and, over a period of several years, in the nineteen-fifties. The work of 1938 and 1949 involved attempts to revise and improve

Marbut's system while retaining much of its basic structure. The work after 1951, however, represented a complete break with earlier systems and an attempt to construct a universal system by means of which all known soils of the world might be classified. The elements of these three systems of soil classification are noted briefly.

The first major revision of Marbut's classification appeared in the Yearbook of Agriculture for 1938, "Soils and Men," which, incidentally, was warmly dedicated to the memory of Curtis Fletcher Marbut. This system was the result of intensive work by men of the Soil Survey under Kellogg's leadership in 1937.

The 1938 system, like that of 1935, was built of six categories. The higher categories, however, particularly categories V and VI were completely redefined. Marbut concept of "maturity" was retained, but the distinction between normal soils and others was made at the highest categorical level. This category, the Order, included the new classes "Intrazonal soils" and "Azonal soils" in addition to "Zonal soils" (comparable to Marbut's "normal" soils). Intrazonal soils were defined as those with

> ...more or less well-developed soil characteristics that reflect the dominating influence of some local factor of relief or parent material over the normal effect of the climate and vegetation (277):987.

And Azonal soils were those

> ...without well-developed soil characteristics either because of their youth, or because conditions of parent material or relief have prevented the development of definite soil characteristics (277):987.

The introduction of these two classes in the highest category thus provided a means for classification of all soils at all categorical levels, and established a number of new Great soil groups in the Intrazonal and Azonal Orders.[24/] The terms "Pedalfer" and "Pedocal" were retained, but no longer represented a separate categorical level, and some Great soil groups such as Chernozem soils and Prairie soils, which had been separated at the highest

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24. Marlin Cline has pointed out that the lack of provision for classification of all soils in the higher categories of Marbut's system constituted a violation of Nikiforoff's "Principle of wholeness of taxonomic categories" (61):87.

category in Marbut's system, one classed with Pedocals and the other Pedalfers, were not separated above category IV.

The redefined classes of category V consisted of groups of Great Soil Groups which were broadly associated geographically or genetically. At category IV, most of the established Great soil groups were not significantly redefined, but a number of new ones were added. Although many of the classes in categories IV and V included soils which were geographically associated, a clear distinction was made between the conceptual classes of soil classification and the actual geographic entities of soil mapping at all categorical levels:

> The fact that an oak tree and a pine tree may be growing side by side is insufficient reason for placing them in the same species or family (277):988.

At category III, the constituent classes, soil families, were defined as intermediate groupings between the multitude of soil series in category II and the three dozen or so Great soil groups of category IV. Although there was clearly a need for such an intermediate category, little use had been made of the soil family groupings of Marbut's system.[25/] In the 1938 system, the need for family grouping was reiterated, but no differentiating criteria were given beyond the suggestion that soil families consist of "...closely related soil series..." (277):986.

The definition of the soil series category II,

> ...soils having horizons similar as to differentiating characteristics and arrangement in the soil profile and developed from a particular type of parent material (277):984,

was relatively unchanged. The range of variability within series, however, was narrowed:

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25. An important exception to the general lack of use of the soil family groupings in category III was the special use of the category in the classification of certain of the many and diverse soils of California. Building on one of Marbut's early definitions of soil families, Charles F. Shaw of the University of California studied the profile characteristics as inferred functions of age in a number of California soils developed in transported materials (171):30. Soils developed from the same parent materials and under the same assumed conditions of climate, etc., and which varied only in the degree of profile development associated with variation in age, were grouped in families (233). The soil families as defined by Shaw (one aspect of the "dissident church" reported by Milne), were subsequently used in soil classification by his successors in California and, as examples of Jenny's "chronosequence," were useful as genetic groupings (143). The California interpretation of the family category dealt with relatively limited and specialized conditions, however, and it was not adopted to any considerable extent outside of the Golden State (224):113.

> Well-developed soils are now being classified in series having but one or two, or at most, three types. As research continues, the series with only one type will become still more common (277):985.

Soil types, as previously, were defined as soils with a soil series which had the same soil texture at the surface.

The broad definitions of the soil series and soil type categories were thus much as before. The definitions of individual soil types, however, particularly as they affected the delineations of soil mapping, were greatly clarified through the redefinition and wider use of soil phases, and through the introduction of redefined mapping units, including the soil association, the soil complex and the miscellaneous land type (148), (277):988. (These redefined mapping units, and their relation both to soil classification and to soil survey interpretation, are noted under "Soil Mapping" in chapter 3.42.)

In a highly significant sense, the system of 1938 reflected another change in the concept of the soil type which was not explicit in the definitions. This was the shift away from Marbut's sole emphasis on soil profile and toward recognition of the soil type as a three-dimensional natural geographic body (4):186. Partial recognition of this new concept of soil type was apparent in the statement that,

> Since the soil is the combined product of climate, living organisms, relief, parent material, and age, each different combination of these factors will produce a different soil. If all variations in each factor were measurable, and had measurable influences on the soil, individual soil types would be so numerous that hey would occupy points. In a strict sense each soil profile is individual; no two are identical in every detail. Since there can be some range in the environmental factors without producing measurable differences in the soil, each soil type occupies an area rather than a point. The size and shape of individual areas varies greatly in different places (277):988.

(It should be noted that the above was less than a complete departure from earlier definitions in that it allowed for variation in "environmental factors," but not in "measurable differences in the soil" within areas of a given soil type. The full recognition of soil mapping units as three-dimensional bodies came a few years later with the development of descriptions based upon a "modale profile," or "central concept" together with clearly defined ranges in variability from the modal condition but within the definition of the unit) (154), et seq., (254):6.

In summary, the soil classification of 1938 was an orderly, comprehensive scheme which provided for the classification of all soil types of the United States known at the time. A major logical defect of Marbut's system had been corrected by making all categories "complete," and the basic unit of classification, the soil type, had become recognized as a natural geographic entity definable in terms of area and shape as well as soil profile. The system was widely adopted; with the relatively minor changes of 1949 noted, the 1938 soil classification remains the basic system in use at the present time (1957).

* * *

The decade following publication of the 1938 Yearbook of Agriculture was a period of active and expanding investigation of the soils of the world. American soil scientists traveled abroad studying soils and assisting in the establishment of soil surveys and other basic research from the arctic to the tropics; foreign soil scientists traveled widely in this country, particularly after World War II, studying American soils and soil classification in the light of their special knowledge of the soils of other continents; the wartime activities of the World Soil Map Unit of the Soil Survey and the postwar research work of the Unit required the characterization of soils of remote parts of the world; additional data on soil characteristics, and additional questions regarding their relations to soil classification, emerged from field and laboratory investigations of soil genesis and morphology, soil fertility, soil physics, soil microbiology, clay mineralogy, and the infinitely complex physical chemistry of soil colloids.

Within the federal Division of Soil Survey, Kellogg reshuffled his Correlation Staff, instituted higher scientific standards in soil correlation, and allocated an increased share of his slim budget to basic soil research (and to travel funds for soil correlators). In the field operations of the Soil Survey, the more accurate delineation of soil boundaries made possible by the use of large-scale airphoto base maps required more precise definitions and narrower ranges of variability for soil types and phases. At the same time, the tremendous increase in the use of soil surveys and of interpretive systems such as "Productivity Ratings," "Land-Use Capability" groupings, etc., demonstrated the vital importance of accurate correlation and classification of soil mapping units (4).

Much of the new knowledge about soils of the world, and many of the new needs of soil surveys, could not be reconciled with the established soil classification of 1938. Accordingly there emerged, from small beginnings about 1950, an international effort, under American leadership, to develop an entirely new natural system for classification of the known soils of the world.

First, however, there was a stopgap effort to "make do" with the 1938 system by limited revision. In a special issue of the journal *Soil Science* for February 1949, the leading state and federal men of the Soil Survey collaborated in a frankly self-critical progress review of soil classification in the United States. Various types of interpretive classifications were presented, as well as the natural classification, and specific revisions of the 1938 system were set forth (154), et seq. The implications of this symposium were important, not so much for the actual revisions made (these amounted only to deletion of the Pedocal-Pedalfer distinction and the addition, deletion, or redefinition of several Great Soil Groups), but in the searching analysis and recommendations regarding the need for a completely fresh approach to soil classification.[26]

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26. From the standpoint of public administration, it is noteworthy that the critical opinions freely stated in the symposium of 1949, and quoted here, were the opinions of soil scientists in the employ, at federal or state levels, of the public. The then-current system of soil classification, of which these soil scientists were critical, represented the past expenditure of a considerable amount of scientific effort, and of public funds. The accumulation of new knowledge, from which the criticism was derived, was itself a clear evidence of additional scientific progress; the tendency to accept and pass over the attainment of knowledge once attained, however, and to concentrate upon critical analysis of areas of knowledge unattained and of problems unsolved, is characteristic of scientific discourse. Such a tendency is not characteristic of many public agencies which, in order to maintain popular interest and legislative support, are more prone to extol the progress of their programs than to point out embarrassingly unsolved problems. Thus the candor of science is subject to misinterpretation, both by legislators and by public administrators.

At the highest categorical level, the soil order the genetic criteria implicit in the differentiation of "zonal," "intrazonal," and "azonal" soils came under close scrutiny in the papers of the symposium of 1949:

> Thus it will be seen that, with a genetic system of classification, soils whose genesis is imperfectly understood cannot be placed in their proper position. Likewise, if the genetic bias in a system is too strong, soils cannot be classified until their genesis is understood. The concept of zonality, intrazonality, and azonality, would seem, then, to suffer from major weaknesses. First, the genetic bias is very strong. The zonal and intrazonal orders can be defined only in genetic terms. The authors are unable to discover any mutually exclusive characteristics of these two order. The azonal order, in contrast, is defined in terms of soil characteristics. Second, the concept that any given group of zonal soils is found in a single climate and biotic zone has many exceptions. Third, some of the intrazonal and azonal soils show many zonal characteristics (264):125.[27/]
>
> It is hoped that terms indicating zonality or lack of it may be abandoned eventually in favor of terms based on soil characteristics. Work in the Division of Soil Survey and among state cooperators has not yet advanced sufficiently to permit presentation of a completely revised system of classification that will be satisfactory to all concerned (264):125.

Of all the higher categories, that of Great Soil Group was clearly acknowledged as the most useful, but it was pointed out that:

> The great soil groups will undergo modifications as our knowledge of soils increased. Some of the currently recognized great soil groups may be combined and new groups will undoubtedly be established. As the detailed study of soils is extending tropical and arctic regions, considerable modifications may be expected. Even at present, a number of soils are known to occur which have not been placed satisfactorily in any existing great soil group (264):125.

Significantly, a coauthor of the comments of 1949 was Guy D. Smith of the Division of Soil Survey, who shortly thereafter was to assume leadership of international efforts toward development of a new comprehensive system of soil classification.

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27. The critique of the concept of zonality in soil classification is in accord with the logic of Glinka, who in 1914 rejected the original application of zonality as defined in Sibirtsev's soil classification of 1898 (106):29.

There was relatively less criticism and revision suggested for the lower categories of the then-current system; it was pointed out that very little use had been made of the soil family category, and also that:

> ....it is still exceedingly difficult to obtain agreement on the need to recognize new soil series which split the older established ones. Our practice in this respect sometimes fall short of the discipline we proclaim to follow (4):188.

* * *

The symposium of 1949 and other concurrent activities in soil science, as noted, led to the development of a completely new system of soil classification. At the start (about 1950), there was no firmly accepted form and content for the new system beyond a general agreement that more categories were needed and a less-unanimous opinion that differentiating criteria based upon inferences of soil genesis should be de-emphasized. Nor was there any guarantee that the new system, like all earlier systems, would not ultimately be invalidated as knowledge of soils expanded in the future.

In two important respects, however, errors of the past were avoided. The fullest possible use was made of the knowledge and experience of interested soil scientists and of research results throughout the world in establishing categories and classes; and the system was repeatedly tested in this country and abroad to uncover defects in structure or definition and to provide the means for classification of all known soils of the world.

Participation by European soil scientists and others contributed to another departure in the new system from the old. The earlier systems had been based upon characteristics of virgin soils only, and thus did not provide fully for classification of cultivated soils, some of which, in Asia and Western Europe, had been modified by man in varying degrees for thousands of years. Characteristics of such “anthropic” soils, and the means for their classification, were recognized in the new system.

The system evolved in various stages through the distribution and intensive testing of a number of successive “approximations.” After worldwide review and criticism of each approximation, the suggested revisions were made, the improved approximation resulting was further tested, and so on. Staff leadership for the work was assigned by Soil Survey

Chief Kellogg to Guy D. Smith of the United States. At different stages of approximation, the system was presented at the Fifth International Congress of Soil Science at Leopoldville, Belgian Congo, in 1954, at the Sixth Congress in Paris in 1956. Review and revision of the system will necessarily continue, but present plans call for publication of the then-current approximation in connection with the Seventh International Congress scheduled for Madison, Wisconsin in 1960.

In 1956, an entirely new nomenclature for all classes in the higher categories of the system was proposed as a replacement for the existing confusion of adjectives and substantives and the babel of English, Russian, German, Latin and Greek names carried over from earlier systems (157). The proposed nomenclature, based somewhat like the Linnaean system, upon Latin and Greek roots, would connote, for any given class, both the categorical level and the class name. The nomenclature was worked out by soil scientists and classics scholars of the United States and Belgium. Pending adoption of the proposed names, decimal symbols indicating category and class were used in the successive approximations. In the elaboration of the approximations prior to 1956, the assignment of names to categories and classes was deliberately avoided so as to focus attention on the concepts of the classes themselves; as noted by Marbut twenty years earlier:

> The definition of soil units is a constructive creative process resulting in the establishment of entities than [sic] had no previous recognized existence (175):12.

In 1957, the system, at the stage of the Fifth Approximation, was still undergoing testing and correcting and will not be described in detail here. Briefly, the soil classification of the Fifth Approximation is a system of seven categories with a number of classes at each categorical level, together with specific and quantitative definitions of terms. The two lowest categories correspond closely to the established soil series and soil type. Differentiating criteria are based primarily upon “soil properties which are observable and measurable,” rather than upon “what the soil was or what it may become.” (Guy D. Smith, personal communication). Among such “observable and measurable soil properties,” special emphasis is placed on the nature of “B” horizons, the characteristics of which generally remain discernible irrespective of modification of the surface horizon by cultivation (255).

3.42 1933-1952, Soil Mapping

Technical developments in field mapping during these two eventful decades were mutually interrelated to the progress in soil classification noted, and to the broad political and administrative evolution of the times. The recognition of individual soil units as three-dimensional bodies with definitive area and shape as well as vertical profiles provided more rational bases for characterizing and mapping soils. The changes in political philosophy that brought publicly-supported technical assistance to American farmers on a field-by-field and farm-by-farm basis called for soil mapping of a scale, detail, and accuracy which would have been impossible to justify before 1933. The rise of a new, and competing, agency making “soil conservation surveys” stimulated the Soil Survey to reassess and improve its own mapping techniques. And finally, but only finally, the Soil Survey was provided with a measure of the support, (measured in dollars), commensurate to the soil mapping job demanded of it.

In place of Marbut’s relative disinterest in techniques of detailed soil mapping, Kellogg’s administration of the Soil Survey promoted a revitalized concern for, and respect for, such techniques. As a means of summarizing, standardizing, and improving soil survey techniques, a Soil Survey Manual, the first in nearly twenty-five years, was issued in 1937 (148). A greatly enlarged and totally rewritten edition of the Manual was published in 1951 (254).

The belated improvements in mapping techniques were thus adopted, but not overnight. The Manual of 1937 was written nearly ten years after the advantages of airphoto base maps were well established (see chapter 3.321). Nonetheless, while it was acknowledged in the Manual that

> considered from the point of view of local detail alone, the best base upon which to place soil survey data is a vertical single-lens aerial photograph of convenient scale and good quality (148):35,

It was also acknowledged that

> The most important base maps used directly in soil surveying are the topographic maps made and published by the United States Geological Survey (148):33.

Relatively several times more space was allotted to instructions on the preparation and use of “plans table and alidade” base maps than to information on the interpretation and use of airphotos for the same purpose. With respect to selection of the proper field scale for detailed mapping, the Manual stated:

> Currently most of the detailed soil surveys are being made on a scale of 2 inches to 1 mile...Aerial photographs of still larger scales are used where they are available and can be used to advantage...If an accurate base map is available and the soil mapping is performed by surveyors of unusual skill in drafting, detailed soil maps can be made on the scale of 1 inch to 1 mile if the soils are not particularly complex (148):13.

Thus on two key elements of soil mapping technique, field mapping scale, and type of base map, the Soil Survey Manual of 1937 reflected a crossover of earlier methods. In 1938 that friendly critic of the Soil Survey, G. Milne of East Africa noted:

> That so much time should have to be spent by the field men in providing their own fundamental topographic information (i.e. base maps) is something of an anomaly in organization (192):15.

As noted in chapter 3.321, the Soil Survey was using airphotos in some states as early as 1928; the delayed, but almost complete, adoption of airphoto base maps by the Soil Survey in the rest of the country occurred in the late ‘thirties as extensive coverage became available through the activities of various New Deal agencies. In some areas, the shift to the new type of base maps was directly influenced by the concurrent expansion of the mapping program of the Soil Conservation Service, in which airphotos were widely used (53):180, (161):226. In 1938, the Soil Survey reported:

> Aerial photography is now rapidly doing away with the necessity for making base maps by the older methods of the soil surveyor (277):1004.
>
> Most of the current field mapping is now on a scale of 2 to 4 inches to the mile... In areas where erosion control and land-use are of immediate concern, the scale of the field mapping is commonly 4 inches to the mile (277):1007.

By 1941,

> Because of the greater accuracy permitted through the use of aerial photographs...it is desirable, if practicable, to delay initiation of detailed soil surveys until aerial pictures can be provided (198):63.[28]

Ten years later, when the new Soil Survey Manual of 1951 was issued, field mapping on airphotos at 4"/mile was taken for granted, and over forty pages were devoted to the use, interpretation, and stereoscopic examination of airphotos for soil survey base maps (254).

With the increased field scale and use of airphotos, soil mapping of greater accuracy and much greater detail was possible. At the same time, the tremendous increase in the use of soil survey maps demonstrated the need for such accuracy and detail and (as told in the following chapter), pointed up some of the severe limitations of the earlier, less-detailed soil maps. The use of soil surveys for intensive purposes such as individual farm planning called for precise classification and careful delineation not only of soil types, but of certain variations with soil type areas due to conditions of slope, erosion, stoniness, etc. Such variation had been broadly delineated in soil surveys for many years, generally as "phases" of soil types, but the delineation of phases on soil survey maps was greatly increased during the 'thirties and 'forties. In detailed soil surveys in the Tennessee Valley of about 1935, slope variations within soil types were delineated according to the following ranges:

Slope Class	Range of slope in percent		
A	0	-	2.5
B	2.5	-	7.5
C	7.5	-	15
D	15	-	30
E	30	-	60
F	Over 60%		

28. This was essentially the same suggestion advanced by Bushnell in 1928.

In addition to the slope variations, five classes of soil erosion conditions (sheet and gully), were mapped, as well as three classes of stoniness, and three classes of soil depth (193):65. The recognition of these and other variations within soil type areas, particularly after the late ‘thirties increased the usefulness, but also the cost, of basic soil surveys.

In a few of these early soil survey (and, almost universally, in the concurrent mapping program of the Soil Conservation Service), such variations within soil type areas were considered as “independent variables” and mapping units delineated regardless of the significance of any one variable to the combination of the others. As noted in more detail, this practice was strongly opposed and rapidly abandoned in the field operations of the Soil Survey, but was retained in the mapping program of the Service.

As mapping detail increased, Soil Survey policy regarding the “minimum size of area” to be delineated was revised. As noted earlier in the present study, soil surveyors of 1899 did not delineate contrasting soil areas of less than a quarter of a square mile; after 1906 this minimum area was reduced to 10 acres (310):30, (274):13. The Soil Survey Manual of 1937 greatly reduced the specified minimum, but stressed the concept of “significance”:

> No categorical definition, applying to all conditions, can be laid down covering this point in terms of area. In the detailed soil survey, areas which influence significantly a unit of operation should be indicated. If, for example, a small spot of excessively stony land, wet land, or steep land, occurs within an area otherwise suitable for crop production it should be shown even if only one-half or 1 acre in size...On the other hand, if two soil types are similar and, although varying somewhat in their crop ecology, small areas of one within the other do not significantly influence the use of the land, areas less than 5 acres should not be separated (148):103.

The Survey Manual of 1951, further stressing the varying significance of such mapping separations, reduced the minimum to “one-half acre or even less....If the contrast in response to management among the soils is very great....” (254):129.

* * *

As noted in chapter 3.41, progress in soils classification during this period emphasized the need for a clear distinction between soil classification units and soil mapping units, and the need for redefinition of some of the latter. Application of the pragmatic criterion of “mappability” showed many such “classification units” to be unsuitable as “mapping units”. Also noted in the chapter, the concept of the “soil individual“ was broadened from simply a kind of profile to a three-dimensional body. In mapping and describing soils under the latter viewpoint, it was necessary to defined both the “modal” or “central” combination of characteristics typifying the soil unit, and the allowable ranges of variability of the various characteristics within the unit (254):6. (Recognition of the distinctions served to reduce the confusion, noted in chapter 3.31, between soils as they actually occurred and soils as they might be conceptually defined and classified.)

The new, or redefined, mapping units included some which were subdivisions of classification units and others which were combinations of classification units. These included the soil phase, the soil complex, the soil variant, and the soil association.

In earlier definitions of the soil phase, criteria had varied widely. Phases had been used to denote variations within a soil type which were too small to be mapped out (properly, “inclusions”), variations of mappable size which were beyond the defined range of an established soil type but which were of such limited known extent as not to justify establishment of a new soil type (properly, “variants”), and variations in a number of other soil and land conditions including geology, slope, land-use, color, erosion, etc. As redefined, the phase

> ...is defined and shown on the soil map on the basis of characteristics of the soil, or the landscape of which the soil is a part, that are of importance in land-use but are not differentiating characteristics of the soil profile (148):92,

or

> ...on the basis of characteristics which, although significant to use of the soil by man, have little or no significance in the genesis of the soil (224):112.

Under the new definition, phases were recognized as subdivisions of soil types but with more narrowly defined ranges in those characteristics most significantly affecting land-use. These included slope, erosion, stoniness, depth, overflow, etc. As soil mapping became more detailed and accurate, and as the maps were used more intensively on a field-by-field basis as guides for land-use adjustments, phases of soil types rapidly replaced the soil types themselves as the basic mapping units on detailed soil surveys. After 1950, the phase was recognized as a means for subdivision of other categories of the natural classification, such as great soil groups, to bring out the characteristic or characteristics potentially significant to land-use (254):289.

Another kind of mapping unit, the soil complex, was defined and used in mapping for areas where two or more soil series, types, or phases occurred in such close association with one another that they could not be mapped out separately at the particular mapping scale used (80):28. The description of a soil complex consisted of names and descriptions of the component soils included, and the pattern and distribution of their occurrence (148):98.

The soil variant, introduced in the late 'forties, was used as a mapping unit to designate soils which were outside the range of any known soil type but which (as noted) were not of sufficient known areal extent to justify establishment of a new soil type. Many such variants were subsequently found to occur over larger areas and were recognized as new soil types (224):113, (4):188.

A mapping unit of particular value in small scale mapping, the soil association was defined as a group of named taxonomic soil units regularly geographically associated in a defined proportional pattern. Significantly, the United States soil map in the Yearbook of Agriculture, 1938, identified the mapping units delineated as "soil associations," whereas Marbut's earlier map in the Atlas of American Agriculture, 1935, showed the distribution of areas identified by the name of only a single soil series (277), (174).

With the redefinition of mapping units, particularly that of the phase of the soil type, and the recognition of the "soil individual" as a three dimensional body, it was possible to group soil units much more accurately, either into higher categories of the natural classification, or into the growing number of special groupings for various interpretive uses. In order to identify all "soil individuals" in a given area, the Soil Survey firmly adhered to its standard policy of providing a separate description for each of the mapping units shown on published soil survey maps. With the advent of the mapping program of the Soil Erosion

(Conservation) Service, a conflict arose (among others) regarding the definition and description of mapping units.

In the work of the Soil Survey, as noted, increasing use was made of phases of soil types as the basic mapping units or "soil individuals" in detailed soil surveys. (To a considerable extent, this increased recognition of the importance of variations in slope, erosion, depth, etc., by the Soil Survey was influenced by the work of the Service which dramatically demonstrated the need for such mapping separations in program of detailed farm planning). In the soil mapping work of the Soil Survey, such phase subdivisions were delineated only where variations within the definition of the soil type exerted significant influence on land-use. Slight variations in slope, for example, might be extremely important in the application of irrigation to deep, fertile soil types well suited to cultivation and irrigation; accordingly a number of slope phases of such soil types would be recognized and delineated in the soil survey. For very stony soils in rough upland areas on the other hand, such minor slope variations exert little or no influence on land-use, and slope phase subdivisions would be much fewer and more generalized. In distinguishing between the criteria of soil type definition and those of phases within soil types, the Chief of the Division of Soil Survey wrote:

> Whereas soil types are defined on the basis of whole sets of characteristics that include all those of practical or genetic significance, phase distinctions within them are based wholly on practical considerations. Thus soil types are everywhere defined the same; but phases are more narrowly defined where the agriculture is intensive and less narrowly defined where it is extensive (153):6.

In the early mapping work of the Service (noted in more detail in chapter 3.441), various classes of erosion, land-use, and slope, in addition to soil type, were mapped as independent variables, and separate mapping units were delineated to show any change in any of the variables irrespective of the significance of such changes in relation to the other factors in affecting land-use and management. After 1945, when the use of soil type designations were discontinued in many soil conservation surveys, a much larger number of "independent variables," and hence of mapping units, were shown on the soil conservation surveys. Such mapping units were neither soil types nor phases of soil types.

* * *

The accelerating progress in soil mapping techniques (and in soil survey interpretation) during the 'thirties and 'forties was reflected in the changing criteria by which the Soil Survey judged the "adequacy" of its older soil survey reports and maps.

Marbut's Atlas of American Agriculture included a map showing the coverage of "Detailed Soil Surveys" as of 1933 in which the individual surveys were undifferentiated as to age or quality (175). (On the accompanying soil map of the United States, however, there was small inset map of detailed soil surveys in which Marbut made a distinction between those of "Primary value" and those of "Secondary value" to him in the preparation of the soil map of the nation (174).)

A similar map, prepared by the Division of Soil Survey for the National Resources Planning Board in 1939, which showed the total coverage of detailed soil surveys to that date, made a distinction only between surveys "published before 1907" and all subsequent surveys (198):62.

In 1950, the Soil Survey reported (with respect to mapping needs in the United States and Alaska):

> ...about 1,000,000 square miles need detailed surveys, including about 325,000 square miles with old and inadequate maps needing revision (288):40.

By the time the new Soil Survey Manual came out in 1951,

> Progress in soil classification, mapping, and interpretation has been so rapid in recent years, since the earlier edition of this Manual, that few surveys made before 1940 would be made in exactly the same way today. Thus the student will find inconsistencies between the methods used in many of the recently published surveys...and those outlined in the Manual. This should be expected in an actively growing field of research. Many methods had to be tried out, tested in actual surveys, before a judicious selection could be made (254):447.

* * *

In summary, the Soil Survey, by 1950, had developed principles and techniques for soil mapping of the highest caliber. Building upon a half century of experience (and, as noted, with a prod from its competitive-cooperative offspring within the Soil Conservation Service), the Soil Survey had increased the field scale of mapping, adopted airphoto base maps, and narrowed the definition of field mapping units; through soil correlation, these mapping units were identified uniformly (or almost uniformly) and classified scientifically (or almost scientifically); through soil survey interpretation, the mapping units were grouped into many different pragmatic interpretive systems for as many specific pragmatic uses; the Soil Survey Manual of 1951 gained immediate (or almost immediate) acceptance as the basic technical handbook for soil surveys, not only in this country, but also in the initiation of, and/or continuation of, soil survey program in many foreign countries.

The greatly increased scale, detail and accuracy of soil mapping, however, resulted in something else besides better soil surveys. The cost of soil surveys rose sharply, and the acreage covered per man per day diminished. By 1950, mapping production per man-day had dropped below a square mile, and costs were estimated at $0.25 per acre.[29/]

The cost figure of twenty-five cents an acre, when considered in view of the precarious budgetary position of the federal Division of Soil Survey during the ‘thirties and ‘forties (see chapter 4.2) could mean only one things. <u>During the period of the greatest national demand in history for modern, detailed, accurate soil surveys, precious few were provided by the National Cooperative Soil Survey.</u>

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29. This cost estimate refers to total costs (exclusive of providing airphoto coverage) for highly detailed soil mapping and for correlation, publication, etc., of soil surveys in areas of intensive agriculture (153):14.

3.43 1933-1952, Soil Survey Interpretation

The broad political and administrative changes noted, and the resultant demand for more and better soil surveys, coincided with an infusion of new leadership in the Soil Survey and the national level. The result was an abrupt reversal of prior Soil Survey policy regarding soil survey interpretation. In 1934, shortly before becoming Chief of the Division of Soil Survey, Kellogg stated the case for the new policy:

> ...pedologists themselves must devote more attention to summarizing the results of their investigations and making them readily available for public use. The use of soil survey data in land classification and land-use planning is essential, but to be of maximum value, <u>pedologists themselves must make the application</u> (145):147. (Underlining added)

This policy statement, while it seemed a new and unpromising departure to some soil scientists, was endorsed by others as a long-delayed recognition of a principle originating perhaps with Hilgard's declaration of 1858 that:

> The agricultural chemist...ought not only to make the analyses, but also to interpret them to the agriculturist (119):vi.

In the restatement of another basic principle reminiscent of Hilgard and Marbut, Kellogg (with J. K. Albeiter) defined the relationship between basic data and interpretive inferences:

> ...unless the physical data are kept clearly and definitely separated from transitory economic considerations, any revisions of the work requires that everything be done again including the taking of the field data. But if the physical facts of soil and relief are once accurately mapped, these maps of the basic data are essentially permanent. From them the practical classification of social units can be adjusted from time to time as necessary with little or no additional field mapping (146):5.

The reversal of Marbut's former policies in this field resulted in the development of a large number of interpretive systems designed to increase the practical utility of soil survey maps and reports. As this work expanded, specialists in the interpretive phases of the Soil Survey were assigned at the national and regional levels. The importance of soil survey interpretations at all levels was clearly recognized in the restatement (quoted in chapter 3.4) of the primary functions of the Soil Survey in relation to purpose (254):23. Some of the more important of the technical developments in soil survey interpretations during this period are noted briefly.

* * *

Before considering the technical progress in interpretations, however, it should be noted that, in terms of broad national policy and specifically in terms of the contribution of the Soil Survey to the vase new public land-use programs, progress was much less conspicuous. The Soil Survey, with federal appropriations cut to the bone, was equipped to carry on current field operations, and hence to make available the new interpretive data, in only a handful of counties in any given year. (An important, but localized exception to this otherwise Lilliputian scale of operations was the soil survey program in the Tennessee Valley). Even for the small number of new soil surveys completed each year, immediate and wide availability of survey results was largely nullified by lack of funds for publication. Under the looming shadow of an unpublished backlog, the time lag between completion and publication of new soil surveys stretched to five, ten, and even fifteen years.

Against the low level of production of new soil surveys, there were exerted the immediate and extensive needs for soil surveys and interpretations by the many new public agencies operating in three thousand counties in forty-eight states. The result was that the needs of the new programs (Tennessee Valley Authority and Soil Conservation Service excepted, as noted), to a considerable extent, were met not by the new soil surveys with improved mapping and interpretive techniques, but by the earlier surveys made before the ‘thirties. The bulk of these available maps and reports had been prepared an published under a Soil Survey administration which had effectively discouraged soil survey interpretation as a part of the soil survey reports themselves (see chapters 3.23 and 3.33).

For many purposes of broad land inventory and planning, the adequacy of these earlier soil surveys was well established, as noted elsewhere in the present study. For the more demanding needs of programs dealing with detailed interpretations of soil differences on a field-by-field and farm-by-farm basis, however, the older soil surveys by-and-large were inadequate, both in mapping detail, and in accompanying soil survey interpretation (194), (198):113, (254):447.

The above circumstances are pertinent to the present study in that they tended to compromise the position of the Soil Survey in the ensuing intermural contests with the mapping program of the Soil Conservation Service, and in the uniformly unsuccessful bids for legislative support appropriations-wise. In such relationships, the Soil Survey, even while effecting great improvements qualitatively in all phases of the work, including soil survey interpretation, had relatively little to show quantitatively for its current program. At the same time, in order to survive as a functioning entity, particularly in competition with the rapidly-expanding, and fully current, mapping program of the Service, the Soil Survey was under the necessity of demonstrating the national scope and extensive coverage of its program. The ambiguity of the position of the Soil Survey was apparent in a report of the National Resources Planning Board on “Land Classification in the United States,” prepared in 1940 (198). In narrative material supplied by the Soil Survey the 1940 report described the most up-to-date techniques of soil mapping and soil survey interpretation. The extent of mapping coverage (detailed and reconnaissance) completed by the Soil Survey, however, was shown as over a billion acres and the quality of the detailed surveys was classified only as “Published before 1907” and “Published since 1907” (198):62.

* * *

To return to consideration of developments at the technical level, soil surveys of all kinds were put to a variety of uses by nearly all early land-use programs of the thirties. In a report of 1934, the National Resources Board found that

> ...already the Soil Survey has been used extensively by those organizations which have such responsibilities as the determination of land-use, the zoning of rural lands, appraisal of farm lands, purchase of lands for farms or forest, and the location of reclamation projects. In fact, the reports and maps of the Soil Survey or the special reports of trained soil surveyors furnish the foundation of the majority of the present State and Federal activities relating to land-use (197):21.

The above findings of the Natural Resources Board continued to characterize the use of soil surveys in the many programs dealing broadly with soil resources and land-use. For such purposes, available soil surveys, including those made early in the century, provided the only comprehensive published source of information on agricultural land resources in most of the countries where soil surveys had been made (198):63, (276):93.

With the growth of public programs dealing, almost for the first time, with soil resources and land-use on a field-by-field basis, however, the earlier soil surveys, as noted, were clearly inadequate. One such program, discussed elsewhere in the present study, was that of the Soil Conservation Service. Another was the cooperative project described in 1935 by M. F. Morgan of the Connecticut Agricultural Experiment Station:

> During the past year the agronomists in each State of the union have been called upon by the economists to assist them in a project for the estimation of the most desirable balance of agricultural production. Sponsored by the Bureau of Agricultural Economics of the Department of Agriculture, this study was designed to provide basic information for a more equitable operation of the Agricultural Adjustment Administration. Obviously the first step in this work was to examine available soil surveys in the State concerned (194):48.

In "...examining available soil surveys..." for his state, most of which were quite old, Morgan cited a number of limitations, but reserved his most severe criticism for the lack of interpretive material regarding soil productivity in the soil survey reports, as he concluded:

> In order that the soil survey may contribute toward a land-use policy, it must be reducible to such terms (i.e. input-output functions) of productivity in relation to the various crops in question, whether they be of the garden, field, orchard, pasture, range or forest (194):52.

Similar criticism of the Soil Survey for inadequate economic interpretations was voiced by other professionals, including John D. Black of Harvard University who noted

> ... a pronounced tendency for the soil surveyors to become principally interested in classification as such. To a scientist with such a fixation, a unique specimen of soil that he finds on the shadow side of a ledge will be of more interest than facts about the effective use of the common everyday varieties. (40):208.

As noted, such criticism of the Soil Survey's chief tangible stock in trade, completed soil surveys of hundreds of millions of acres, naturally affected its position administratively and politically; such criticism, however, also demonstrated clearly that soil surveys were being used as never before, and the net effect was to reaffirm the need for the improved mapping and interpretive techniques already being developed in the newer survey maps and reports (155):2.

The most important of the new interpretive techniques were those involving the development of crop yield estimates and productivity ratings for specific soil types and other mapping units described in the soil survey reports and delineated on the maps. Within the federal Division of Soil Survey, the development of productivity ratings began in 1933, when Division Chief Marbut finally acknowledged the long-felt need for elaboration of the interpretive material in the soil survey reports. At that time, upon Marbut's request, Carleton F. Barnes, then of the Bureau of Agricultural Economics, made a study of various means of assembling and presenting crop yield and soil productivity data for use with soil survey reports. Initially, Barnes analyzed existing published reports and prepared unpublished interpretive supplements to them. This retroactive work was soon abandoned, however, in favor of preparation of productivity ratings for the reports then currently in process of publication (Carleton F. Barnes, personal communication).

In the first soil survey reports to include productivity ratings, an attempt was made to rate soils on the basis of a productivity level variously described as, natural productivity, "The ability of the land to produce, under a management capable of maintaining the natural level of productivity, but without irrigation, drainage, or the addition of lime and fertilizer," or as inherent productivity, "That level of productivity at or near that existing when the virgin conditions became adjusted to tillage practices" (79), (95). Soils shown on the maps and described in the reports were rated, on the above bases, on a scale of 0 to 10, or in later reports, 0 to 100. The top levels (10 or 100) were set at the productivity level of the most productive soils in the United States for the particular crops considered.

Work on productivity rating had just begun when the Soil Survey was called upon by the newly formed National Resources Board to provide data on soil productivity as part of an inventory of national resources. These data were provided by Soil Survey Chief Marbut in the form of a rating of the soils of the United States in terms of natural productivity (i.e. without artificial drainage, irrigation, or soil amendments), on a scale of 1 to 5 (196):126. Although Marbut's conditions and definitions were clearly stated, the use of the "natural productivity" base led to many anomalous results, and the soils section of the National Resources Board report, published in 1934, came in for considerable criticism. It was pointed out, for example, that certain soils in arid regions were given low ratings whereas, under irrigation, they were among the most productive in the nation. Similarly, soils of low natural fertility, but which were highly responsive to fertilization and hence capable of high production were given low ratings in the 1934 report (213):17.

Shortly after becoming Chief of the Division of Soil Survey in 1935, Kellogg established the policy of including productivity ratings in all new soil survey reports. Meanwhile, leadership in the interpretive work of the Division of Soil Survey was assigned to J. Kenneth Ableiter, previously associated with Kellogg at North Dakota Agricultural Experiment Station in the development of a system of rural land classification based upon interpretations of detailed soil survey data (146).

As the work progressed (and in view of the defects in the ratings prepared for the National Resources Board) practical questions of usefulness and theoretical questions of definition led to discontinuance of the "Inherent productivity" basis for rating soils. In the soil survey report for Franklin County, Pennsylvania, soil types and phases were given ratings, on a scale of 100, in terms both of inherent productivity, and of current practices which "include the use of soil amendments such as lime and commercial fertilizers" (118). In both cases, the top rating of 100 was taken as equal to "...the inherent productivity of the most productive soil in the United States for that crop." For each soil type and phase, the two sets of productivity ratings were given for nine of the most important crops in the county, and for tree fruits and for permanent pasture. Yield estimates for the particular crops on the particular soils were not given explicitly, but the yield figures which, for each crop, represented a rate of 100 (i.e. for potatoes, 200 bushels; for wheat., 25 bushels, etc.)

were given. Yield estimates for any particular crop and soil could then be obtained by multiplying the soil productivity rating as a percentage of the yield figure representing the standard of 100. In the productivity ratings for specific crops, an attempt was made to assign to each soil type a general “Productivity Grade” on a scale of 1 to 5. This general grading was based upon a weighted average of the ratings for each of the several crops, such weighting being based upon the real extent of the production of each crop over the broad agricultural region of which the county was a part. (The serious limitations in any such general grading have been pointed out by Ableiter (2):418.

In other early soil survey reports from different parts of the country, the types of productivity ratings varied somewhat from those described for the Franklin County report. In the Northern Great Plains, for example, an all-important factor in crop yield levels was the variation in annual precipitation. According to the report of the soil survey of McKenzie County, North Dakota, the soils were given two ratings for each crop, depending upon rainfall. One rating referred to productivity with “average” rainfall, and the other to “estimated average for the better years” (80):83. The assumed management level for both ratings was that “...under the prevailing practices.” For the irrigable soils, this report also included a special table of productivity ratings for crop production under irrigation (80):81.

As a variation from the essentially deductive processes involved in the ratings, other methods, particularly those developed by R. Earl Storie of California, which employed a more inductive or synthetic approach, were developed in the West (261). The “Storie Index,” which was incorporated into many California soil survey reports, was a system of productivity rating based upon an interpretation of the inferred influence of soil characteristics in relation to the requirements of a general, deep-rooted agricultural crop. Such ostensibly inductive types of ratings were less specific than productivity ratings and yield estimates based upon actual crop yield records, but they were of particular value in newly-developed agricultural areas where crop yield records were sparse or nonexistent (262):79, (2):417.

As techniques were involved in the late ‘thirties, and as the use of productivity ratings was applied to land appraisal, detailed farm budgeting, etc., the actual yield estimates for each crop and soil were found to be of more immediate value than the productivity ratings expressed simply as percentages. Also during this period, research work in the Department and in the state experiment stations pointed up the need for more quantitative definition of the management variable in arriving at yield estimates by crops and soils. In Illinois, the work of Guy D. Smith and R. S. Smith demonstrated that the management variable should be recognized in at least three quantitatively defined management levels, such that, for a particular crop on a particular soil, a separate yield estimate could be given for each defined level of management (240). The studies in Illinois also revealed in quantitative terms, the relationship, noted elsewhere in the present study, between the accuracy of interpretations such as yield estimates on the one hand, and the accuracy of soil classification and soil mapping on the other. A statistical analysis of the reliability of the yield estimates indicated that standard deviation of the estimates could be kept within acceptable limits only when soil mapping units were narrowly defined and accurately mapped. The methods of Smith and Smith, based upon available crop yield records, were primarily deductive, but they concluded:

> ...ratings may be made inductively for many of minor soil types when sufficient data have been collected on a reasonable number of the major types which cover the range of physical properties encountered In the minor types (240).

With the use of both deductive and inductive methods, with the improvements in accuracy and detail of soil mapping and classification, and with the recognition of a number of defined management levels, yield estimates of a high order of probability were developed for soil survey reports during the nineteen-forties. One of these was the soil surveys of Tama County, Iowa (field work 1938, published 1950). A portion of the yield estimate table is reproduced. For each of the soil mapping units shown, Tama silt loam and five phases of Tama silt loam, yield estimates for five crops are given to the nearest bushel or tenth of a ton. The management variable is clearly specified, and the yield estimates of a particular crop on a particular soil vary in accordance with type of crop rotation, use of lime, fertilizer, and manure, and the application of conservation practices including contour cultivation and strip cropping. In addition to the yield estimates, an estimate of the "probable erosion hazard" is given for each of the management systems shown (1).

On a nationwide basis very few soil survey reports with yield estimates as specific and detailed as those of the Tama County report were available in 1950. (By that time, soil conservation surveys, interpreted in terms of land-use capabilities for the program of the Soil Conservation Service were far more extensive than new basic soil surveys interpreted in terms of yield estimates). Even with such limited coverage, however, the development of this technique of soil survey interpretation was highly significant because of its potential applications to land policy, land economics, and land-use planning, to all such applications, quantitative yield data, expressed in terms of defined soils, crops, and management levels, were and are of unique value in that they represent the first approximation to <u>production functions</u> for agricultural production. The nature and use of production functions, and their relation to crop yield data might be explained as follows.

* * *

On any given soil, the level of production of a given crop is clearly not a constant. It varies as a function of the types and amounts of capital and labor inputs applied by management; it varies also with changes in external factors (i.e. climate) beyond the control of management. While yield on a given soil is thus a variable, however, the pattern of response of yield to variations in the other inputs, or the input-output schedule or <u>production</u> function is relatively unchanged. With quantitatively defined inputs (i.e. fertilizer, seedbed preparation, etc.) and outputs (crop yield), the production function, *ceteris paribus*, is a characteristic feature of each soil. For different soils with widely dissimilar soil characteristics, production functions are totally different (148):87.[30/]

30. An early review of the logic, if not the nomenclature, of soil productivity functions is included in a study by Simonson and Englehorn in 1938 (235).

In all types of production, industrial as well as agricultural, wherever input-output data are available, production functions are basic tools in the determination of “efficiency” and “capability,” in estimating the optimal combination of inputs and level of production, and in quantifying the effects of the law of diminishing returns (38):408. Production functions, *per se*, express strictly physical relationships, but the corresponding economic relationships, such as the relative profitability of alternative levels of production, for any given cost and price levels are expressed by relating input factors to costs and output factors to returns.

In practice, of course, the application of the above type of analysis to soil productivity is far less factual than that of the theoretical model. For one thing, the accumulation of firm crop yield data in relation to a wide range of management levels, while holding other variables constant, constitutes a sizable research project, even if limited to a single crop on a single soil; for another, be it noted, production functions for soils, once determined, are of limited value unless applied to areas where soils have been properly classified and accurately mapped.

By partially overcoming such problems, however, the development of productivity ratings and yield estimate tables described represent the first and best approximation to soil production functions. For a given crop on a given soil, two, three, or more yield figures shown in relation to as many different levels of management inputs define two, three, or more points on the production function curve for the given crop and soil.

The interpretation of such production functions is an essential step in comprehensive land-use planning activities where the objectives include the determination of alternative types and levels, including adopting profitable levels, of production, consistent with safe and non-exploitive land-use. Such comprehensive planning procedures include those developed for application at the farm, town, county, and State bases by John D. Black and his associates at Harvard University (305), (42), (41), (40).

It should be noted that soil survey interpretations in terms of crop yields and hence of production functions, and such interpretations in terms of the “Land-Use Capability” classes of the Soil Conservation Service, are by no means incompatible. The capability concept, as initially applied in the Service program, dealt not with evaluation of soil pro-ductivity, but with consideration of the measures needed for soil protection. In the discussion, soil production functions are considered to be relatively unchanging expressions of the reproducible relationship between inputs and outputs. The assumed applicability of the soil production function holds true only so long as the soil itself is not modified by deposition, severe erosion loss or other irreversible change; the production function of a soil is meaningless if the soil is no longer in place. Thus the two interpretive concepts, production functions and capability classes, may be considered complementary in the sense that the latter expresses the broad limits of safe land-use and the intensity of practices needed for soil protection, while the former expresses the range of productivity of the soil, within the broad limits of land-use and given the necessary protection. [31/]

* * *

In addition to the interpretive techniques involving soil productivity ratings and yield estimates, many other types of soil survey interpretation were developed and applied by the Soil Survey during the ‘thirties and ‘forties. Some of the more important of these are noted briefly.

In the cooperative soil survey program for the Tennessee Valley, soil surveys were interpreted, after 1934, in terms both of productivity ratings and of “use capability classification” (193):67, (198):114. The use capability classification was simpler, but roughly comparable in purpose to earlier systems developed by the Soil Survey in 1909, and also to the “Land-Use Capability” classification subsequently adopted by the Soil Conservation Service in 1939 (322):1493, (199):16. In the Tennessee Valley surveys, soil types and phases

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31. The relationships have been recognized by Earl O. Heady of Iowa State College, in one of the very few attempts to subject the elusive concept of soil conservation to quantitative definition. In Heady’s proposal, maintenance of the soil production function is a measure of the presence or absence of a “soil conservation problem.” Yields may fluctuate up and down, along the curve of the production function, in accordance with varying input levels; but so long as a given output level may be regained through application of the same input level that originally produced it, there to no “soil conservation problem.” If however, because of soil loss or other deterioration, the application of the given inputs result in a lower level of outputs, the production function has been diminished, and a “soil conservation problem” exists. Thus under Ready’s definition, soil conservation is the prevention of diminution of the soil production function (115).

were assigned productivity ratings (at three levels of management); on the basis of the ratings, the soils were grouped into productivity classes; finally, as a general interpretation of productivity, erosion hazard, etc., the use capability classification further grouped all soils broadly into categories such as:

CROP-ADAPTED SOILS	NON-CROP-ADAPTED SOILS
lst Class	Pasture-adapted soils
2nd Class	1st Class
3rd Class	2nd Class
etc.	etc.
	Forest-adapted soils
	(193):67, (98):59

With the interpretations for productivity and use capability, soil surveys were widely used in the Tennessee Valley as a base for land-use planning, and for research and demonstration programs in uses of fertilizer (98):113.

Elsewhere, during the nineteen-thirties, many individual States utilized soil survey data in the preparation of various types of inventories of soil productivity.[32/]

Soil survey interpretations for purposes of land appraisal in rural tax assessment, utilized off and on from early beginnings in 1907, were developed to a high degree during the 'thirties and 'forties as the result of improved mapping techniques and productivity ratings of the new soil surveys (88), (161):69. Such interpretations, even as the new surveys themselves, were of very limited extent nationwide; but locally, particularly in North Dakota, Iowa, Mississippi, and California, the demonstrated value of detailed soil surveys as a primary basis for tax assessment led to increased contributions from states and counties for soil survey work (146), (213):84. In Polk County, Iowa, following completion of a new tax assessment based upon a special interpretation from the detailed soil survey, the

32. An extensive bibliography on the relation of soil surveys to various interpretive classifications as of 1940 is available in the Proceedings of the First National Conference on Land Classification, published as Missouri Agricultural Experiment Station Bulletin No. 421 (213). A more general review of the same subject matter is included in a National Resource Planning Board publication of March, 1941 (198). A comprehensive analysis of the relation of soil mapping, units to interpretations in terms of soil productivity is included in a monograph of 1942 by Marlin G. Cline (60).

County Assessor reported a sudden change in the general attitude of the rural constituency whereas the Assessor's Office had received over three thousand official protests under the previous methods of assessment, only seventy-six such protests were received following the new assessment based on the soil survey.

With the advent of war in the 'forties, soil survey interpretations for military purposes were again developed, and to a much greater extent than in World War I (see chapter 3.23). Following the Guadalcanal campaign, a temporary unit was set up within the Division of Soil Survey to cooperate with the War Department and the Military Geology Branch of the U.S. Geological Survey in making soil maps of strategic areas and interpreting them in terms of military needs. Such interpretations were largely for engineering purposes and the results were classified information. After the war, the work was continued, on reimbursable Defense Department funds, by the "World Soil Map Unit" of the Division of Soil Survey under the leadership of A. Clifford Orvedal. In addition to the continuing classified work on the soils of strategic areas throughout the world, detailed soil surveys were made of all American territories and possessions in the Pacific. While the support (i.e. funds), for work on the world soil map derived mainly from its value in military interpretations, highly important perquisites included scientific study of the nature and genesis of soils of other continents, development of techniques for schematic soil mapping, and better understanding of the uses of soil survey data as applied to engineering work. As a long-range project of the unit, preparation of a uniform-legend, uniform-scale (1:1,000,000) soil map of the world was begun. In the compilation of this world map, the need for which had been recognized at international conferences in Rome in 1924 and in Washington, D.C., in 1927, soils were classified at the categorical level of Great Soil Group, and delineated as associations of phases of Great Soil Groups (203), (202).

Other wartime pressures, shortages of rubber, oils, and fibers, called for a number of special soil surveys and interpretations. In cooperation with the Emergency Rubber Project, state and federal men of the Soil Survey conducted field studies on the soil requirements, and on interpretation of soil surveys, for the production of Guayule (*Parthenium* *argentatum*), Russian dandelion (*Taraxacum kok-saghyz*) and Goldenrod (*Solidago levenworthii*). For the Guayule plantings, the Soil Survey carried out a crash program of soil mapping from 1942 to 1944 involving detailed soil surveys of over a million acres and reconnaissance soil surveys of over thirty million acres (220). Other, more limited, studies and interpretations were made in connection with the wartime production of oil-yielding crops such as peanuts and castor beans, and of fiber crops such as American hemp (*Cannabis sativa*). After the war, extensive soil surveys and interpretations were made in Central and South America to locate potential areas for production of Abaca or Manila hemp (*musa texilis*).

Within the federal Division of Soil Survey, a position of “Chief Analyst” had been set up in the ‘thirties to provide functional leadership in the broad field of soil survey interpretation. After the war, comparable positions, designated as “Regional Analyst” were established for each of the four inspection and correlation regions of the Soil Survey. (In 1953 the euphemism “group of states” was substituted for the term region, their number was increased to five, and the formed “Regional Analyst” positions were redesignated as “Soil Correlator for Interpretation.”)

Soil Survey interpretations to meet the needs of the more extensive types of land-use such as timber and range management and watershed protection were not as highly developed as those relating to production of cultivated crops; soil surveys had never been made of many vast areas of forest and range lands, particularly in the West (99):151. Extensive portions of the Great Plains had been covered by early reconnaissance soil surveys but the survey reports were deficient in interpretative materials (213):241. The value of soil survey interpretations for the more extensive land-uses was recognized however, and received increasing attention, particularly after the war. For forestry purposes, a number of systems were developed that related productivity measures such as “forest site index” for important commercial tree species to specific soil types or groups of soil types (99). Progress was also made in the development of interpretive techniques for application to range management and watershed protection, but on a lesser scale until the reorganization of the Soil Survey in the nineteen-fifties.

Soil survey interpretations for planning and development of irrigation, which had begun with the Soil Survey itself in 1899, were developed and applied in detail during the nineteen-forties. Soil survey reports covering arid valleys of the West included special groupings of soil types and phases in terms of productivity, with and without irrigation (28):143. In five states within the Missouri Basin, and elsewhere in the West, new basic soil surveys were utilized by the Bureau of Reclamation, Department of Interior, in large-scale irrigation and reclamation projects (213):260. (Because of the aforementioned dearth of up-to-date soil survey coverage, the Bureau of Reclamation and also the Indian Service organized independent land mapping programs which were cooperative, in part, with both the Soil Conservation Service, and the Soil Survey (198):71.)

Interpretations for engineering purposes were refined and applied. Existing cooperative field and laboratory studies of soil mechanics as related to specific soil types were continued with the Bureau of Public Roads, as were studies of pipeline corrosion with the Bureau of Standards. The work of the World Soil Map Unit in developing military interpretations (noted), further demonstrated the value of soil survey data in planning and construction of airstrips and in predicting "trafficability" for heavy vehicles. State highway agencies (of which that of Michigan was the most active), made increasing use of soil maps, generally with additional on-site deeper borings and tests, in highway design and construction and in locating deposits of sand and gravel for grade material and of suitable surface soil for use as "topdressing" on cuts and banks to be planted (18), (254):40. With the rapid postwar expansion of urban and suburban areas, soil surveys were intensively used in many local areas in connection with location and construction of buildings, and with sanitary engineering and drainage.

One of the most recent, and certainly the most bizarre, applications of soil survey data has brought the field of interpretation into the atomic age. The nuclear and thermonuclear explosions of the last decade have occasioned worldwide investigations of the nature, intensity, and effects of radioactive fallout. In this country, analyses of surface soil and of plant and animal tissue over wide areas indicated a very significant, but unexplained, variation in residual radioactivity among samples assumed to have been subjected to comparable levels of fallout. The full mystery of this variability is by no means resolved, but the first important clue was provided by Lyle T. Alexander, Chief of the Soil Survey Laboratories. Working in cooperation with the Atomic Energy Commission, Alexander demonstrated that the observed differences in residual radioactivity from strontium 90 were correlated broadly with the distribution or different kinds of soil. Levels of radioactivity in the soil were found to correspond to the broad patterns of climate and precipitation, the same forces that determined the distribution of the "zonal" Great Soil Groups. Within such broad zones the intensity of fallout, and hence the level of strontium 90 in the soil, was relatively uniform. Local variation was still observed, however, in the radioactivity of plant and animal tissues, and this variation was further correlated with soil differences within the broad climatic zones. Because of the atomic similarity of the elements, strontium could be absorbed and utilized by plants as a partial replacement for the more common nutrient, calcium. Alexander established a limited correlation between the strontium 90 content of plant materials (and of fluid milk supplies), and the calcium content of the soils from which they had been derived. In "high-lime" soils well-supplied with calcium, uptake of strontium 90 was relatively less than from acid soils of low calcium supplying power. Alexander's interpretation not only helped to account for the observed variability of fallout effects, but also offered a means for improved prediction of future intensities and effects. In studying the relationships, he sampled and analyzed soils and biotic tissues at remote locations throughout the world. For his contributions in this unique application of basic soil science, Alexander received the Distinguished Service Award of the Department of Agriculture in 1956 (281):1101.

The different types of soil survey interpretations and land classifications noted by no means include all the uses to which basic soil surveys were being applied by 1950. The diversity of such uses is clear, however, as well as the close relationship between the specific types of soil survey interpretations and the particular purposes for which each was designed. The latter point is worth noting here because it represented a major point at issue between the program of the National Cooperative Soil Survey and the much more extensive mapping program of the Soil Conservation Service. As noted in chapter 3.442, the Soil Conservation Service developed the system of Land-Use Capability classification as a means of simplified interpretation of its soil conservation surveys. The capability system was designed primarily for use in the conservation land-use planning program of the Service. Beginning in the late 'forties, however, the Land-Use Capability classification was represented by Service spokesmen as a comprehensive system of land classification for all purposes, and its use was recommended for diverse applications ranging from rural road building to adjustments in agricultural credit and land tenure (283):1101.

On this point, the position of the Soil Survey was that, while basic soil survey data were applicable, through interpretation, to a large number of uses, no single system of interpretation could serve all such uses. As stated in the Soil Survey Manual of 1951:

> Another source of confusion in land classification to many has been the search for a simple, all-purpose classification of land according to its characteristics and capabilities.... If the classification is simple, relevant factors must be omitted.... the classification cannot be simple except for an easily defined, narrow, single purpose... it is generally far cheaper to make a basic soil survey from which a great many simple groupings, or "land classifications" may be derived by interpretations than to concentrate on one narrow immediate objective at a time in separate surveys.
>
> Nor can there be an all-purpose classification or grouping. A grouping made primarily to indicate erosion hazard and for planning erosion control will not serve adequately as a grouping for tax assessment, for example. It will fail one purpose or the other (251):29, 30.

The Soil Survey viewpoint regarding the need for different interpretive systems for different uses of basic soil survey data was embodied in the pamphlet "Sound Land Classification Rests on Soil Surveys," issued by the Bureau in March of 1951. This pamphlet (Figure IV) also represented a tactical maneuver to counter the proposed "National Land-Capability Inventory" program of the Soil Conservation Service.

3.44 Physical Surveys of the Soil Conservation Service

The foregoing discussion of soil surveys during the period 1933 to 1952 dealt primarily with the National Cooperative Soil Survey program of the states and the federal Division of Soil Survey. With the growth of the Soil Conservation Service, the mapping work of the new agency was nominally coordinated with the Soil Survey. For reasons which are treated in detail in subsequent chapters, however, the mapping program of the Service almost immediately diverged from that of the Soil Survey to the extent that the two programs are discussed separately in the present study.

As noted briefly in chapter 3.33, research activities in "Soil Erosion Investigations" were reactivated under the Bureau of Chemistry and Soils in the late 'twenties. These investigations, under the direction of Hugh Hammond Bennett, were carried on cooperatively with the Bureau of Agricultural Engineering and the Forest Service, and with several State Agricultural Experiment Stations. On September 19, 1933, Bennett was transferred to the U.S. Department of Interior to administer a soil erosion and work relief program, the Soil Erosion Service, under funds allotted by the Federal Emergency Administrator for Public Works. On March 25, 1935, Interior's Soil Erosion Service was transferred to Agriculture and, on April 27, it was designated the Soil Conservation Service, with Bennett as Chief (105).

The mapping of soil and land conditions was only one of a number of closely coordinated activities of the Service program, but it was, and is, an essential one. Service Chief Bennett, a soil surveyor since 1903 and a Soil Survey Inspector since 1909, built his program on the basis of planning land-use and soil erosion control only in accordance with the results of detailed surveys of physical land conditions, including soils. The history and program of the Service are extensively documented elsewhere and will not be noted here except as they relate to the in-Service development of the program of physical surveys (105), (110), (37), (34), (32).

The mapping program of the Service vas not concerned with soil classification in the sense that the term is used elsewhere in the present study. Rather, the emphasis was on field mapping and on interpretation and use of such maps. The technical aspects of these two activities are noted separately in the two chapters. Administrative aspects of the work, particularly as they involved coordination of the Service's mapping program with that of the National Cooperative Soil Survey, are discussed in subsequent chapters.

3.441 Field Mapping

The mapping program of the Service began with the Service itself. And the mappers shared the semantic metamorphosis of the Service. Overnight, in 1935, "soil erosion specialists" making "erosion and cover surveys" became "soil conservation surveyors" making "soil conservation surveys" (33), (250), (98).

At the start, these men were drawn, as was Bennett himself, almost entirely from the ranks of the Soil Survey (250):55. There were important differences, however, not the least of which was a liberal supply of emergency relief funds, between the old mapping program and the new. In December of 1935, an active State participant in the Soil Survey reported that:

> The work of the SCS projects with aerial photos on a scale of 10" per mile has in effect put the soils under a microscope and thus made mapping more accurate and comprehensive. At the same time the field men are released from the old restrictions of low cost and high speed required, and everyone has become accustomed to the higher costs and slower rate of progress needed to adequately solve the problems of proper use of land in individual farms, which are the units through which land-use is actually accomplished (53):181.

Early in 1935, while the Service (Erosion) was still in Interior, a nationwide meeting of soil erosion surveyors was held at Meridian, Mississippi. Meeting Chairman Glenn Fullert, "Chief Erosion Specialist" of the Service, spoke for many another old soil surveyor:

> You have an opportunity for which every soils man who has been in the Soil Survey has looked forward to as a sort of a Utopian dream since the Soil Survey first started. Those of us who were in the Bureau of Chemistry and Soils, were out on survey work and have always looked forward to the day when we could make actual use of our soil surveys. We have made these maps year after year, and we have seen very little use made of them in many cases. ...Now, right here has been presented to us a chance to make a practical use of the Soil Survey.... We have gone several steps farther than the initial classification of soils when we incorporated into the survey the degree of slope, the kind of cover, and the degree and extent of erosion....
>
> Mr. Bennett, at the beginning of the organization, emphasized the fact that every piece of work we should do on the farm on all of our projects should be based primarily and

fundamentally upon the conditions of the soil. The program adopted on these projects was adopted to correct conditions of the soil (250):36.

Thus, while the soil erosion surveys represented a carry-over, both of personnel and techniques, from the Soil Survey, the techniques were applied on a much more intensive and detailed scale, and the personnel were much more closely associated with the immediate use of their maps for a specific purpose. Moreover, the authorizing legislation (sec. 202(b) of the National Industrial Recovery Act of 1933), had specified "...prevention of soil erosion...," and further Congressional concern for the menace of soil-erosion was aroused and maintained by Service Chief Bennett (270). As a result, the surveys initially developed for the Service program were "soil erosion surveys" in more than name only. The identification of other factors, including soil type was often subordinated to the recognition and mapping of a large number of classes of soil erosion. By 1935, over a hundred classes and combinations of classes of sheet, gully, and wind erosion and deposition were recognized (98), (199):12. Erosion hazard was also reflected in the criteria for defining slope classes. In the legend for the "Erosion and Cover Survey" of the Salt Creek Erosion Control Project, Zanesville, Ohio (one of the earliest Service projects, begun in the Spring of 1934), slope classes were defined as:

A Slopes — Those level areas upon which there is a minimum of erosion under normal conditions

B Slopes — ...that range of slopes on which erosion is a problem on areas in cultivation under normal conditions but on which effective control measures can be established... (248):1

In these early surveys, soil types were identified and mapped in accordance with the classification system developed by the National Cooperative Soil Survey. In erosion surveys such as that for the Salt Creek Project, soil types were indicated by the identical letter symbols used on the standard published soil surveys of the areas (248). The four factors, erosion, land-use, slope, and soil type, were shown on the field sheets (airphotos at 8 to 10 inches to the mile, when available) by means of a fractional composite symbol, with erosion in first place and soil type in last. According to instructions issued in 1936,

> The survey will always show the four factors: ...They should be shown in a composite symbol expressed in the following order:
>
> $$\frac{\text{Erosion (sheet, gully, wind removals, wind accumulations) - Land Use}}{\text{Slope - Soil}}$$
>
> (98):19.

In the use of this fractional symbol for field surveys, the four factors were considered as completely independent variables:

> A change in any one factor will necessitate the delineation of another area with a new complete symbol incorporating the change, i.e., a complete symbol showing all four factors must be used for each area delineated (98):9.

During the initial trial-and-error period of the development of soil erosion surveys, when personnel and funds were abundantly available, the use of the 10"/mile field scale, the multiplicity of erosion classes, and the limitless number of combinations of factors distinguishable with the above “open” legend, gave rise to some of the most detailed and complicated mapping ever produced in this country.

The practical and theoretical difficulties inherent in such uncontrolled and ultra-detailed mapping were pointed out by Soil Survey Chief Kellogg (see chapter 3.42), and by other State and federal spokesmen for the Soil Survey. In 1939, Kellogg wrote:

> Variations in any one soil characteristic that may have much significance in one combination may have no significance in another. What, for example, is the use of mapping fine differences in stoniness, that may be of great significance in one situation, in another situation, another combination of soil characteristics, where there is no possibility for the development of arable farming? I have made some of these same mistakes, on occasion, and regret them exceedingly (253) :6.

This criticism was readily returned by surveyors and farm planners of the Service who found many of the older 1"/mile published soil surveys, and there were few newer ones, to be inadequate in scale and detail for application in the Service’s intensive program of conservation farm planning on a field-by-field and farm-by-farm basis (208):138.

Additional criticisms of the erosion surveys, and much more effective than that of the Chief of a rival agency, was expressed by the farm planning technicians of the Service itself (208):138. These technicians soon found that the mass of detailed data on the 10"/mile maps and the split-hair erosion classification tended to obscure the significant differences in physical land conditions which were the objective of the surveys. Concurrently, as the Service became established as a permanent agency in Agriculture and greatly expanded its operations under regular appropriations, the high cost and inefficiency of earlier surveys supported by emergency relief funds could no longer be justified. As the surveys were completed for a number of entire counties and watersheds, the maps were published, together with descriptive reports (213):302, (198):65. These published surveys, designated as "Erosion and Related Land Use Conditions" until 1938, and "Erosion Surveys" or "Physical Land Surveys" thereafter, included many of the elements of published soil survey reports, and the experience of the Service in compiling and publishing such surveys further pointed up the consequences of the earlier complex and uncontrolled survey legends.

For all the above reasons, the conservation surveys were partially simplified. In 1939, three years after issuance of the instructions quoted, a new "Soil Conservation Survey Handbook" was issued by Ethan Allen Norton, Chief of what had become the "Physical Surveys Division" of the Service. The Handbook of 1939 specified a field scale of 4"/mile for most detailed surveys, and the use of airphoto base maps wherever available and suitable (199):3. The earlier complication legend of erosion classes was retained, but a grouping of the classes was suggested since,

> 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...The groups should not be shown on the map, but they are necessary for interpretation and use of the survey (199):12.

The handbook did not specifically call for "closing" of the uncontrolled legends. The number of independent variables in the four-factor symbols of 1936 were reduced to three, however (land use was mapped separately), and conservation surveyors were instructed

> ...to maintain a record of the approximate acreage and typical locations of each new delineation until...a significant area has been mapped (199):25,

and to prepare

> ...a complete list of every soil separation mapped, giving the field number and the field name (199):31.

Such listings, however, were generally compiled only for the soil type separations, and most of the soil conservation surveys continued to use "open legends" with respect to the additional separations for slope and erosion classes.

An additional factor affecting simplification of the surveys, although widely variable in the extent of its influence, was the introduction of the interpretive system of the "Land-Use Capability" classification in the program of the Service. This interpretive system is noted in the following chapter.

In soil conservation surveys as per the Handbook of 1939, soil types were identified ostensibly in accordance with the established classification system of the Soil Survey, and conservation survey data were

> ...assembled for detailed consideration in correlation of soils by the Soil Correlation Committee, Soil Survey Division, and for review by the Department Committee on Soil and Erosion Surveys (199):24.

(The activities of the "Department Committee on Soil and Erosion Surveys," and of other administrative arrangements for coordination of soil surveys and soil conservation surveys are described in detail in chapter 4.4.)

In the burgeoning growth of the Service program, however, the coverage of soil conservation surveys far outstripped the capacity of the Division of Soil Survey to provide the necessary field investigations and laboratory studies for adequate soil correlation in the mapping program of the Service.

> In many soil conservation surveys, soil type delineations were transferred directly from the available published 1"/mile soil survey maps to the 4"/mile airphotos used as conservation survey field sheets. Field mapping was then completed by conservation surveyors who delineated only additional slope and erosion conditions within the areas of soil types, and/or phases, transferred from the published maps. This was a timesaving

procedure, and generally satisfactory when applied in the few areas for which recent soil surveys were available. Elsewhere, however, soil type mapping was sometimes transferred from old soil surveys which had been made without airphoto base maps and without the detail and accuracy of location with which slope and erosion conditions could be shown in the conservation surveys. Acceptance of such composite maps by the Service in some areas was a reflection of a still prevalent tendency to recognize slope and erosion conditions as independent of, and more important than, soil type differences. In other areas, efforts by the Service and other agencies to use the composite maps for farm planning on a field-by-field basis served further to demonstrate the inadequacy of the old soil surveys for application to intensive purposes for which they had never been designed (194), (198):113, (208):138.

It has been pointed out that, while the mapping work of the Service became less highly detailed and less "erosion-oriented" during the nineteen-thirties, concurrent developments in the Soil Survey led to increased detail and field scale of mapping in basic soil surveys. In these converging trends of mapping techniques, the two survey programs were clearly influenced, one by the other. Effective administrative coordination was still years away, but on some major technical points at issue, a small beachhead of common ground had been achieved. Thus, in the late 'thirties, the first of a small but gradually increasing number of mutually acceptable surveys was made jointly with the Service, the Bureau (Division of Soil Survey), and the States cooperating (see chapters 3.42 and 4.4).

Such joint surveys, however, comprised only a small part of the rapidly increasing coverage of soil conservation surveys. The very success of the total Service program, particularly with the subsequent growth of "soil conservation districts" and the Service policy of basing the application of conservation measures on the findings of conservation surveys as interpreted by Land-Use Capability, exerted a mounting stress on personnel of the Physical Surveys Division. The small cadre of experienced soil surveyors of the early days was soon training hundreds of young men, of whom college degrees were required, but not college training in soil science, to be soil conservation surveyors. Locally, when the demand for conservation surveys for farm planning ran too far ahead of the supply, farm planning technicians (soil conservationists) of the Service, on occasion, went ahead and made their own surveys as best they could. As the Service program shifted from demonstration work on the early erosion control projects to providing technical assistance to individual farmers cooperating with local soil conservation districts, a greater proportion of soil conservation surveys were made in small scattered parcels covering individual farms. This discontinuous and fragmented approach to field mapping was clearly recognized by soil conservation surveyors as far less efficient and less accurate than the progressive, contiguous mapping over large areas (as was the rule with basic soil surveys and also with soil conservation or erosion surveys on many of the early Service projects); in the broad program of the Service, however, the separate mapping of individual farms was considered an overriding need as a means of providing technical assistance to district cooperators on a priority basis.

Under these conditions, all of which were further intensified by the wartime personnel shortages, soil conservation surveys of the early and middle forties were essentially pragmatic, and of widely variable quality. Within the Service program, these surveys, with the more simplified legends and the reduction in field mapping scale, were considered much more acceptable than the complicated soil erosion surveys of ten years earlier, and in-Service criticism of the surveys was reduced. Acceptance and use of the conservation surveys in the Service program was further facilitated by the development and widespread application of the Land-Use Capability system for survey interpretation. From outside the Service program, however, and specifically, from federal and State proponents of the National Cooperative Soil Survey, the conservation surveys sustained strong criticism, altruistic and otherwise (see chapter 4.3 and 4.4). Impartial appraisals were scarce, but perhaps one such was that of G. Milne, the visitor from East Africa (whose succinct comments on the Soil Survey are noted in chapter 3.41). Milne reported:

> Some of the surveys for conservation purposes may...be found to have lacked the basal quality that is desirable in all soil surveys; the areas added as ‘surveyed’ to the index map during this period of rapid expansion may not all be permanent gain (192):47.

* * *

The end of hostilities (military and naval) brought a number of profound changes to the mapping program of the Soil Conservation Service. Field personnel again became available in large numbers; the total Service budget, including funds for soil conservation surveys, was increased to nearly double the prewar level; and all but the last vestiges of formal coordination at the national level between the mapping work of the Service and that of the Soil Survey were dissolved.

This latter development, the administrative decision resulting in the virtual end of national coordination, is noted in more detail in chapter 4.4. This decision to abandon attempts at more effective coordination was heavily influenced by the wartime experiences of "utilitarian surveys," manpower shortages, and breakdown of adequate soil correlation procedures; ironically, however, the administrative instrument which established the new and semi-independent status of the two survey programs was signed on September 4, 1945, two days after the Japanese surrender.

Under the new arrangements, soil conservation surveys were carried on more or less cooperatively with the states, with two-way memoranda of understanding in states where the Bureau's Division of Soil Survey had no work underway, and under three-way memoranda where the Service cooperated with the Bureau and the States in basic soil surveys. A Service employee of P-4 grade with the title of "State Soil Scientist" was assigned to each state, or group of small states, to provide technical supervision of the soil conservation surveys and to cooperate with the State soil survey agencies, where such existed (204).

The establishment of the State Soil Scientist positions represented a certain amount of decentralization from the Service's seven regional offices. The regional offices, however, had already achieved formidable autonomy. As a result, under the line-and-staff organizational structure, the Regional Directors, as line officers, retained administrative control of the conservation surveys work within their respective regions and were generally successful in resisting efforts by the Chief of the Service's Division of Soil Conservation Surveys to develop and to maintain uniform technical standards, nationwide. In relations with the Regional Directors, the Division Chief, nominally the head of the conservation surveys program at the national level, was not only a staff officer dealing with line officers; he was also a full grade lower in rank. The program of soil conservation surveys which thus emerged, while marked with considerable uniformity within some States and regions, did not constitute an integrated national survey.

As noted earlier in the present chapter, most soil conservation surveys, prior to 1945, were based upon “open” legends designed generally to show the nature and distribution of soil types and of slope gradients and erosion conditions, in addition to current land use. This type of survey (a collateral, if unacknowledged, derivative from earlier surveys), was continued in many States through the early nineteen-fifties. Elsewhere, however, and even before the formal administrative separation in September of 1945, a new and greatly different kind of soil conservation survey was evolving (142). The adoption of the new survey was most rapid in those regions, such as the Far West and the Southwest, where coverage of basic soil surveys and the availability of adequate soil correlation service were even more thinly spread than elsewhere.

In the new conservation surveys, present land use was mapped separately, as before, and slope and erosion conditions were mapped in accordance with various classes derived from the Handbook of 1939. The big change was in the definition and delineation of soil conditions other than slope and erosion.

Neither soil type nor any of the established higher categories of soil classification were considered in the identification and mapping of soil conditions. Instead the new legends provided for the field estimation and delineation of a number of separate soil conditions, considered as independent variables. As listed in the “Supplement to Guide for Soil Conservation Surveys, May 1, 1948,” these independent variables included the following:

Effective depth
Texture of topsoil
Permeability of first significant zone under present topsoil
Permeability of second significant zone under present topsoil
Type of underlying material
Natural soil drainage
Reaction
Organic matter content

Inherent fertility
Available moisture capacity
Thickness of surface soil
Thickness of subsoil
Thickness of first significant zone under present topsoil
Thickness of second significant zone under present topsoil

In addition, “Associated Land Features” (grouped with slope and erosion), included the following:

Wetness
Salinity
Overflow

The actual soil conservation survey legends and the surveys themselves that were developed in the Service program in the late ‘forties varied widely, and generally by administrative regions, from the national standards given in the “Guide for Soil Conservation Surveys” of May 1, 1948. In the administrative regions where the use of soil type classification was abandoned completely, the legends commonly provided for composite fractional symbols for mapping units, such as the example from California. Despite the wide variability, however, nearly all soil conservation surveys were heavily influenced by the specific, but limited, requirements for adaptation of the surveys to the system of Land-Use Capability classification. On this point, the National Guide of 1948 specified:

> Soil mapping units are separated from each other according to mappable differences in the soil characteristics known to be significant in conservation farm planning. Some of these characteristics can be observed directly, others my be inferred from observable indicators (131):5.

The relation of the conservation surveys to the Land-Use Capability classification was even closer in much of the West, where conservation surveyors indicated Capability classification at the same time they made the conservation survey (142); (333). A survey guide for California in 1948 directed that, The land conditions will be shown on the aerial photographs by a fractional symbol followed by the land-capability class. The subclass will be used when needed.

Sample symbol:

$$\frac{4L - d2}{2A - 0 - w1} = IId$$

Interpretation of symbol:

Soil Depth (18”-36”)	Capability Class
Light Texture	Subclass
Standard Soil Profile	(depth limitation)
	(hardpan)
Percent Slope	Slightly Wet
Slope Group	No Erosion

Land use will be shown by a symbol detached from the fractional symbol (330):3.

(The factor identified in the fractional symbol as “Standard Soil Profile” was a local departure from the national Guide and, with additional local variations, was used in a number of Western states for coding soil conditions in the soil conservation surveys) (330), (256), (131). Elsewhere, the soil conservation surveys that adopted the composite fractional symbol more commonly indicated the estimated permeability at one or two levels, as called for in the national Guide. In states and administrative regions where the soil conservation surveys continued to use the established soil type classifications, the composite fractional symbols were frequently not used at all in field mapping. In other instances, the connotative field symbols were used, but the soil characteristics were synthesized in terms of, and keyed to, established soil types.

The quality, as well as the form of soil conservation surveys varied widely; over much of the country, the surveys were still made on a scattered farm-by-farm basis and, when the demand for maps could not be met, soil conservation surveys were still made by farm planning technicians. In other areas, the surveys were well and carefully made, and conservation surveyors, many of whom by the late forties were ten- or fifteen-year veterans, developed important innovations in mapping techniques.

For the immediate pragmatic purposes of the field operations of the Service program, the soil conservation surveys were generally more than adequate, and the surveys that utilized the composite fractional field symbols had several advantages (in addition to the advantage of being, in most instances, the only detailed survey of any kind available). Since they were designed specifically for such purpose, in fact their major purpose, the surveys could be hastily interpreted in terms of the Service's Land-Use Capability classification; in using the maps, a few general facts and/or inferences about soil conditions could be read directly by Service technicians without the need for an understanding of soil type descriptions or legends; since the separate mapping of individual "single factors" did not require the mental synthesis involved in soil classification as such, the surveys were relatively easy to make, and did not require much professional training in soil science (at the time, the Service was recruiting many of its conservation surveyors from the ranks of foresters and graduates of "general agriculture" curricula).

The pragmatic nature of the Service's mapping program and the importance of high rates of mapping production were strongly stressed (in part, as an effort to accentuate the differences between it and the "research-oriented" and slower-moving mapping program of the Soil Survey). In 1949, the leaders of the Service's Soil Conservation Survey Division reported:

> The soil scientist in an operations program must quickly obtain his facts, evaluate them, make his decisions, and go on to the next job. He seldom has opportunity to wait for a statistical analysis, check his results by another method or even delay his report until he obtains more data. After he maps a farm, for example, the map may be sent for reproduction at once, and handed to the farmer a few days later. The soil scientist is thus in a 'production' job...
>
> Practicing soil scientists in some places use the results of laboratory work in making their operation decisions. The whole question of laboratory tests and when to use them must be explored further. Undoubtedly some persons without technical training tend to place too much confidence in a soil analysis. Perhaps some of the laboratory-trained

scientists encourage them to do so...

The practicing soil scientist who makes maps faces an inevitable comparison of his own record, in terms of acres-per-hours, with the record of his fellow workers. His work must be acceptable in quantity as well as in quality (258):323, 324.

For purposes of application beyond the immediate needs of the Service program, the soil conservation surveys, to varying degrees, were generally found to be less than adequate. This was particularly true in the case of the "single factor" surveys in which established soil type classification was not shown. Aside from mechanical difficulties of the unwieldy size of the symbols, perhaps the most serious point of criticism of the surveys, particularly by the Colleges in attempting to relate them to their programs of research and extension, was that the mapping units could not, in most instances, be related to the existing body of knowledge about soils. Specific knowledge of soil behavior, such as productivity, erodibility, etc., developed for specific soil types (as well as the more general knowledge of Great soil groups), could be applied to practical programs only if the soils were classified, or classable, in the same system. In some of the "single factor" soil conservation surveys, through careful selection of soil characteristics considered, and through recognition of the variable significance of such characteristics, the soil mapping units were so classifiable; in many others, however, they were not. The lack of classification, and of the recognition of "soil individuals" also rendered difficult the grouping of the mapping units into interpretive systems, even, in the final analysis, into Land-Use Capability classes.

Among the criticisms was that of Soil Survey Chief Kellogg in 1951,

...the most confusing of all are maps purporting to display a soil or land classification, but which are actually maps carrying selected notes of features without classification. Most commonly, these indicate areas by compound symbols with individual numbers or letters, perhaps in a 'numerator' and a 'denominator,' each keyed to a <u>separate</u> legend. Thus we might look at the symbol of a mapped area and find from the various keys that it had the following features: deep soil, slopes of three to eight percent, brown soil, loam surface soil, a corn crop,...and so on. But what is the bounded area? We cannot tell what kind of soil exists from these notes, nor from a longer list. Any list that would be long enough to indicate differences in the degrees of expression of all features that are

> relevant in at least some combinations would be most unwieldy. Then too, division of soil slope at three percent and at eight percent may be quite proper in some combinations, whereas in others six percent may be the critical limit.
>
> These schemes appeal because their use avoids classification and because men untrained in classification can use them. Lacking a regular nomenclature, of course, the map is not useful for translating the results of research into predictions. Yet a map with such a multiple legend, uncontrolled in the sense that any combination of symbols may be used by the note-taker in the field, may have thousands of separate combinations of symbols for an area with only 75 or 100 significantly different kinds of soil.
>
> Classification is a hard job. The classifier must decide what features are relevant. He must develop standard notations for degrees of expressions of each feature. He must define combinations of features with varying degrees of expression, in such a way that each one is given its proper weight relative to the others in the integrated whole. He must test his classification for homogeneity and for omissions and overlaps. Finally, if the classification is to be used on maps, he must test it in the field to be sure that his units are mappable and relevant and that the boundaries among them come at significant places.
>
> The taking of notes in compound symbols on maps avoids this work. Such maps should never be confused with classification....
>
> Where the map has enough paper space for them, connotative compound symbols may be used for classified areas to help the reader select certain individual characteristics or qualities at a glance. Such symbols can never be complete and can be developed accurately only <u>after</u> classification. With nearly all maps, however, it is best to use short symbols, so they can be placed within small areas, and to show the selected features or qualities in a table on the map or attached to it (156):507, 508.

Equally strong criticism of the soil conservation surveys of the Service was voiced by Land-Grant College spokesmen (see chapter 4.3), and the program was defended fully as vehemently by Service Chief Bennett (as noted in chapter 4.4) (34), (285):1022, (251):259.

All such criticism and such praise of the program of soil conservation surveys in the late forties, as they related to the scientific and technical aspects of the surveys, can be interpreted fully only in the light of the prevailing political and administrative relations among the three protagonists of the soil survey controversy, the Service, the Division of Soil Survey, and the Land-Grant College Association. These relations were increasingly strained as the result of a culmination of events between 1949 and 1951.

With ever-increasing coverage of soil conservation surveys, and with concrete evidence of political support (such as that of the Hope bill of 1948, noted in chapter 4.1), the Service, in 1949, proposed to change the name of its soil conservation surveys program to a "National Land-Capability Inventory." The result was an abrupt change in Service policy with respect to public statements on the uses of its soil conservation surveys and land capability maps. Previously considered purely as an auxiliary phase of the total Service program, not intended for broader use, the conservation surveys began to achieve a new status and, tentatively, the new name.

The surveys themselves were not appreciably changed; as noted, most of them, except those few made in full cooperation with the Bureau's Division of Soil Survey and the States, were designed in general accord with national and regional directives of 1948 and 1949 which specifically limited the objectives of the mapping to the immediate needs of conservation farm planning (131), (142). Nor was great emphasis placed upon the distinction between the basic data provided by the conservation surveys, and the interpretations from those data expressed in terms of Land-Use Capability. With the advent of the proposed "National Land-Capability Inventory," however, Service policy shifted toward emphasis upon the broader uses of such maps and interpretations; the use of "land-capability maps" was advocated nationally for purposes including rural tax assessment, rural road building, rural electrification, agricultural credit, land tenure adjustment, etc. (259), (130), (283), (132).

On the administrative and political level of the soil survey controversy, the proposal of a "National Land-Capability Inventory," with its emphasis on the broad uses of such an inventory beyond the needs of the Service program, represented a vigorous bid by the Service to eclipse and/or absorb the program of the National Cooperative Soil Survey. The intensified rivalry that resulted, however, and the renewed criticism by federal and State proponents of the Soil Survey, served only further to submerge the technical points at issue, and to obscure the actual technical progress in both basic soil surveys and soil conservation surveys.

As noted, the program of soil conservation surveys, because of the administrative lines of authority at the regional offices, and because of its auxiliary status in the Service operations, did not constitute an integrated national survey capable of application, nationally, to the broad purposes cited in support of the "National Land-Capability Inventory" (the eight classes of the Land Use Capability system were used nationally in the Service program, but, as noted in the following chapter, definitions and interpretations of the classes varied widely). The fact was, however, that some of the better soil conservation survey maps were being used locally for purposes beyond those of the Service program; moreover, limited use had been made by other agencies of national summaries prepared by the Service showing the estimated extent of areas of the country falling within the eight Land-Use Capability classes (292), (256), (334). Techniques of soil conservation surveys were applied in a number of technical assistance projects involving establishment of soil conservation programs abroad (132). Other technical progress in the program is noted. In soil conservation surveys made with "single factor" legends, the soil mapping units, as noted, were not classified. In the resulting preoccupation with the measurement and/or estimation of the individual factors, however, some important techniques were developed. Among these were methods for estimating soil permeability (an "inferred" soil property, not measurable in the normal course of mapping). Conservation surveyors and research specialists of the Service, by establishing limited correlations between observable soil characteristics such as soil texture and soil structure, and measured rates of water percolation through core samples of the soils observed, developed greatly improved techniques for the estimation of permeability (266). In soil conservation surveys that retained the use of soil type classification, such percolation measurements and permeability estimates were applied to specific horizons of specific soil types. In basic soil surveys, some of the techniques for determining soil permeability were applied to investigations of soil genesis and morphology, as well as to the more immediate applications in soil survey interpretation (101). And in the Soil Survey Manual of 1951, credit was given (in what appears to be the sole reference to the Soil Conservation Service) to the Chief of the Soil Conservation Surveys Division for contributions to the Manual's section on soil permeability (254):167.

Another inferred soil property that received special study was that of "erodibility" or the variable extent to which different kinds of soil were subject to accelerated erosion. On the bases of research and field observation of the extent of erosion as related to soil conditions, degree of slope, vegetative cover, rainfall intensity and frequency, etc., various methods of evaluating soil erosion were developed. Among these was the "Probable Soil Loss Formula." The great variability in "erodibility" among different soils pointed up the importance of soil classification, and the results of the research were fully applicable to the soil conservation surveys only in those areas where established soil classification was retained. As noted in the following chapter on Land Use Capability classification, determinations of "probable soil loss" such as this provided one of the very few quantitative bases used in the Capability classification (195).

The significance of variations in soil "erodibility" in setting the slope ranges for mapping units, a point of critical comment in Kellogg's statement quoted, was recognized to varying degrees, in most of the soil conservation surveys, even in some of those using the "single factor" legends (333):11, (131):15, (142):13. The method of accounting for this variation was generally to establish different slope ranges to be used with soils of different "erodibility" in delineating mapping units.

In providing airphoto base maps for soil conservation surveys and for use in the primary program of farm planning, the Cartographic Division of the Service developed techniques of airphoto compilation which were the best of their kind and were adopted by the Map Service of the United States Army. In the mapping program of the Service, many conservation surveyors, like their opposite numbers in the Soil Survey, became highly proficient in techniques of airphoto interpretation and use of the stereoscope for more accurate mapping.

* * *

From the discussion of the technical aspects of the work, it is clear that, at that height of the soil survey controversy about 1950, there were not only many serious points of scientific and technical difference between the mapping program of the Service and that of the Soil Survey, but a considerable area of similarity and agreement on techniques. Aside from the technical and scientific aspects of the soil conservation surveys program, however, and the factors, favorable and unfavorable, determining the quality of the work, the most compelling fact affecting the position of the program vis-à-vis that of the Soil Survey was its overwhelming lead in the scope and pace of mapping coverage. Covering more than 30 million acres a year in 1950, the Service was making detailed soil maps and putting such maps to use on a scale never approached by the Soil Survey (131). At the time, the Division of Soil Conservation Surveys counted more than 700 mappers; the Division of Soil Survey, well under 100 (258):323. Whereas the Division of Soil Survey was able to cooperate in basic soil surveys in only about half the states, the Service's soil conservation surveys were underway in all forty-eight (285):788. As one result, the Service, in a number of instances, replaced the Bureau as the representative of the Department of Agriculture in cooperative survey activities with various state and federal agencies dealing with soils and other natural resources (238), (256), (334).

As the coverage of the Service's mapping program continued to expand, and as a comparable expansion in the coverage of basic soil surveys seemed unlikely, the work of the soil conservation surveys evoked the support of some leading professionals not affiliated with the Service, and not unsympathetic to the Soil Survey. One of these was Firman E. Bear, Chairman of the Soils Department at Rutgers University, and editor of the journal Soil Science. In testimony before the House Subcommittee on Agricultural Appropriations in 1950, Bear stated:

> It is my considered opinion, growing out of a careful study of what the Soil Conservation Service is doing in the way of mapping land according to its capabilities, that this is one of the most far-reaching enterprises in its potentialities for both private and public good that has ever been undertaken in this country. In proportion as the making of a complete land inventory of the United States can be speeded up, we shall more quickly be prepared to cope with the great variety of problems in land use that now confront us.

The following year, in a preliminary review of American agricultural potential for the President's Materials Policy Commission, John D. Black of Harvard University reported:

> The most useful analysis of the land of the United States from the point of view of this report is that made by the Soil Conservation Service.

In the final report of the President's commission in 1952, Black made use of summary estimates of nationwide land conditions (as interpreted in terms of the Land Use Capability system), furnished by the Service (292).

3.442 Land Use Capability Classification

From the preceding discussion of soil conservation surveys, it is apparent that, after 1939, an important phase of the conservation operations program of the Service was that involving the classification of land areas in terms of what the Service defined as "Land-Use Capability." (The term is here capitalized to distinguish it from other, similarly-named systems developed independently of the Service, and with different definitions.) In essence, the Land-Use Capability classification was a means for interpretation of the soil conservation surveys. In the Service program, however, it was, in most instances, the only means for such interpretation. As a result, the distinction between data and interpretation was frequently obscured; individual soil conservation survey maps, with or without interpretation, were commonly called "capability maps" or "capability surveys" and, as noted, the entire program of soil conservation surveys was tentatively redesignated as the "National Land Capability Inventory."

Prior to the integration of 1952, the Land-Use Capability system of the Service had little direct influence, although considerable indirect effects, upon the program of the National Cooperative Soil Survey. Federal and State proponents of the Soil Survey strongly opposed the system as initially defined and applied in the Service program. Since then, there has been a great deal of published comment, expert and otherwise, pro and con, regarding the merits and demerits of the concept of Land-Use Capability and of the extent of its applicability.

Some of the points of difference, and some of the lines of relationship, between the Service's interpretive system of Land-Use Capability, and various interpretive systems developed by the Soil Survey are noted in chapter 3.43. The development of the Capability system and its use in the Service (subject matter worth in themselves of extensive analysis), will not be discussed in any detail in the present study except to the extent that such development and use relate to the program of the Soil Survey.[33/]

* * *

It was noted in the preceding chapter that the physical land surveys of the Soil Erosion Service and of the early Soil Conservation Service were extremely complicated and that simplification was demanded by the conservation planning technicians. The result was a new "Soil Conservation Handbook" that provided for less detailed mapping in the soil conservation surveys, and for a simple system of survey interpretation in terms of a few classes of "use capability" (199).

The Capability system of 1939 (which had previously been put into use in Service projects in Winona County, Minnesota and in a few other areas) consisted of a single category with five Capability classes for use in "...regions of arable soils" (43), (213):305. These five classes, as briefly defined, were

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 (199):16.

33. Following integration of the Department's soil survey activities in 1952, the wide use of the Capability system as an interpretive device in the conservation farm planning operations of the Service was continued essentially intact. Until about 1955, however, relatively little use was made of the system in published soil survey reports. Since about 1954, an intensive review of criteria, assumptions, and definitions implicit in the Capability system as currently applied in the Service program has been carried on under the leadership of the Soil Survey Interpretations staff of the Service. It is expected that, upon completion of this review, certain aspects of the Capability system will be modified, but that the system will remain in use.

Differentiation of these classes was ostensibly based solely upon physical factors without regard to social or economic conditions:

> 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 soil or its climatic environment (199):15.

"Productivity," however, was considered a "physical factor" and was given some slight weight in the differentiation among the Use Capability classes:

> 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 (199):17.

The concept of "intensity" was also implicit in the system:

> These classes indicate the most intensive tillage that can be practiced safely with permanent maintenance of the soil....(199):14.

The confusion resulting from the economic assumptions implicit in determinations of "productivity" and "intensity" in the nominally physical criteria of the system are noted briefly.

The Use Capability classification of 1939, with local variations, was adopted throughout the Service, and its use became an integral part of Service policy and operations. In the early forties, the single category was expanded to eight classes, and identified as "Land-Capability" classes (129). For the immediate, limited purpose of generalizing and interpreting the more complex soil conservation surveys for use by farmers and Service technicians in applying conservation practices to the land, the Capability system was of considerable value (213):305. The eight classes were easily remembered and, in local areas where soil conditions were not too variable, the Capability classes were broadly homogeneous. Throughout much of the country, however, soil conditions were extremely variable and, in such areas, the Capability classes became so heterogeneous that they had little meaning.

An official definition of 1943 read

> Class IV land is suitable for only occasional or limited cultivation. It may be steeper than class III, more severely eroded, more susceptible to erosion, more difficult to drain or irrigate, less fertile, more open and porous and so give excessive permeability, or otherwise less suitable for cultivation than class III land (129):24.

The great range of variability (as well as the complete lack of quantitative differentiating criteria), among the conditions included in class IV permitted of very little generalization, and no specification whatever, regarding recommended land use, conservation practices needed, etc. As a result of this clear need for a finer breakdown (which had been noted when the Capability system was first proposed in 1939), various capability "subclasses" were recognized locally during the 'forties. The extreme simplicity of the eight-class system, however, had been well received by Congress and by the general public, and Service Chief Bennett was strongly opposed to complicating the system. In 1950, he gave official sanction to the Capability subclasses, but limited the <u>kinds</u> of subclasses to four, which were to be adopted nationwide. In an administrative directive of that year he approved the following:

Each land-capability class may be subdivided into a <u>maximum</u> of four subclasses according to the <u>kind</u> of land limitations. The subclasses recognized, and symbols to designate them, are as follows:

- **e** Dominant limitation is susceptibility to erosion, by either water or wind.
- **w** Dominant limitation is excess water, such as that produced by seepage, high water table, or floods.
- **s** Dominant limitation is an outstandingly unfavorable soil characteristic, such as low moisture capacity, very high density (imperviousness), excess gravel or stones, shallow effective depth, etc.
- **c** Dominant limitation is climate, chiefly extremes in precipitation or temperature.

No subclasses are recognized in Capability Class I 9245.

Meanwhile, however, subdivisions of Capability classes of various kinds (sometimes referred to as "land treatment units") were long since in use (131). By 1949, an additional category, the "Land Capability Unit," was described, completing the three-category system of

Land-Capability class	- (Degree of limitations)
Land-Capability subclass	- (...kind of limitation)
Land-Capability unit	-(Land-management groups based on permanent physical characteristics)

(133):384.

In the 1949 system, the process of generalization was described as a matter of "grouping" soil conservation survey mapping units into appropriate Land-Capability units, grouping the Capability units into subclasses, and so on (133).[34]

In the early fifties, the Capability unit category came into general use throughout the Service, and the three-category system noted remained in use down to the present time. In the category of the Land-Capability unit, the Capability system finally had a means for an interpretive grouping of all reasonable homogeneous soil conditions for agronomic purposes. The conservation survey maps, with Capability interpretation, continued to show the eight classes and, less commonly, the subclasses and even units. Increasing use was made of the Capability unit groupings for in-Service handbooks, "Technical Guides," etc., however, not by Service planning technicians. While the simple eight-class color remained the most useful general device for gaining initial understanding by farmers of the significance of broad differences in soil conditions to the application of conservation practices, the more homogeneous Land-Capability units came to be the basis for specific recommendations by the technicians.

34. In the evolution of the system itself, however, as noted, the highest category was defined first, later the subclass category, and finally that of Capability unit; this is in the reverse order to the pure logic of classification which requires that definition of classes and determination of categories be carried through by grouping from the lowest category up (61).

In the evolution from the simple and vaguely-defined Capability classes of 1939 to the more meaningful groupings of Capability units of ten years later, the Service, in some respects, duplicated a similar sequence in the earlier experience of the Soil Survey work in soil survey interpretation; from the one-category systems and dubious definitions of classes of “inherent productivity” developed in the Soil Survey in 1933 emerged the diverse, detailed, and quantitatively-defined soil survey interpretations of the forties (see chapter 3.43). In other respects, however, as noted elsewhere in the present study, the interpretive system of the Service and those of the Soil Survey were widely divergent.

There was little that was new in the logic of the initial five, and then eight Capability classes. Roughly comparable systems were in use in the early Soil Survey of 1909, and in the Tennessee Valley operations of the Soil Survey in 1935 (322):1493, (193):67. The overriding fact that distinguished the Capability system of the Service from other similar systems, in fact from all other types of soil survey interpretation, was related, not so much to technical aspects and matters of logic and definition, but to the reality that, in the Service, the Land-Capability classification was institutionalized in a survey and land use planning program of unprecedented areal scope and of widespread popular and political influence. The technical aspects of definitions of the classes were subject to pointed professional criticism, particularly on the part of agricultural economists and of the senior staff of the Soil Survey, immediately upon adoption of the system by the Service in 1939 (213):309, (213):43, (150), (210):286, (189). It was the rapid expansion of Service operations during the ‘forties, and the rigidly institutionalized nature of its Capability system, however, that brought both into violent contact with the diverse but uncentralized activities of the Land-Grant Colleges and with the program of the National Cooperative Soil Survey. When the capability classes, originally an in-Service tool for local use by planning technicians with farmers, appeared as colored delineations (that sublimated the more basic data of the soil conservation surveys), in published “Physical Land Survey” reports of the Service, opposition from the Colleges and from the Soil Survey intensified (189), (210). (The Soil Survey, however, had briefly used a comparable procedure for indicating “use capability” in some of its own published soil survey reports for the Tennessee Valley area) (198):63.

Aside from considerations growing out of the inevitable political and administrative antagonism, professional criticism generally centered on (a) the lack of quantitative criteria for differentiation of Capability classes and subclasses, and hence the great variability in the interpretation and application of such definitions across the country; (b) the lack of explicit assumptions regarding economics throughout the entire system; (c) logical defects, in that criteria applied at the subclass level, such as in distinguishing very poorly drained areas from others with steep slopes, or with shallow, stony soils, were commonly of more significance than criteria applied at the higher categorical level of the Capability class, such as in the distinction between level areas and gently sloping areas of the same kind of soil; (d) the "negative" orientation of the system, emphasizing, by definition, the "hazards" and "limitations" of alternative land uses, with relatively little consideration given to productive potential, and none whatever to "production functions"; (e) the preoccupation with "physical" or "engineering" practices, such as terraces, diversions, contour strip cropping, drainage, etc., in the Service's interpretation of the classes, to the relatively lesser concern for the agronomic and soil management practices such as liming, fertilization, seedbed preparation, selection of varieties, etc.; (f) and the limited single purpose, conservation farm planning, controlling the selection of criteria and, hence, the limits of applicability of the system.

Most of the points of criticism were directed to defects in the Capability system at the class level; moreover, most were recognized by the soil conservation surveys staff, although, as noted, not by Chief Bennett and other line officers, within the Service itself. The interpretive value of the Capability system as used by the Service technicians was tremendously improved by the introduction of the Capability unit category. At the Capability class level, some scattered efforts were made to establish quantitative criteria in place of the subjective judgments generally applied in the differentiation of what were and what were not "simple" practices," "moderate limitations," "severe limitations," "very severe limitations," etc. Among such efforts at developing quantitatively defined class limits, some of the most significant were those undertaken in Illinois and elsewhere, whereby the specific conditions of soil type, slope, etc., to be included in each of the Capability classes were defined in terms of quantitative limits of tonnage of soil loss by erosion as measured at erosion experimental stations, and extrapolated to other areas by means such as the "Probable Soil Loss Formula," noted in the preceding chapter (A. A. Klingbiel, personal communication). While such improvements were made within some states and administrative regions of the Service, there was little uniformity, particularly at the Class level, in the application of Land-Capability classification across the country. Because of the vagueness and logical defects in the Capability class definitions, indeed there could be no reasonable uniformity in such application.

As noted in the preceding chapter, the Service, in the late forties, without appreciable change in either the soil conservation surveys or in the Capability interpretations, mustered its potent popular and political support in favor of a proposed "National Land-Capability Inventory." In prepared testimony before the Cotton Subcommittee of the House Committee on Agriculture in October of 1947, Bennett wrote as follows:

> Detailed surveys to determine the use capability and the conservation needs of each acre of farm land in the South should be completed at the earliest possible time (283):1107.
>
> Land capabilities should be used as a guide for the wise expansion of rural road building, rural electrification, and the orderly development of many other community services and improvements, particularly those of a permanent nature....
>
> Land capabilities ... should be used as the basis for beneficial adjustments in agricultural credit, taxation,...land tenure....[and] production adjustment... (283):1101.

At the time, Bennett was still reluctant to recognize the need for much change or subdivision of the eight Capability classes shown on Capability maps in the Service program (251):272.

The year before, in a general broadside against opposition to the Service program, Bennett spoke out.

> Fortunately, the quibblers and the sticklers who, either willingly or unwillingly, would thwart the national conservation program, will not prevail. They are but a very tiny minority... (34):31.

The "quibblers and the sticklers" referred to by Bennett were not further identified. But as promotion of the "National Land-Capability Inventory" gathered headway, and was repeatedly advocated by Service spokesmen as <u>the</u> general purpose interpretive system applicable to all the purposes cited by Bennett, the Chief of the Bureau's Division of Soil Survey, and acknowledged leader of the National Cooperative Soil Survey, took strong issue with the entire thesis then being promulgated by the Service. In 1951, Kellogg, in defense of the Soil Survey position, wrote the following:

> Search for a simple, all-purpose classification of rural land according to all significant characteristics and capabilities is hopeless. A classification can be simple only for an easily defined, narrow, single purpose. In practice it is most efficient and cheapest to make a basic soil survey from which a great many simple groupings, or "land classifications" may be derived by interpretation, than to concentrate on one narrow, immediate objective at a time, so that a new survey needs to be made each time another problem is given attention (156):508.

In a thoroughly transparent reference to the Capability system of the Service, Kellogg asserted the following:

> As a general program guide, soils are commonly grouped into eight classes according to use-suitability with emphasis upon soil conservation. Class I includes soil safest to use under intensive cultivation; classes 2, 3, and 4 can be used for cultivation, but with increasing erosion hazard or with other limitations; class 5 is useful for grazing or forestry, although not for cultivation; classes 6 and 7 have increasing limitations for these uses; and, finally, class 8 is not suited to producing crops, grasses or trees. Even though homogenous in such broad terms, the soils within each class vary widely in characteristics, crop adaptability, productivity, management requirements, and other qualities....These may be subdivided <u>locally</u> according to management requirements.
>
> No matter how successfully such a soil grouping serves one specific purpose, it should not be used for some other purpose, such as the basis for land appraisal, let us say. For example, a pair of soils may be safe to use and still vary so widely in other qualities that, under the optimum management for each, they have entirely different input-output rations. Another pair may be highly erodible under simple tillage, but not so with the proper combination of tillage, terraces, liming, fertilization, and rotations in which sod crops are prominent. Yet, here again, input-output rations may be entirely different.
>
> For land appraisal, a soil grouping is needed that reflects the generalized input-output

> rations under assumed sets of the commonly used practices. Then, for each tract, the potential use is determined on the basis of all the significant features that influence the management of the tract. Within the uses assigned, the land is rated in terms of capability for those uses, as adjusted for location and, according to local law, for improvements. Thus the soil grouping most suitable for this purpose is unique. Nor does it stay fixed. Yet, if the kinds of soil are defined in a basic soil survey, the groupings can be revised and reinterpreted with changes in economic conditions and in the agricultural arts, changes that influence the relative advantage of the different kinds of soil and the other features in the appraisal (156):509-510.

The exchange serves further to illustrate the fundamental difference in understanding the nature of interpretations of basic data that distinguished the technical program of the Soil Survey from that of the Soil Conservation Service (see chapter 3.43).

* * *

Before ending this brief discussion of the Capability system as applied in the Service program, it should be reiterated that, entirely aside from the controversy regarding its technical soundness and unsoundness, the system, for better or worse, was being so applied on a vast scale. Moreover, since no alternative service was available nationally on anything approaching a comparable scale, such application was overwhelmingly "...for better...." The soil conservation surveys program of the Service, and the interpretation of such surveys in terms of Land-Capability, should thus be considered not only in comparison with the technical and scientific quality of the basic soil surveys and interpretations of the National Cooperative Soil Survey, but also with reference to the virtual nonexistence of such basic soil surveys and interpretations in all but a very few of the agricultural areas of the nation. As Kellogg chose to sacrifice quantity for quality, Bennett just as boldly chose the reverse; and they each achieved impressive, if disparate, results.

Chapter 4 Coordination of the National Cooperative Soil Survey

The early physical surveys of the Soil Erosion Service were based upon an intensive application of techniques and standards already established by the National Cooperative Soil Survey. As the preceding discussion has shown, however, the tremendous expansion of the new erosion control program was accompanied by increasing conflicts between the mapping activities of the two new agencies. Since, initially, two departments of the federal government, Agriculture and Interior, were concerned, such conflicts presumably might have been referred to the federal Board of Surveys and Maps, but there is little evidence that the Board became involved. [35] Instead, the coordination of the national Soil Survey, or more specifically, the lack of such coordination, became a matter for prolonged debate by a succession of Secretaries of Agriculture, by the Land-Grant Colleges, individually and collectively, and, to a very limited extent, by the Congress.

Coordination of the Soil Survey at the national level was never achieved; the impasse, at least as it involved the two federal agencies, was resolved only by direct integration in 1952. Locally, however, coordination was effected in many instances as cooperative soil surveys were carried out jointly, not only by the Bureau, the Service, and the state Experiment Stations, but also, on occasion, with participation of county governing bodies and of other state and federal agencies (100). The success of such locally coordinated and mutually advantageous work pointed the way toward the final emergence of a single Soil Survey program for the nation.

In the next four chapters, the problem of coordination of the Soil Survey is considered as a "case study." The influence of the Congress is noted, in terms both of authorizing

35. The Board of Surveys and Maps of the federal government was established by Executive Order No. 3026 of December 30, 1919, to coordinate and promote improvement of surveying and mapping activities of the federal government. The name was changed to federal Board of Surveys and Maps by Executive Order Bo. 7262 of January 4, 1936. The Board was abolished and its functions transferred to the Bureau of the Budget by Executive Order No. 9094 of March 10, 1942. (See chapter 3.32.)

legislation and of federal appropriations; the position of the Land-Grant College Association with respect to the soil survey controversy, and the influence upon that position by the larger conflict of interest between state and federal programs of public aid to agriculture, is considered; finally, the many efforts at coordination within the Department of Agriculture, and some of reasons for the failure of such efforts, and the circumstances of the administrative integration of 1952 are discussed in detail.

4.1 Soil Survey Coordination and the United States Congress: Authorizing Legislation

Among the various attempts to coordinate or to integrate the soil survey work of the federal government, there were a few which appeared, generally as incidental parts, in bills brought to the floors of Congress. None of these was enacted. The field remained fertile, however, because there was not, nor is there now, an organic law on the books specifically authorizing a National Soil Survey.

As noted in chapter 2.2, the establishment of the "Division of Agricultural Soils" in 1894 and the initiation of field mapping by that agency in 1899 were purely administrative actions. Aside from some joint resolutions dealing with publication and distribution of soil survey reports, legislative authorization for federal participation in the Soil Survey, throughout its existence, has rested solely upon provisions in the year-by-year Agricultural Appropriation Acts.

Of the Joint Resolutions mentioned, Public Resolution No. 8, approved on February 23, 1901, provided:

> A JOINT RESOLUTION providing for the printing annually of the Report on Field Operations of the Division of Soil, Department of Agriculture.
>
> Resolved by the Senate and House of Representatives of the United States of America in Congress Assembled, that there be printed seventeen thousand copies of the report on Field Operations of the Division of Soils, Department of Agriculture, for nineteen hundred, of which three thousand copies shall be for the use of the Senate, six thousand copies for the use of the House of Representatives, and eight thousand copies for the use of the Department of Agriculture; and that annually hereafter a similar report shall be prepared and printed, the edition to be the same as for the report herein provided (267).

Subsequent Joint Resolutions in 1904 and 1922 revised the number and distribution of soil survey reports printed (268).

Authorization for the federal Soil Survey in the annual appropriation acts was generally covered by a brief reference such as that in the appropriations for fiscal 1934 which provided

For the investigation of soils and their origin, for survey of the extent of classes and types, and for indicating upon maps and plates, by coloring, or otherwise, the results of such investigations and surveys,....(271).

In other years, the appropriations acts specified that the work was to be done,

...in cooperation with other branches of the Department of Agriculture, other Departments of the Government, state Agricultural Experiment Stations, and other state institutions,...(269).

In the case of the soil conservation surveys of the Soil Conservation Service, full legislative authorization existed for the making of such surveys, but only as an adjunct to the primary authorized program of the Service. Public Law no. 46 of 1935, the organic law establishing the Service and authorizing its program, provided authority

To conduct surveys, investigations, and research relating to the character of soil erosion and the preventative measures needed, and to publish the results of any such surveys, investigations, or research...(234).

Thus neither the mapping program of the National Cooperative Soil Survey not that of the Soil Conservation Service was supported by any specific, continuing law providing for a national, basic, soil survey for general use and distribution.

The lack of any such organic legislation is generally the rule for “subsidiary” or “service” functions such as those of the Service’s soil conservation surveys (335); in the case of the federal Soil Survey, however, this lack is in marked contrast to the solid legislative footing of such other basic survey agencies as the U.S. Geological Survey (257).

Any individual agency might favor having a specific tailor-made law formalizing its unique functions and responsibilities. Administrators at the Secretarial level, however, are less enthusiastic about the resultant limitation of their freedom of administrative movement since, as an Under Secretary of Agriculture testified (not with reference to the Soil Survey):

...if Congress sets up a bureau itself then pretty soon that bureau begins to believe it has special favors of some kind granted to it (110):178.

The legal orphanhood of the Department’s soil survey work received little attention from U.S. Congresses preoccupied with the recurring crises of the 1930’s and 1940’s. In the late forties, however, possible reorganization of the two federal agencies appeared as a minor facet of the cluster of House and Senate bills aimed at a major overhaul of the nation's agricultural program. One of these was the "National Land Policy Act" introduced by Congressman Hope. The Hope Bill (HR 6054) of 1948 proposed establishment of an "Agricultural Resources Administration" within which (as an "Agricultural Land Service") the Soil Conservation Service would assume additional functions and responsibilities. Among the existing agencies to be transferred to the proposed Administration were

> All of the functions, powers, and duties relating to soil survey...now exercised by the Bureau of Plant Industry, Soils, and Agricultural Engineering (286).

More significantly, the bill provided for a:

> CONSERVATION SURVEY
>
> Sec. 7. In order to effectuate the purposes of this Act, the Secretary of Agriculture shall, as rapidly as practicable, make a conservation survey of the Nation's present and potential agricultural lands, and he is authorized to analyze, publish, and distribute information concerning such survey and to provide land-use capability maps to land owners and operators applicable to their units of land and to assist them in interpreting and analyzing such maps (286).

The Hope bill came as the last of a rapid-fire series of four bills involved in the legislative tug-of-war between the proponents of the decentralized Extension Service and those of the centralized federal agencies (109). Understandably, the bill was supported by the Soil Conservation Service. [36/] The Office of the Secretary, however, took the opposite view. Criticizing the bill for attempting to legislate what he considered to be matters for administrative determination, Under-Secretary N. E. Dood testified:

> An appropriate illustration of the principle I have in mind pertains to the soil survey and those other research functions in water conservation and soil physics, which would be transferred to the proposed Agricultural Resource Administration.... These research functions are closely allied with, in fact are a part of, other phases of agricultural

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36. As noted in chapter 3.441, this bill and similar legislative proposals encouraged the Service to launch the program tentatively designated as the 'National Land Capability Inventory' in the late 1940's

research relating to crop and livestock production. To properly serve all the agricultural programs they are designed to serve, including those dealing with conservation, it would be unwise to freeze them in an organizational pattern which experience might prove less than fully effective (289):42. (Underlining added.)

For reasons only remotely attributable to its provisions affecting the Soil Survey, the Hope Bill was defeated (39).

A bill of much more limited scope, one dealing solely with federal programs of basic mapping, was introduced by Congressmen Peterson on January 20, 1950. His bill, “To Provide an Accelerated Program for Surveying and Mapping of the United States, its Territories and Possessions” (HR 6900), provided authorization for immediate expansion in the basic national programs of topographic, geologic, geodetic, hydrographic, and soil surveying and mapping. In provisions affecting the Soil Survey, the bill specified.

> Sec. 5. The Bureau of Plant Industry, Soils and Agricultural Engineering, is authorized to recruit and train additional personnel; acquire and maintain additional instruments, equipment, and facilities; and develop and participate in cooperative programs with federal and non-federal governmental agencies, the land-grant colleges, and other educational and research institutions, in order to provide most economically and effectively for an expansion of soil mapping from the present level of activities within a period of not more than five years, to a level of activities sufficient in size and scope to complete the soil mapping of the United States within a period of thirty years and to meet the needs for the effective development of resources and orderly settlement of Alaska and other Territories and possessions (288):16.[37/]

In the course of the hearings on the bill, the Bureau’s Division of Soil Survey prepared a strong supporting statement, subsequently published by the House (288). Firm support for the bill came also from the Office of the Secretary of Agriculture. In testimony, Assistant Secretary K. T. Hutchinson cited the broad uses of soil surveys, including engineering

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37. A similar, although somewhat ambiguous proposal for completion of the Soil Survey in twenty years was included in the report of the President’s Water Resources Policy Commission in 1950 (293).

and other nonagricultural applications, and pointed out that

> Unfortunately the collection of information on our soils has not kept pace with many of the programs and activities in which it is most needed. For this reason there is a growing demand for a speeding up of soil surveying and mapping. HR 6900 would help us to meet that demand (290):7.

In Committee, the bill was amended, upon recommendation of the Bureau of the Budget, so as to vest authority for the various mapping programs in the Secretaries of the appropriate Departments rather than in the particular bureaus concerned. (This shift of authority to the Departmental level was in line with one of the major recommendations of the Hoover Commission.)

HR 6900 was favorably reported out by the Committee on Public Lands on July 18, 1950. In unanimously recommending enactment of the bill, the Committee also acknowledged candidly the political facts of life which accounted, in part, for the fact that such legislation was not long since on the books:

> Great construction programs, being more spectacular than a mapping or scientific program have taken the greater portion of our appropriations, but in many instances, such construction programs have had to proceed on the basis of inadequate knowledge of the resources with which we are working.
>
> The total cost of these surveys and maps will probably not equal even one percent of the total value of the construction programs based on natural resources. This small relative cost will be saved many times in reduced costs of construction and will be of even greater value in insuring wise development of our resources (290):3.

In keeping with the Committee's observations regarding the limited political potential of basic scientific program, the Eightieth Congress did not enact HR 6900.

Among the basic mapping programs recognized in HR 6900, there was no mention of the soil mapping program of the Soil Conservation Service, either in the bill itself, or in the supporting testimony from the Department of Agriculture (290). The following year a somewhat similar bill, "The National Survey and Mapping Act of 1951" (HR 1636), was introduced. As originally worded, this bill, like HR 6900, recognized the basic Soil Survey of the Bureau, but not the soil conservation survey program of the Service. By 1951, however, the Service had gained considerable support for its proposed "National Land Capability Inventory." As noted in chapter 4.4, Service policy regarding the functions of its conservation surveys program had shifted from emphasis on their strictly utilitarian applications within the program of the Service, to emphasis upon the national scope and broader utility of soil conservation surveys and land capability maps for other purposes beyond the specialized needs of the Service program. Accordingly the Service, through the Office of the Secretary, urged revision of HR 1636 so as to include recognition of the soil conservation surveys and land capability maps among the proposed list of authorized national basic mapping programs.

HR 1636 was tabled in Committee, perhaps because of other events taking place in 1951 and 1952 which led to integration of the two federal survey agencies without legislative action. (See chapter 4.4.)

4.2 Soil Survey Coordination and the United States Congress: Appropriations

It has been observed by Charles Hardin, a distinguished non-mycologist, that "the soil carries magical properties, only one being streptomycin (110):97." Antibiotics aside, the soil unquestionably has exerted a strong and semi-mystical attraction for the human imagination. Translated into political response, this popular concern for, and association with, the soil, nurtured by farm bloc legislators and administrators alike, has been a potent force in support of public programs and the allotment of public funds devoted to the protection, reclamation, and improvement of the soil resources of this country. "Grass roots" is not without significance.

Any consideration of this popular concern for the soil, and of the political response to it, are clearly beyond the scope of the present study. What is pertinent here is the legislative allocation of public funds, and specifically the demonstrated position of the United States Congress in the choice between support of the basic scientific programs of soil investigations (i.e. the Soil Survey), and support of more immediate and tangible action programs (i.e. the Soil Conservation Service). In a case study of the coordination of the National Soil Survey, Congressional actions regarding allocation of funds are, in many ways, more important than those noted in the preceding chapter, regarding authorizing legislation.

* * *

During the Coolidge and Hoover Administrations, appropriations for the federal contribution to the Soil Survey received modest increases which more than regained the budgetary cuts of 1920 and 1921. For fiscal year 1925, federal appropriation for the Soil Survey was $195,000. This was increased to $253,000 for fiscal 1929, and to $328,000 for fiscal 1932 (16), et seq. Total state contributions to the Soil Survey during the same period were about equal to, or slightly less than, the fiscal appropriations.

For the crisis years of 1933, '34, and '35, however, in the face of unprecedented demand for soil survey information, the mushrooming growth of new public agencies dealing with land-use planning, and the exponential increase in total government spending, federal funds for the Soil Survey received successive cuts (19), et seq. Not until the era of World War II did the appropriation again reach the level of 1932.

The federal Division of Soil Survey was not alone in this situation. Research programs throughout the Department of Agriculture were cut back, and total appropriations for agricultural research remained below the 1932 level until 1937 (108):669. In strictly political terms, the reasons for such curtailment, in the midst of the great expansion of total federal appropriations may be considered, first in relation to some short-run effects of the election campaign of 1932, and, secondly, in relation to the long-run legislative record regarding support of basic research.

In the bitter campaign of 1932, both major parties were committed in their platforms to the imposition of stringent economy measures in governmental operations, although it was recognized by both candidates that funds for large-scale emergency governmental programs were desperately needed to cope with the deepening depression (117). Thus pre-election promises of "...an immediate drastic reduction of governmental expenditures" came home to roost following the Roosevelt landslide in November. The same Congress which enacted the Administration-supported "Economy Act of 1933" in March, also rubber-stamped the "National Industrial Recovery Act of 1933" less than three months later (270). [38/] What resulted, briefly, was a sort of "double-entry bookkeeping" whereby the regular appropriations for existing federal agencies were sharply curtailed (and the campaign promises fulfilled), while simultaneously billions of dollars in emergency relief funds were appropriated and allocated to dozens of new agencies (and the depression crisis overcome).

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38. The present discussion deals primarily with Congressional responsibilities in allocation of funds for the Soil Survey. It should be noted, however, that administrative influence upon Congressional action, particularly during the early part of the first Roosevelt Administration, was at an all-time high (332), (140), (117). Bills sought by the Administration-or by certain administrators within it-were drafted in the Executive Branch in wholesale lots to be introduced on the floor by like-minded Congressmen. Congressional activity affecting the Soil Survey was thus strongly influenced by Administration policies through legislation including the Economy Act of 1933, and the National Recovery Act of 1933. More directly, the national Administration, through the Bureau of the Budget, specifically rejected some proposals for expansion of the Soil Survey through the use of emergency relief funds. (Archives).

This situation did not last long, but it lasted long enough to erase the possibility of carrying on a National Soil Survey of anything like the scope and extent required by the times. From September of 1933 to March of 1935, the federal Division of Soil Survey in Agriculture, and the Soil Erosion Service in Interior, were on opposite sides of the double-entry ledger.

The trimmed-down Division of Soil Survey was not completely cut off from use of the emergency funds. In a general way, the relief funds were available to almost every agency, old and new, which could come up with a program to “put men to work.” On October 7, 1933, Bureau Chief Knight was informed, as doubtless were the other bureau chiefs, by Secretary Wallace, that

> The President has asked that every effort be made to get men to work at the earliest possible moment under the emergency public funds allotted to this Department. (Archives).

In addition to this nudge from the Secretary, Knight was deluged by urgent requests (noted in chapter 4.3) from state College Deans and Experiment Station Directors individually and from the Land-Grant College Association collectively, for immediate expansion of the Soil Survey through the use of the emergency relief funds.

Accordingly, Acting Division Chief Kellogg developed a proposed Public Works Administration project which was to provide personnel and materials for cartographic and publication work, on a scale sufficient to eliminate within one year the entire backlog of unpublished soil survey reports, and to place the publication program on a current basis. This proposed project, together with an itemized plan for completion of the detailed soil survey of the agricultural area of the United States in ten years (also prepared by Kellogg), was forwarded by the Bureau Chief to the Information Director Eisenhower, and to the Office of the Secretary. Neither proposal ever saw the light of day. (Archives).

With the growing demand for soil surveys and the emergence of the various New Deal land-use agencies, Knight made a few other efforts to secure emergency funds for use in accelerating the work of the Soil Survey. In these, he had only indifferent support from budget officers in his own department and in the Bureau of the Budget, and no important help from Capitol Hill. In part, this lack of effective legislative support was an expression of the resentment and chagrin of some individual Congressmen who, having once actively fostered local soil surveys in their constituencies in good faith, were still waiting for the results years later because of the seemingly hopeless snafu in the publication program of the Bureau's Division of Soil Survey. In any case, most of Bureau Chief Knight's proposals were on a small scale, and, with a conservatism shared by many another administrator with an established program, he made clear his preference for obtaining additional funds through increases in the regular Bureau appropriations rather than by means of a special allotment of emergency relief funds (Archives). As it happened, he got neither.

In only one area of operations was the Soil Survey supplied with funds to effect an expansion commensurate with the demands upon it. This was in the Tennessee Valley. In a memorandum of Understanding of November 20, 1934, the Department of Agriculture, the Land-Grant Colleges in the seven Valley states, and the newly-formed Tennessee Valley Authority agreed to cooperative program of research, demonstration, and land-use planning. Within this general agreement, a cooperative soil survey program was begun in the middle ‘thirties, whereby the Authority contributed about $50,000 annually to the Division of Soil Survey and to the several Colleges, for accelerating soil surveys in the Valley (48). At the time, the total federal appropriations for soil surveys on regular funds were averaging less than $300,000 (27), et seq.

* * *

Across the Mall, and on the other side of the ledger, things were different in the Soil Erosion Service of the Department of Interior. Under Section 202(b) of the National Industrial Recovery Act of 1933, which provided for unemployment relief through activities including the "...conservation and development of natural resources...[and] prevention of soil erosion...(270)" the Service was launched with an allotment of $5,000,000 through Emergency Public Works Administrator (and Secretary of the Interior) Harold Ickes. By the end of 1934, additional grants totaling $20,000,000 had been received from the same source (33):9. With the ready availability of funds, and with the prevailing buyer's market for personnel, Service Chief Bennett organized and carried out a vigorous and well-publicized program of soil erosion control on thirty-nine local projects, mostly small watersheds, throughout the country (105):2. In the field operations of the new program, the making of detailed physical land surveys was recognized as an essential phase. (See chapter 3.441.)

The work of the Soil Erosion Service, and the personality of its Chief, received wide attention. As legislative interest increased, the program of the Service became a pawn in maneuvers by Secretaries Ickes and Wallace, each of whom wanted to see the agency set up as a permanent unit in his respective Department. Each also apparently had legislative support, but Ickes lost out. In attempting to placate his stormy Secretary of Interior for having been overruled, President Roosevelt cited the buildup of Congressional pressure for transfer of the Service in Agriculture (140):343.

Ickes maintained that "The present Division of Erosion Control [sic] is a creature of P.W.A...." (140):325. This was not wholly the case since, as noted in the present study, the work had its origins in the Bureau of Chemistry and Soils, but it was Emergency Public Works money entirely which had built the Service to healthy size by the time it was returned to Agriculture and established as a permanent bureau there in the Spring of 1935.

During this period, the early years of the New Deal, the emerging "conservation movement" enjoyed immense national popularity. Public Law No. 46 of 1935, which established the Soil Conservation Service, passed both Houses of Congress without a dissenting vote. A year later the potent and proven appeal of conservation was brought to bear in passage of the Soil Conservation and Domestic Allotment Act of 1936, a successful Congressional coup designed to salvage the price, support and production, control phases of the unconstitutional Agricultural Adjustment Act of 1933 (29):351, (110):108.

The program of the Soil Conservation Service, of course, benefited from this widespread interest in conservation, for which, indeed, the Service itself was largely responsible. Moreover, through the vicissitudes of administrative strife, some of which are noted in the present study, the Service had continuity of leadership by a Chief with vastly more political acumen than his fellow bureaucrats (110):85. Bennett's rapport with Capitol Hill, to quote Hardin again,

> ...helps explain the long periods of near autonomy of S.C.S. in the USDA. That is, bureau autonomy is directly proportionate to the bureau's ability to maintain its appropriations independently from the budget-making process in the Department (110):89. [39]

With such popular interest, political support, and shrewd and vigorous leadership, the Service, unlike numberless other ephemeral New Deal agencies, was to achieve permanent recognized status as the federal government's prime agency in the field of soil conservation. In the emerging controversy over administration of the federal share of the National Cooperative Soil Survey, the very factors that fostered the growth, and the autonomy, of the Service tended to render it nearly immune to the repeated efforts by the Secretary to effect coordination of the Department's soil survey activities.

Under Bennett's leadership, the Service received annual appropriations on regular funds of about $20 to $25 million dollars before World War II, and about twice that amount thereafter. In addition, until shortly before the war, the Service continued to administer allotments of Emergency Relief funds, particularly for operations of the Civilian Conservation Corps (105).

In the total program of the Service, expenditures for soil conservation surveys accounted for perhaps ten percent of the annual budget. Thus funds devoted to the making of soil conservation surveys by the Service amounted to several times the appropriation available to the Bureau's Division of Soil Survey for cooperating in basic soil surveys and carrying on he concomitant basic research in soil morphology, genesis, and classification.

* * *

The record of Congress in passing over politically neutral program of basic research, surveys, and investigations in favor of the more immediate, tangible, and costly, actions programs has been a subject for critical comment not only by scientists, but by legislators,

39. Arthur Maass has succinctly demonstrated the same principle as it applied to the bureaucratic autonomy of the Army's Corps of Engineers (167).

administrators, and political scientists (288):3, (290):3, (276):83, (108). The same tendency (on the part of state legislatures), was made clear to investigators Hitchcock and Hilgard a century and more ago, as noted earlier. As it affected the latter-day soil survey controversy, the demonstrated attitude of Congress on this issue was one of the prime factors in the final decision to integrate the soil survey work of the Department (including the basic soil research projects transferred with the old Division of Soil Survey), within the Soil Conservation Service, an "action" agency, rather than within one of the bureaus of the Agricultural Research Administration.

The question of Congressional support of fundamental scientific research is, of course, far more general than its implication to the Soil Survey noted. Moreover, the Congressional position on the question is not likely to reverse itself overnight. That position constitutes a majority determination of representative government by a Congress which is politically responsive, and politically responsible; the electorate of the United States is no more composed solely of scientists than was Plato's Athens, much less the Empire of Marcus Aurelius, populated exclusively by philosophers.

The federal government, nonetheless, is committed to the support of basic research and apparently will be asked to increase that support. Members of Congress are asked to appropriate public funds, and to justify such appropriations to their constituents, for scientific investigations the immediate practical value of which neither they, nor their constituents, nor the scientists themselves can fully foresee. This is, and will remain, a difficult problem for the Congress (Constitutionally enjoined to "...promote the general welfare,..."), for science administrators and for scientists.

One aspect of the problem was illustrated in testimony of J. Robert Oppenheimer (Director of the laboratory at Los Alamos, New Mexico, where development and testing of the first atomic bomb was completed), before a Congressional Appropriations Committee.

On behalf of the Atomic Energy Commission, Oppenheimer was defending postwar requests of appropriations for basic nuclear research. He was pointedly reminded by a member of the Committee that such research work had already absorbed billions of dollars in the course of developing the atomic bomb. Oppenheimer, who had administered the expenditure of some of those billions, replied that the major part of the crash program of the atomic bomb involved not basic research, but technological innovation and production engineering based upon application of the known results of prior basic research. Nourished by the work of Einstein, Meitner, Fermi, Bohr, and others, the fruits of basic nuclear research and theory had been gradually ripening. To build the atomic bomb, said Oppenheimer, we just shook the tree.

4.3 Soil Survey Coordination and the Land Grant Colleges

The state Land-Grant Colleges, individually and collectively, were deeply involved in the prolonged problem of coordinating the national Soil Survey. Before considering the position of the Colleges in that coordination, the background of College participation in the Soil Survey is reviewed briefly below.

It was largely upon the recommendation of the Association of American Agricultural Colleges and Experiment Stations in 1891 that the Division of Soils, antecedent of the federal Division of Soil Survey, was established in the Department of Agriculture. Many of the personnel of the federal Division, including Soil Survey Chiefs Whitney, Marbut and Kellogg, held prior positions with state agencies. From the first year of field operations, soil surveys, with minor exceptions, were carried out cooperatively under various memoranda of understanding. [40] Even early opponents California (in 1913), and Illinois (in 1942) entered into the cooperative program. Much of the basic research in soil genesis, morphology and classification, and most of the field experimental work relating soil management and crop production to specific soil types were carried on at state Experiment Stations. Contributions to technical and scientific standards of the national Soil Survey were made by state representatives through participation in the American Soil Survey Association and, later, in National Cooperative Soil Survey Technical Work Planning Conferences. In financial support of the program, state contributions accounted for a large proportion of the total cost and at times, such as the early ‘twenties and early ‘thirties, when the federal appropriations were cut, the total of state contributions surpassed that of the federal agency. Except for the Bureau of Soils’ “Soil Erosion Investigations” early in the century, the Experiment Stations had conducted the only research on soil erosion control prior to Bennett’s work in the Department starting in 1928.

* * *

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40. It has been pointed out that the various cooperative agreements covering soil survey work provided for “Inter-areal, inter-functional, and inter-level cooperation...” (100), (84):120. Three examples of these memoranda of understanding are reproduced in the Appendix. The examples from North Carolina (1913), and from Oklahoma (about 1930) provide for two-way cooperation by the federal Bureau and the state Agricultural Experiment Station. The more recent memorandum from Iowa (1943) is a three-way agreement among the Bureau, the Service, and the Iowa Station.

To return to consideration of the part played by the Colleges in coordination of the Soil Survey, a number of individual Experiment Station Directors and Deans, in 1933, '34, and '35 urged the Secretary of Agriculture to expand the program of the Soil Survey, either with the emergency funds then available, or through increases in funds from regular appropriations. When no such expansion was forthcoming and, instead, federal funds for the Soil Survey were actually cut, the Colleges took action collectively through their Association of Land-Grant Colleges and Universities (207):310. On May 11, 1936, following a meeting of the Association's influential Committee on Experiment Station Organization and Policy, the Association went on record with a letter to Secretary Wallace. In the name of the Association, the Committee Chairman wrote that

> A knowledge of our national soil resources, which only a carefully executed soil survey can provide is of such vital importance to the development of effective measures of soil conservation and land utilization that we deem it our duty to use every proper means to encourage the early completion of the soil survey which the Bureau of Chemistry and Soils has had under way for many years. To this end the Committee...instructed me to inform you of our deep concern in this matter and to express the hope that you may find it practicable...to advise us of your estimate of the funds that will be required to enable the Bureau, in cooperation with the Experiment Stations, to complete this program in the shortest practicable time.
>
> ...It was the considered judgment of the group, representing all told twenty-two state Agricultural Experiment Stations, that our own work, as well as the progress of the national program of soil conservation, is being severely handicapped by the failure of our respective institutions and the Department of Agriculture to accelerate the advancement of the detailed soil survey of the agricultural areas of the nation. (Archives) (207):310.

In order to promote its interests in the Soil Survey and to keep informed on progress, the Association then established a "Committee on National Soil Survey" under the sponsorship of its Committee on Experiment Station Organization and Policy (207):311. Later in the year, the Association further went on record with the recommendation that

> Cooperation should be established with all agencies interested in serial mapping, so as to make rapidly available serial maps for all agricultural counties where satisfactory

> topographic maps have not been prepared. The use of aerial maps will greatly reduce the time necessary for the completion of the Soil Survey and it will reduce the actual field cost about one-half (207):310.

Meanwhile, under the direction of Division of Soil Survey Chief Kellogg, the time and cost estimates for completion of the Soil Survey, requested by the Association, were prepared. The proposed program of accelerated soil survey work envisioned completion of field mapping for agricultural areas over a ten- or twelve-year period with a multimillion dollar budget providing also for publication of reports of the expanded Soil Survey and for a large increase in supporting chemical and physical soil investigations within the Bureau (Archives).

Kellogg's estimates were forwarded to the Association. On November 16, 1936, the Chairman of the Association's Executive Committee sent the following telegram to President Roosevelt:

> Land-grant college executive committee and experiment station directors regard completion of soil surveys throughout nation in approximately next ten years as of great importance to entire land-use and soil conservation programs. May we respectively urge necessary increase in appropriation to the Bureau of Chemistry and Soils in the Department of Agriculture for this purpose. It is fundamental to sound procedure in existing programs...(Archives).

The only tangible result of this recommendation was a politely noncommittal response in the name of the President. There was no increase in federal appropriations to the Bureau's Division of Soil Survey for the following fiscal year. (See chapter 4.2.)

The continued failure of the Congress and the Department to provide the means for accelerating federal activities in the National Cooperative Soil Survey resulted in strained relations between the federal Soil Survey Division and the various state agencies. In a number of states, not a single full-time federal Soil Survey man was assigned, and in others, state contributions of funds, personnel, and equipment for soil survey work exceeded those of the federal agency. While very real, however, such antagonism resulting from the paucity of federal Soil Survey funds was largely sublimated in relations with the emerging program of the Soil Conservation Service. This new development tended to draw together the Bureau and the states in mutual opposition to the soil and land mapping activities of the Service.

Thus the soil conservation mapping program of the Service, particularly in its early years, did not have the support of most of the state Land-Grant Colleges. In accounting for this opposition on the part of the states, however, a clear distinction should be made between the purely technical and scientific differences of opinion regarding the mapping program on the one hand, and the less well-defined differences arising indirectly from the broader contest between the states and the federal government over control of public aid to agriculture. The nature of this latter, and essentially political, conflict of interest has been dealt with extensively (110), (29), (103), (39). It is of pertinence to the present study only to the extent of its influence upon actions and attitudes of the Colleges and of the federal agencies in the otherwise technical and scientific problems of soil survey work.

As stated bluntly by Charles Hardin,

> Administrators of colleges of agriculture scrutinize federal farm programs for effects upon their own interests. They work unceasingly to extend and consolidate their own operations and to counter the threat of competing agencies. In their stand against federal 'encroachment' the colleges are sustained by their own strength as established institutions, by their collective power in their Association, by political alliances (especially with the Farm Bureau), and by popular attitudes which hold that educational institutions should be free of national political control (110):20.

With the growth of large-scale federal action programs in agriculture, the Colleges, collectively, though not in all cases individually, strongly supported legislative and administrative efforts aimed at decentralization of such programs through transfer of their functions from federal to state control and the establishment of "Grants-in-aid" procedures. In the case of the Soil Conservation Service, the states made strong bids to gain control in 1938, 1948, and 1953 (110):25, (285). In 1949, the Hoover Commission's Task Force on Agriculture, with its members drawn predominantly from the Colleges, recommended changes in the administration of the national soil and water conservation program which were essentially in accord with the views of the Association (135).

One of the most articulate advocates of the College position was Milton Eisenhower, who, after a distinguished career in the Department of Agriculture, became President of Kansas State College, and later, of Pennsylvania State University. After unsuccessful organized efforts by the Colleges to gain control of the Service, Eisenhower, in 1951, candidly took the position of "If-we-can't-lick-'em-let's-temporarily-join-'em":

> While the two agencies will not be consolidated in the near future, this should be a specific goal. To that end, the colleges should cooperate wholeheartedly with S.C.S. and at the same time should inform Congressmen, farm organization leaders, and others of the reasons why consolidation is desirable (212):157.

In the net, this general atmosphere of rivalry tended to intensify the existing technical points at issue between the states and the Service, and to inhibit cooperation in soil survey work even after many of the technical differences had been resolved.

The above position of the states vis-à-vis the Service and other federal action programs was in marked contrast to the status of cooperative relations with such federal research agencies as the Bureau's Division of Soil Survey. There were several reasons for this. The Division of Soil Survey was an "old" agency, with a long tradition of successful cooperative work with the states; the states, through their Deans, Directors and soil survey leaders, had a strong voice in the administration of the Soil Survey within their borders and, to a lesser extent, nationally; the Division was a "small" agency and, even with the expansion urgently recommended by the Association, was considered much less apt to overwhelm the state programs than were the large action agencies such as the Service; as part of a research agency, traditionally apolitical and decentralized, the Division of Soil Survey had demonstrated none of the potential for generating the strong (and federally-oriented) political support engendered by the "Washington-to-farmer" programs of the action agencies.

Throughout the nearly twenty years of the soil survey controversy, the Land-Grant College Association was rarely able to exert decisive influence upon the Secretary of Agriculture regarding coordination of the Department's soil survey work. In this respect, the counter-influence of the Soil Conservation Service was more telling. The relative weight of College opinion was increased, however, in 1942, through the establishment of the "Joint Committee on the National Soil Survey." The Joint Committee was made up of three federal officials (Chiefs of Bureau of Plant Industry, Soil Conservation Service, and Extension Service), and three state representatives selected by the Land-Grant College Association (211):195. (Since the Joint Committee on the National Soil Survey functioned as an advisory body to the Secretary of Agriculture, its recommendations regarding soil survey coordination were acted upon only when issued as Departmental directives; such recommendations are discussed in the following chapter.)

At the close of the controversy, the Association gave only cautious approval to Secretary Brannan's final decision of 1952, whereby the mapping program of the Division of Soil Survey was integrated with that of the Service. The Departmental reorganization of the following year, however, of which the provisions affecting the Soil Survey constituted a very minor part, was strongly supported by the Association and was generally recognized as a victory for the college viewpoint. The abolishment of the Service's regional offices, a long-sought goal of the state colleges by Secretary Benson's reorganization of November 2, 1953, was one reflection of the relatively stronger college influence in the policies of the new Republican Administration (39):66, (280). As will be noted, an incidental result of Benson's reorganization, but highly significant in the administration of the Soil Survey, was the clear recognition of the technical responsibility and authority of the field soil correlation staff in the organizational structure of the reconstituted Soil Survey.

* * *

So much for the political and administrative bases for the colleges' alignment in support of the survey program of the Division of Soil Survey and in opposition to that of the Soil Conservation Service. At the technological and scientific level, the Land Grant College Association similarly favored cooperation with the Soil Survey Division, but at this level there was less unanimity among the states. In generalizing upon the position of the colleges, therefore, the comments quoted are drawn only from statements endorsed by the entire Association by one of its standing committees, or by a large group of states within the Association.

The states were critical of the quality of mapping produced by the Service in the early years of its growth:

> The funds available for this work have been more abundant than the supply of adequately trained personnel. As a result, men without the necessary technical training have been employed and an effort made to correct this deficiency in scientific background by a short period of intensive training in rudiments of soil surveying (189):282.
>
> ...it now seems certain that, in spite of any aid the states can offer, the immediate demand for such maps for use in farm planning may result in the preparation of many soil maps of poor quality. This matter is likely to become a very serious one in a number of states (189):2.

The large scale, expense, and complexity of the Service's early surveys also came under fire:

> ...it is probable that the average mapping cost per square mile to the states will at least be double that required for the basic soil survey alone. This increased cost will result from the greater time and detail required in mapping the features other than soil types, and from other conditions causing a general slowing down of the work (189):1.

Another bone of contention was what the colleges considered to be an overemphasis on erosion at the expense of basic soil characteristics and a lack of concern with production economics in the mapping of the Service. Thus, logically, the colleges initially opposed the Land-use Capability concept:

> In view of the shortcomings of the system of "land-use capability classification" the maps based on this classification should not be published in color or used in unpublished form without changing their name and character (210):286.

On the question of the research nature of the Soil Survey, the Colleges recommended that

> The basic soil survey should be recognized as a research function and the techniques of the survey should be determined by a research agency (209):325.

In the later years of the dispute, when the Service, in some of its administrative regions, had abandoned the Soil Survey's natural system of soil type classification in making soil conservation surveys, a committee of the Association reported that

> As all states, except one, want to use the natural system of soil classification as the theoretical framework, it would seem logical to conclude that the states would prefer to cooperate with federal agencies sympathetic to and actively using and developing this system. To a very large majority of the states, this agency would mean the Bureau of Plant Industry, Soils, and Agricultural Engineering (225):5.

As noted, these points of technical criticism, specific and essentially valid, were made in a general atmosphere of conflict between the Land-Grant College Association and the Department of Agriculture for administrative control of the national soil conservation program. An additional factor which affected the position of the Colleges on the points at issue was a certain lack of familiarity with, and understanding of, the real progress of the soil conservation surveys program in improving techniques of field mapping and in putting the maps to use. Preoccupied with the scientific shortcomings of the Service's mapping program, the College spokesmen frequently overlooked or underrated its technical developments. Answering College criticism of the larger mapping scale used in soil conservation surveys, a top Service official pointed out, in 1939:

> The conservation map is made on varying scales, depending on many factors. In agricultural sections, as a rule, it is made on a 4-inch-to-the-mile scale, which is large enough to show individual fields. The inch-to-the-mile map advocated by Dean Miller will not in agricultural sections enable the farmer to locate the fields on his farm and so cannot be relied on for anything but general information (208):138.

Later, when the quality of soil conservation surveys improved, and the quantity of basic soil surveys did not, a number of states cooperated more actively in making soil conservation surveys, and technical criticism of the surveys by the Colleges was somewhat diminished (256), (334).

As a final comment on the position of the Colleges in relation to the survey programs of the two federal agencies, it might be pointed out that in areas where state-Service relations were particularly strained (i.e. Missouri, the Tennessee Valley, etc.), state relations with the Bureau's Division of Soil Survey were particularly cordial.

4.4 Soil Survey Coordination and the Department of Agriculture

It has been shown that the Land-Grant Colleges and, to a much lesser extent, the Congress, were concerned with the long drawn-out soil survey controversy and with the resulting lack of a vigorous, coordinated national Soil Survey program. Much more directly concerned with the controversy, but not much more successful in settling it, were the top officers of the Department of Agriculture. The following discussion traces out the repeated attempts in the Office of the Secretary to effect coordination of the soil survey work of the Department. As a case study of uncoordinated and frankly antagonistic field operations within the Department, this discussion illustrates some of the limitations in the exercise of administrative authority by the Secretary over certain "subordinate" agencies of the Department.

* * *

Immediately following the transfer of the Soil Erosion Service to Agriculture in March of 1935, and its redesignation as the Soil Conservation Service, Secretary Henry Wallace set up a Departmental committee to study and to prepare recommendations on how

> ...all branches of the Department may contribute most effectively to the greatly enlarged program of soil conservation (294).

This committee, consisting of the Department's Director of Information, Milton Eisenhower and Chiefs of Bureau of Public Roads, Forest Service, and Bureau of Plant Industry, devoted six weeks to the assignment (Archives).

Meanwhile, Wallace received additional evidence of the need for coordination. Among these was a letter from Robert M. Salter, Head of the Agronomy Department at Ohio State College. Salter's letter, in retrospect, is of particular pertinence to the present study because of his subsequent career as Chief, first of the Bureau of Plant Industry, Soils, and Agricultural Engineering, and later, of the Soil Conservation Service. On May 16, 1935, Salter wrote,

> I am particularly hopeful that the survey work of the Division of Soil Survey and that of the new Bureau of Soil Conservation [sic] be closely coordinated. I feel that the wide

experience and scientific concepts of the Soil Survey organization are necessary to insure scientific accuracy and proper regional coordination in surveys dealing with soil features. To guarantee the needed coordination, some probably will urge that the Soil Survey be transferred to the new Bureau of Soil Conservation. I do not presume to advise you in this matter. However, I do feel that it would be a mistake to separate the Soil Survey from the Division of Soil Chemistry and Physics since upon the work of the latter division must depend much of the future advance in our scientific knowledge of field soils.

Notable progress has been made in recent years toward placing the field classification of soils upon a truly scientific basis. The superficial and arbitrary survey methods of 20 years ago are gradually being replaced by methods based upon sound scientific facts developed thru [sic] the excellent work of Dr. Marbut and his coworkers. The more recent work of Dr. Byers and his staff in the Division of Soil Chemistry and Physics has helped greatly toward a solution of many questions of soil genesis and morphology. Given the proper opportunity, the next few years should see still greater progress made toward a better scientific understanding of soil characteristics that can be used in soil classification and of their meaning in terms of soil utilization. I would urge that any reorganization of the soil survey work make provision for future advancement along these lines. (Archives)

On June 5th, the Secretary's Committee on Soil Conservation submitted its report. As they applied to soil survey work, the recommendations in the report specified

(6) that if, in rare instances, the Soil Conservation Service finds it necessary to undertake studies or surveys similar to, or paralleling those of another agency of the Department, the agencies involved coordinate their efforts and enter into a written agreement between themselves, and with the state Agricultural Experiment Stations, where state agencies are involved.

Specifically,

The Soil Survey of the Bureau of Chemistry and Soils has been carried forward over many years in cooperation with the state Agricultural Experiment Stations. This survey is basic to land-use in all its phases and is closely related to research in agronomy, irrigated agriculture, dry land agriculture, horticulture, farm finance, etc. At the same time, soil surveys are necessary in connection with soil erosion control activities. Coordinated

> effort of the Bureau of Chemistry and Soils, the state Agricultural Experiment Stations involved, and the Soil Conservation Service in a soil survey project should result in the acquisition of the basic data needed for all purposes without slowing down the work or unduly emphasizing only one phase of the soil survey objectives (294):12.

The report was approved by Wallace and sent to Bennett on June 6, 1935. Its recommendations were implemented by Secretary's Memorandum No. 675 of August 9th, which established procedure for inter-bureau review and cooperation in research projects affecting soil conservation. This coordinating function was assigned to a new ad hoc committee consisting of James T. Jardine, Chief of the Office of Experiment Stations, W. C. Lowdermilk, Associate Chief of the Soil Conservation Service, and Information Director Eisenhower. (In common with its various successors noted, this coordinating body had no real authority to effect the coordination sought.)

Reports of trouble continued. On October 22, 1935, Henry G. Knight, Chief of the Bureau of Chemistry and Soils, wrote the following to Eisenhower:

> I wish to call your attention to the fact that reports are coming to us from our soil survey men and inspectors in the field, with regard to which there can be no question, that the Soil Conservation Service men are going over the identical ground which we are covering in connection with our soil survey work, thus duplicating the expense and projects which we have underway. This has just been reported from Santa Cruz County, California, and certain sections of the Northwest, particularly in Washington and Oregon. As I understand it, this is in direct conflict with the recommendations of your Committee and with the orders of the Secretary. (Archives)

Such instances of "duplication," however, were secondary. The real point at issue was the rapid expansion of field operations of the Service and the inability of the Soil Survey, still on a budget well below that of 1932, to supply the survey needed by the new program. The Service, accordingly, proposed an expanded mapping program of its own to service its increasing activities of demonstration and technical assistance in soil conservation. When this proposed mapping project was submitted to the Bureau of Chemistry and Soils for review in accordance with Secretary's Memorandum No. 675, Bureau Chief Knight, on November 13, 1935, commented,

...It is our feeling that soil survey work, correlation of soil types, and the preparation of soil surveys for publication in the Department of Agriculture is a function of the Soil Survey Division of this Bureau. In the proposed project...attention is drawn to the fact that there are insufficient employees in this Bureau for doing the soil survey work needed by the Soil Conservation Service. Of course, to the extent that additional funds are available for such work in the Department, the Soil Survey Division of this Bureau would be able to increase their activities to the extent of available personnel in the United States for carrying on such investigations. That is to say, if competent personnel is available to the Soil Conservation Service, of course the same personnel could be available to this Bureau. (Archives).

The growing controversy was keenly felt by the membership of the American Soil Survey Association, drawn as it was, from both federal agencies involved, as well as from the Land-Grant Colleges. Meeting in December of 1935, a committee of the Association read a report based upon an informal study of the soil survey situation across the country. The report cited the increased use of air photo base maps resulting largely from the work of the Service, but noted widespread concern for

...more work in correlation of soils and concern about the seeming lack of specific provision for correlating the soil classification work of the Soil Conservation Service with that of the Soil Survey. While many men now in the Soil Conservation Service are old federal or state soil surveyors who are familiar with the established classifications, this work is dynamic and classifications naturally diverge unless special efforts are made to correlate the soils...

There are already cases of Soil Surveys which map accurately, and in detail the soil types, slopes, erosion, cover or use, quality of homesteads, etc., which show that a complete physical inventory can be accomplished by evolution of the Soil Survey without necessarily creating a 'new' survey under some different designation (53):180.

(It should be noted that this committee consisted of federal and state Soil Survey men, and did not include a representative of the Service.)

Repeated resolutions by the Association calling for immediate expansion of the Soil Survey were sent to the President, the Congress, federal department and bureau heads, state governors, etc. without noticeable effect (219), et seq. The continuing soil survey controversy was a contributing factor, among others, to the demise of the American Soil Survey Association which, in November of 1936 merged with the Soils Section of the American Society of Agronomy to form the new Soil Science Society of America.

As it became apparent that the Jardine-Lowdermilk-Eisenhower committee could exert little influence in effecting coordination of the Department's soil mapping activities, Secretary Wallace again stepped in. At his direction, a "Memorandum of Understanding...in regard to Soil and Erosion Surveys" was drawn up by the two bureaus. This agreement specified that

> It is recognized that detailed maps of the physical features of the land are basic to all phases of rural land-use planning and classification. In order to utilize the best technical skill in the Department to the fullest advantage, to avoid any possibility of duplication, and to effect the desired cooperation, the two organizations agree to cooperate around to the following principles:
>
> 1. It is recognized that the Bureau of Chemistry and Soils is the responsible federal agency for the identification, classification, correlation, nomenclature, and mapping of the soils of the United States. All detailed soil maps will be made and published by the Bureau of Chemistry and Soils. The Bureau of Chemistry and Soils will assist the Soil Conservation Service where necessary in correlating soil data with other data regarding land which makes up the complete erosion survey.
>
> 2. It is recognized that the Soil Conservation Service is the responsible agency in the Department of Agriculture for carrying on investigations and operations for the establishment of erosion control measures. In order to plan such measures, the Soil Conservation Service must make farm-by-farm surveys as work sheets for the development of farm management plans that will control erosion. <u>These maps will not include soil surveys as such.</u> The Soil Conservation Service will have the responsibility for erosion surveys as such where these do not involve soil surveys as such. Soils may be grouped according to erosion conditions by the Soil Conservation Service but where soil names are used, these will conform to the nomenclature established by the Bureau of Chemistry and Soils.
>
> 3. It is recognized that the Bureau of Chemistry and Soils is the responsible agency of the Department of Agriculture for cooperating with other federal and state agencies for

> making soil surveys, and the Soil Conservation Service is the responsible agency of the Department of Agriculture for cooperating with other federal and state agencies of erosion surveys and erosion control projects.
>
> 4. Where either organization publishes or releases for publication data obtained in whole or in part from the other, full credit will be given. (Archives) (underlining added).

This Memorandum of Understanding was signed by Bennett and Knight on January 7, 1936, and approved by Wallace the following day. Copies were immediately sent to all field personnel of both agencies under a cover memorandum signed by Bennett and Knight which stated, in part:

> It must be thoroughly understood by every one that there is no thought of nor necessity for combining any of the work of either organization with that of the other. The functions of both bureaus are clear and distinct. As with all bureaus of the Department, mutual problems will be attacked through cooperative effort. (Archives)

Under the terms of the Memorandum of Understanding, an “Inter-bureau Soil Correlation Committee,” with representatives from both the Bureau and the Service, was established. One function of the Inter-bureau Committee was to determine the needs for soil correlation in the various projects covered by soil conservation surveys (no longer called soil erosion surveys) and to recommend that such correlation be provided by soil correlators of the Bureau’s Division of Soil Survey, at the expense of the Service on a reimbursable basis.

In April of 1936, the Service issued a handbook, ”Procedures for Making Soil Conservation Surveys,” which specified that

> The system of classification of soil types and series as established by the Division of Soil Survey, Bureau of Chemistry and Soils, will be followed on all Conservation Surveys,...Final correlation of soil types will be made by the Inter-bureau Soil Correlation Committee,... (98):19.

Friction developed immediately over the latter point, since the Bureau maintained that responsibility for such final correlation, particularly as it involved the recognition, characterization, and naming of new soil series and types, rested solely with the correlation staff of its Soil Survey Division. Agreement on this issue was not reached, but during

1936 and 1937, the Service frequently requested and obtained the services of Bureau personnel for soil correlation on soil conservation surveys.

With the great differences in level of federal appropriations, and the growing disparity in the volume of survey work of the two agencies, it became increasingly difficult for the Bureau to meet its obligations both to the established cooperative soil surveys with the states and to the extensive new surveys of the Service. On the other side of the coin, the program of the Service was occasionally hampered locally by delays in inspection and correlation of its field mapping work. In an effort to increase the correlation service available for soil conservation surveys, the Bureau requested that the Service prepare an annual estimate of the soil correlation work needed on such projects, and then transfer the necessary funds to the credit of the Bureau. This suggestion (which, a few years later, became official policy at the direction of the Secretary) evoked little enthusiasm at the time from the Chief of the Soil Conservation Service. In response to the Bureau's request, Bennett, who had already demonstrated a brisk willingness to forego, when he could, any cooperative entanglements affecting the autonomy of the Service, notified Knight on October 24, 1936 that: (110):229.

> ...on many of the projects no field inspection by the Bureau of Chemistry and Soils is necessary due to the fact that such Soil Conservation Service surveys are located on areas where acceptable soil surveys have already been made and where the Inter-bureau Committee accepts the recommendations of the Inspectors of the Soil Conservation Service for correlation purposes. Therefore it is impossible to foretell what the recommendations of the Inter-bureau Soil Correlation Committee may be relative to field inspection during the current fiscal year. Therefore, it would be inadvisable for that reason, among others, to transfer a lump sum to the Bureau for soil inspection purposes. In addition, the Soil Conservation Service has encountered considerable difficulty when it has attempted to transfer funds to other Bureaus for services, even when the requirements for such services could be evaluated more definitely than in the present case (Archives).

In view of the personalities involved, it seems likely that there would have been administrative difficulties in coordinating the surveys even had there been no technical differences in viewpoint. It should be noted, however, that in the mid ‘thirties there were important technical differences, such as that between the overly-generalized mapping of the Soil Survey and the overly-detailed and erosion-oriented mapping of the Service, underlying the administrative conflict. Commenting on a technical point at issue early in 1937, Knight wrote to Eisenhower that

> While this may seem to be a small matter it is just such small matters which may in the end produce yawning gaps. I should dislike much to see a controversy start such as split soil science wide open because of differences between Dr. C. G. Hopkins of Illinois and Dr. Milton Whitney of the Bureau of Soils, many years ago of which we are still feeling the effects even today. (Archives)

By mid-1937 the New Deal land-use programs were in full swing on a dozen fronts. Most of the federal agencies involved were in the Department of Agriculture and their varied and far-flung activities presented to Secretary Wallace a coordination problem which dwarfed the relatively minor soil survey disputes discussed here. To achieve a more unified Departmental program, the Secretary (actually Acting Secretary M. L. Wilson) on July 12, 1937, established the Office of Land-use Planning and named Milton Eisenhower as its chief with the title of Coordinator (295). The new Office, set up in the Office of the Secretary, was to function through the Coordinator and a small staff together with a group of “Liaison Representatives” from the several agencies involved. [41/] These included Agricultural Adjustment Administration, Bureau of Agricultural Economics, Bureau of Biological Survey, Bureau of Chemistry and Soils, Extension Service, Forest Service, Bureau of Public Roads, Resettlement Administration, and Soil Conservation Service. Liaison Representative for the Soil Conservation Service was Dillon S. Meyer, and for the Bureau of Chemistry and Soils, it was Charles E. Kellogg.

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41. In large measure, the establishment of the Office was an outgrowth of recommendations of an ad hoc committee set up by Under Secretary Wilson a few months earlier. Together with Wilson, and special consultant John D. Black of Harvard University, this committee had representation from Agricultural Adjustment Administration, Forest Service, Soil Conservation Service, Resettlement Administration, and-informally-Extension Service, Bureau of Public Roads, Civilian Conservation Corps, Division of Soil Survey, etc. (39):11.

Among a number of other functions, the Office of the Coordinator was directed to

(4) Review and coordinate all survey work, and whenever necessary, initiate:

Aerial photography

Soil surveys

Erosion surveys

Flood control surveys

Land-use surveys

Forest surveys

Establish uniform standards for the above.

Establish a system of advance clearance on all survey projects so as to eliminate duplication and have the surveys meet the needs of all agencies especially the action agencies.

(5) Strive to coordinate survey and land-use planning work of the Department with that of state agencies (295):2.

Eisenhower and his staff began immediately and vigorously efforts to carry out the Secretary's directive. One of the first coordination problems considered was that involving the Department's soil mapping activities. Within a few weeks a policy statement on "Establishment of Joint Committee on Soil and Erosion Surveys and Outline of Procedure for Making Surveys" was prepared through the Coordinator's Office and signed by Knight, Bennett, and Eisenhower. On September 25, 1937, Wallace approved the agreement with the comment that:

If unnecessary duplication of work is to be avoided and if reliable information necessary to the work of many bureaus of the Department is to be promptly and efficiently obtained, it is essential that we coordinate and integrate the surveys carried out by the Bureau of Chemistry and Soils and the Soil Conservation Service. This is an essential first step in coordinating all survey activities of the Department. (Archives)

Wallace's apparent optimism was perhaps an expression of his confidence in the ability of his Land-use Coordinator to whom, for the remainder of his tenure as Secretary, he delegated major authority for soil survey coordination (296), (27):19. In any case, the Secretary's optimism was a bit premature.

Under the terms of the policy statement of September, 1937

> The Bureau of Chemistry and Soils, responsible for the classification and nomenclature of soil types, series and phases, and the Soil Conservation Service, responsible for the standards for the determination and delineation of kinds and degrees of soil erosion, shall each designate one member of the Joint Committee. The Office of Land-use Coordination shall designate one of its staff as a third member. Full membership of the Committee should have the approval of the Chief of each organization signatory to the agreement (Archives).

Accordingly, the Joint Committee on Soil Erosion Surveys was set up, with Kellogg representing the Bureau, E. A. Norton (Chief of the Physical Surveys Division) for the Service, and Carleton P. Barnes (formerly of the Bureau's Division of Soil Survey) for the Office of Land-use Coordination. The Joint Committee was authorized to review for approval work plans, initial and final inspection reports, and memoranda of understanding for all soil surveys and soil conservation surveys. An additional change, perhaps more significant in terms of technical as well as administrative control, was the establishment of new procedures for field inspection of the survey work of both agencies. Previously, the Bureau's Division of Soil Survey had maintained a staff of five regional inspectors with correlation and inspection responsibility for the standard cooperative soil surveys (As noted, these men also carried responsibility, more or less recognized, for correlation of soil type mapping by the Service's soil conservation surveys.). The Service, meanwhile, had also assembled a field staff of five inspectors of its own. Under the new procedures, inspection areas were reapportioned among all ten inspectors, with various parts of the country assigned to the five Bureau inspectors and the remainder to the five Service inspectors. With this arrangement, a single survey inspector, regardless of whether he was a Bureau or a Service employee, assumed field correlation and inspection responsibility, subject to review by the Joint Committee, both for soil survey and for soil conservation surveys in his assigned territory. In states which maintained an active interest in the work, and this included most states, three-way memoranda of understanding were signed by representatives of the Service, the Bureau, and the state.

In spite of Henry Wallace's optimism and the good will and hard work of the Office of Land-use Coordination, the procedures promulgated by the Secretary's memorandum of September 25th provided coordination in name only. A basic policy question remained unanswered. To meet the widely acknowledged need for extensive, detailed soil surveys required for many purposes, should individual action agencies (i.e., the Service) be authorized to organize staffs to make their own surveys for their own purposes with funds allocated to their programs, or should the necessary funds be provided to existing agencies (i.e., the Bureau) of which such survey work was already a primary authorized function? This question, in which, as noted in chapter 4.3, Land-Grant College interests strongly supported the latter alternative, remained unresolved in terms of formal Department policy. For all practical purposes, however, the issue was rendered almost academic by the Congress, which maintained and even increased the disparity in appropriations for the two agencies, in favor of the Service.

Quite aside from the inequality in federal funds, a fundamental difference in internal administrative structure between the two mapping agencies further hampered effective coordination. The cooperative program of the Soil Survey was coordinated with state agencies in all field work (and to a lesser extent in general planning of the program), but in establishing and maintaining national technical and scientific standards for soil correlation, publication, etc., the federal Division of Soil Survey could and did function in a straight-line organization. Absolute uniformity in the work of the Soil Survey was neither achieved nor sought; indeed, as noted earlier, individual differences of opinion in technical and scientific questions was characteristic. Since soil scientists in the federal division at all levels reported administratively to other soil scientists and on up to the Division Chief, however, broad policy decisions, scientific and technical standards, etc., once determined at the national level, were applied nationally (albeit thinly-spread).

In contrast, the survey work of the Service was organized as a staff or auxiliary function whereby soil scientists, as staff officers, reported administratively not to other soil scientists in the survey program, but to line officers (soil conservationists) at the national, regional, and, later, state and area levels. Thus, while technical standards were generally established and maintained for the surveys within the purview of a line officer at a particular level (such as at a regional office), such standards and the rigor of their maintenance varied widely between administrative regions. The difficulty of developing a coherent survey program under such a structure was apparent even in the days of the Soil Erosion Service, but uniformity of survey standards was not an important objective so long as the surveys were considered merely as working tools to be made and used locally, as the soil conservationists saw fit, for the sole purpose of facilitating the major Service program of planning and application of soil conservation measures (250). With the growth of the Service's soil mapping activities into a project of national scope, however, and the continuing attempts at coordination with the National Cooperative Soil Survey, the implications of the staff-and-line structure of the conservation surveys were more clearly seen. At the national level, the Chief of the Conservation Surveys Division, himself a staff officer to the Service Chief, could exercise his technical authority over the survey program only to the extent that he could successfully compete with regional line officers for support by Chief Bennett (234):306. Since the organizational structure which placed all line responsibility in the hands of soil conservationists was Bennett's own creation, the not surprising result was that the regional line officers were successful in preventing the exercise of strong technical control of the conservation surveys program by the Division Chief at the national level. (See chapter 3.441.)

Thus, in deliberations of the Joint Committee on Soil and Erosion Surveys, Kellogg could speak for the entire federal field force of the Soil Survey, but Norton had no such authority to speak for the much larger federal field force making soil conservation surveys (Neither, of course, could speak officially for the states.).

In the net, while the Joint Committee went through the motions of its assigned functions of review and approval of both soil surveys and soil conservation surveys, there was inadequate technical and administrative control through the "pooled" inspectors, for the maintenance of uniform standards nationwide. All of the soil surveys and most of the soil conservation surveys continued to use the soil series and soil type classification developed by the Soil Survey. In many areas, however, the classification lost much of its meaning because of inadequate correlation and insufficient field characterization and laboratory analysis needed for such correlation.

While little or no progress was made toward coordination nationally, a few scattered soil surveys were being made locally on a cooperative basis by personnel of the Bureau, the Service, and state agencies. These few surveys, (two in New York, three in Indiana, etc., by 1939), are highly significant to the present study in that they demonstrated, even before 1940, that the seemingly divergent objectives of the Service on the one hand and of the Bureau and the states on the other, could be served by a single cooperative soil survey (198), (53):180. As noted in earlier chapters on technical developments, the Service, by the late 'thirties, had abandoned many of the ultra-detailed mapping techniques of 1934; concurrently, the Soil Survey had increased the scale and detail of its mapping and its use of air photos. Thus the prototype of a mutually acceptable soil survey became a technical reality even when the possibility of its administrative existence seemed remote. Survey techniques of the Service and of the Soil Survey continued to diverge in some regions, but elsewhere, the number of cooperative surveys gradually increased. By the late nineteen-forties, fully cooperative Bureau-Service-State soil surveys were being made in about twelve to fifteen states.

In October of 1938, the Division of Soil Survey, with all funds and personnel, was transferred from the Bureau of Chemistry and Soils to the Bureau of Plant Industry. [42/] Beyond implicating another Bureau Chief, E.C. Auchter of Plant Industry, this change had little influence on the status of the Division of Soil Survey. At about the same time, and in rapid succession, the "Soil Conservation District Movement" gained headway; the multi-level land-use planning activities envisioned by the "Mount Weather Agreement" began; the Service was confronted with the emergence of a durable rival in its national program of soil conservation, the reconstitutionalized Agricultural Adjustment Administration; and meanwhile, like the siege of Troy, the Homeric contest between the States and the federal

42. Under provision of Secretary Memorandum No. 784 of October 6, 1938, effective October 16, 1938, and the Agriculture Appropriation Act for fiscal 1940 (53 Stat L. 939), basic soils research was consolidated in the Bureau of Plant Industry by transferring to it from the Bureau of Chemistry and Soils, the Division of Soil Chemistry and Physics, the Division of Soil Survey, and the unit conducting research relative to plant mineral constituents derived from soils.

government for control of public assistance to the nation's farmers ground on. Amidst all these indications of immediate or potential need for soil surveys, the breach in the supposedly coordinated national survey program of the Service, the Bureau, and the States was conspicuous by its presence.

Between the Bureau's Division of Soil Survey, and the Service's Division of Conservation Surveys, there was, of course, intramural criticism of each by the other aplenty. Mutual public criticism by the two agencies, however, was fairly restrained and, in any case, on the plane of bids for broad public understanding and support, the Soil Survey was hopelessly out-gunned. In another, and more oblique, type of competition for public recognition, both agencies played it to the hilt. This was the refined technique whereby one agency created the impression that the other simply did not exist, or at least was unimportant.

Service Chief Bennett was perhaps the most adept at this technique. Addressing a Congressional Committee in 1935, Bennett cited the Reconnaissance Soil Erosion Survey of the United States (which had been completed in two months of 1934 under his direction by a large field staff at the rate of about two days per county per man) and called it "...the most comprehensive chart ever made of land conditions in this country" (33). As noted earlier, Bennett's former chief, Curtis Marbut, between 1927 and 1931 completed a soil map of the United States which was published at a scale of 1:2,500,000 (175), (174). Marbut's map drew directly upon the work of the Soil Survey through the thirty years of its existence and upon his own extensive field studies; but as for any mention in Bennett's statement to Congress, Marbut might just as well have mapped one of the moons of Saturn.

In 1941, Division of Soil Survey Chief Kellogg, in a 370-page book "...about the soil and how people get on together," devoted all of one entire medium-sized sentence to the work of the Soil Conservation Service (150):286. Bennett did him one better, however, in 1947. Bennett's 407-page "Elements of Soil Conservation" included a list of "Other USDA. Agencies" in the conservation field, with no mention whatever of the Soil Survey (37):146.

In 1949, there appeared to be a standoff. For a United Nations Scientific Conference on the Conservation and Utilization of Resources, the two agencies produced a couple of papers as neatly self-canceling as a brace of paired votes in the U.S. Senate. In a paper on

“Soil Survey in relation to Soil Conservation,” the Chief of the Division of Soil Survey managed to avoid any and all mention of the Soil Conservation Service, even among the fifteen references cited (153). A rebuttal shortly appeared in a similar effort from the Chief of the Division of Conservation Surveys: “Land Inventory Basic to a Soil Conservation Program,” together with a bibliography of six citations, maintained a pristine innocence of any reference to the Soil Survey (132).

As noted in chapter 3.442, the Service, in 1939, adopted the device of the Land-use Capability Classification as a means of interpreting its soil conservation surveys for purposes of planning and applying soil and water conservation. There was nothing new about the capability concept (see chapter 3.131) but the system as initially applied in the Service program was oversimplified and logically inconsistent in the view of the Bureau’s Division of Soil Survey and of most of the Land-Grant Colleges. This joint opposition to the application of the initial capability system brought the Bureau and the states closer together while further alienating both from the leadership of the Service.

For fiscal year 1941, federal appropriations for the Bureau’s Division of Soil Survey (down $25,000.00 from the year before), amounted to $275,000.00. For the same year the Service appropriation was $21,090,750.00, of which perhaps 10%, or about $2,000,000.00 was available for conservation surveys (20). Under such circumstances, as the absorption of the personnel and functions of the Division of Soil Survey by the Soil Conservation Service became an increasingly real possibility, most of the states stood firm in defense of the smaller agency. Simultaneously, national spokesmen for the Land-Grant Colleges were urging absorption by the states of personnel, funds and functions of the Service.

Land-Grant College pressure, theretofore largely ineffectual in the soil survey controversy, directly influenced two developments in 1942. One was a directive issued by the Secretary of Agriculture which changed the existing survey inspection procedures; the other was the establishment of a “Joint Committee on the National Soil Survey” which provided for increased College participation in coordination of soil surveys nationally.

By Secretary’s Memorandum No. 1020, as amended, Agriculture Secretary Claude Wickard, on November 28, 1942, assigned responsibility for inspection and correlation of both soil surveys and soil conservation surveys to the Bureau's Division of Soil Survey. Since the added duties more than doubled the correlation and inspection work of the Bureau, provision was made for transfer of funds, on an annual basis, from the Service to the Bureau. Wickard's directive abolished the unwieldy joint inspection procedures in effect since 1937, but it retained a perennially troublesome administrative snag, the assignment of important technical responsibilities in the program of one agency (the Service) to personnel whose administrative responsibility was to a different, and hostile, agency, the Bureau.

The other important development in 1942 was the establishment of the "Joint Committee on the National Soil Survey" (211):195. Organized, "...to discuss and formulate policies having to do with soil survey activities by both Federal and State agencies" (217):1. The Joint Committee consisted of three federal representatives (Chiefs of Bureau of Plant Industry, Soil Conservation Service, and Extension Service) and three state representatives (generally Agronomy department heads from state colleges where interest in soil survey work was strong) selected by the Land Grant College Association. The Joint Committee dealt to some extent in technical matters, but it operated primarily at the policy level as an advisory body to the Secretary of Agriculture. One of the first acts of the Joint Committee was to approve the revised inspection and correlation procedures of Secretary's Memorandum No. 1020; another was approval of a three-way memorandum of understanding between the Bureau, the Service, and the states for cooperative work in surveys. [43/]

In common with some other efforts going on in the world in 1942, the provisions of Secretary's Memorandum No. 1020 seemed too little, too late. Even before the assignment of all inspection and correlation responsibility to the Bureau, the survey work of the Department and of the states had felt the impact of the wartime mobilization. Cartographic facilities and trained personnel were needed for military map-making; field survey parties

43. At the time the Joint Committee was formed, the Division of Soil Survey was a unit within the Bureau of Plan Industry. Following the establishment of the Agricultural Research Administration in 1942, there was a regrouping of the older research bureaus, and the Division of Soil Survey became part of the new Bureau of Plant Industry, Soils, and Agricultural Engineering. (Agricultural Research Administrator's Memorandum No. 5, of February 13, 1943).

melted as soil surveyors, like everybody else, found themselves in uniform; soil scientists together with geologists and others, developed and applied techniques of military interpretation of soil maps; special field parties were assigned to extensive soil surveys such as those for the planting of guayule by the Emergency Rubber Project; the Bureau's stock of unpublished soil survey reports, already in paralyzing backlog without a war, accumulated further, as the publication program was cut to less than half of capacity.

The dislocations in personnel and equipment, together with the all-out demands for wartime food production, required some changes and some "shortcuts" in the survey work of the Department and states. Accordingly, the Joint Committee on the National Soil Survey met in Washington in August of 1943. At that meeting, approval was given for the use of semi-detailed, or "utilitarian" surveys as an emergency measure provided that such surveys

> ...still maintain the standards of quality necessary to ensure that surveys will contribute to the permanent inventory of the nation's soil resources (217):1.

Very few changes were made in the legends and techniques of the standard soil surveys as a result of the Joint Committee's action. In the much more numerous and more extensive soil conservation surveys of the Service, however, the shift to the "utilitarian" type of survey was made widely. Surveys made with "utilitarian" legends could be made more quickly and with less competent personnel than previously, since many soil differences were simply ignored, and the mapping units drawn were often broad groupings of soil types which would have been separated in a detailed soil survey.

Through the war years, inspection by the Bureau, transfer of funds from the Service, and the three-way memoranda of understanding with the states remained in effect. The degree of technical and administrative agreement between the agencies involved varied greatly from state to state, but, on a nationwide basis, the attempt to coordinate soil surveys and soil conservation surveys on the basis of Secretary's Memorandum 1020 was unsuccessful. A major cause for this failure, of course, was the loss of trained personnel to the war effort. In addition, the appropriation for the Division of Soil Survey, even with the additional funds allotted from the Soil Conservation Service, was inadequate to provide the rigorous inspection and correlation, supporting laboratory work, and the continuing research in soil genesis and morphology needed to maintain adequate technical standards for both soil surveys and soil conservation surveys. Within the Service, the lack of trained personnel, coinciding with the rapid growth of soil conservation districts, left an increasing gap between the demand for soil conservation surveys and the means to supply them. As a result, in many districts, soil conservation surveys were made by farm planners and others without training in soil science. The "utilitarian" surveys, while they served to speed up the production of soil conservation survey maps at a critical time, were considered unsatisfactory by all concerned, and particularly by the states concerned. [44/]

Following three meetings in 1944, the Joint Committee on the National Soil Survey met in Washington in January of 1945 and took a long hard look at the situation described. In a report of January 15th, the Joint Committee listed the following conditions:

1. The survey load resulting from formation of more than 1100 Soil Conservation Districts has been greater than available personnel can handle by regular procedures.
2. Modified procedures based on mapping groups of soils or on mapping on a farm-to-farm basis have been inaugurated to meet this emergency, but have failed (a) to supply adequately the information needed for comprehensive farm planning and (b) to satisfy adequately the diverse needs of the three cooperating agencies, whose objectives differ.
3. Appropriations by the States have not permitted them to carry their full responsibility in the cooperative program.
4. Appropriations to the B.P.I.S. & A.E. have had to be supplemented by transfers of funds from S.C.S. for inspection and correlation, creating an unusual situation of uncertainty of future actions.
5. Mechanisms for inspection and correlation have broken down under conditions of heavy load dispersed over exceptionally large areas and of uncertain and limited funds (217).

The Joint Committee further acknowledged that a major source of difficulty in achieving a coordinated program lay in the fact that the Bureau, the Service, and the states

44. Other wartime casualties were Federal participation in land-use planning activities deriving from the Mount Weather Agreement (1942); National Resources Planning Board (1943); Agriculture's Office of Land-use Coordination (1944) (27):22, (191):150, (302):169.

had different objectives in soil survey work. These were

> a) The objective of the Bureau of Plant Industry, Soils and Agricultural Engineering is to study the more permanent and basic properties of soils in both field and laboratory to develop a system of classification, mapping, and interpretation of widest possible permanence and usefulness to all interested in any of the numerous uses, agricultural and otherwise, to which soils may be subjected.
>
> b) The objective of the Soil Conservation Service is, primarily, to provide soil maps and reports that will serve as a basis for planning on individual farms. The Soil Conservation Service is mainly interested in erosion control and water conservation.
>
> c) The objective of the states is to provide bases for the research and educational programs within the state, by means of soil classification and productivity studies, and by maps and reports of the soil resources. The states are interested in a wide variety of uses (217):3.

In conclusion, the Joint Committee agreed that

> A strong nationally coordinated Soil Survey program that will serve the previously mentioned objectives of all agencies is needed (217)L 5.

In the Committee's recommendations, however, there was little evidence of any such "...strong nationally coordinated...program...." Instead, the Committee recommended the recognition of two types of survey, which were to be technically related but administratively independent. These two types were designated as "basic soil surveys," (formerly, and subsequently, known as standard soil surveys) and "maps of individual farms," variously known as soil erosion surveys, erosion and cover surveys, physical land inventories, soil conservation surveys, land capability surveys, farm planning surveys, etc.

In the recommendations of the Joint Committee, "basic soil surveys" were to be the responsibility primarily of the states and the Bureau. Such surveys would be located initially in "...a representative county or counties with similar soils and types of farming...(217):8" and the data obtained thereby on soil classification and soil survey interpretation were to serve as benchmarks for guidance in the Service's "maps of individual farms" made in the surrounding area. As the initial "basic soil surveys" were completed, "...basic surveys will be made of the other counties of the area with the objective of completing the basic soil survey of the United States as rapidly as possible" (217):9. Administratively, "The respective states and the Bureau of Plant Industry, Soils, and Agricultural Engineering will have the primary responsibility for the inspection, correlation, and nomenclature of these basic surveys, with the Soil Conservation Service cooperating." (217):8.

For the conduct of the other type of surveys, the "maps of individual farms," in areas not yet covered by basic soil surveys, the Joint Committee recommended that:

> Maps of individual farms will be made by Soil Conservation Service technicians in cooperation with the State Agricultural Experiment Station, under general supervision of the Soil Scientist of the Soil Conservation Service assigned to the State, and without the regular procedure of inspection and correlation as defined for the basic surveys. These maps will not be considered a part of the basic soil survey of the United States (217):10. (Underlining added)

Thus, in effect, the Joint Committee's proposals would turn control of the soil conservation surveys back to the Service (with state cooperation) and control of the basic soil surveys back to the Bureau and the States (with Service cooperation). To a considerable extent, this would simply be an acknowledgment of what was the *de facto* status of attitudes and interests in the survey work. In spite of *de jure* responsibilities in the survey work of the Service, the Bureau had reserved its major interest, and concentrated its slim resources in the long-run program of basic, or standard, soil surveys. This attitude was shared by most of the states. Because of the limited extent of the basic surveys and the great demand for soil maps in the soil conservation districts, the Service was much more interested in its own program of soil conservation surveys. And production-minded line officers of the Service chafed under the requirement of Bureau inspection and correlation of these surveys. There was, therefore, considerable support from all factions for the Joint Committee's proposals of January 15, 1945.

The divisive aspects of the recommended survey program were considered to be temporary. The making of "individual farm maps" (i.e. soil conservation surveys) was to continue only until basic soil surveys should become available for all areas. Since a great increase in the production of basic soil surveys was thus indicated, the Joint Committee strongly recommended increases in direct appropriations for the Bureau's Division of Soil Survey and for the soil survey program of the cooperating states.

Two additional points in the report should be mentioned in connection with the present study. The first of these was that the Division of Soil Survey position was represented on the Joint Committee by Robert M. Salter, Chief of the Bureau of Plant Industry, Soils and Agricultural Engineering. [45] Salter, mentioned earlier in this chapter, was a much stronger supporter of the Soil Survey than the preceding chiefs of the preceding bureaus which had control of the Division of Soil Survey. The other point of interest was the committee's affirmation of the research nature of soil survey work. The report recommended that

> Since the development of soil classification and its interpretation is based upon the results of research, the full authority for the direction of the technical features of the soil survey program as well as complete administrative authority over the technical personnel should be given to the research administrators in the various groups (217):12.

After a delay of several months, most, but not all, of the recommendations of the Joint Committee were put into effect through an "Amendment to Procedure for Soil Inspection and Correlation" signed by Salter and M. L. Nichols (for Bennett) on September 4, 1945. This directive clarified the distinction between "basic soil surveys...in which progressive and contiguous mapping of soils according to the standard nationwide soil nomenclature within a whole county or other comparable area is undertaken," and "farm planning surveys...made for the primary purpose of obtaining information needed in planning soil and water conservation measures on farms." The assignment of major responsibilities for making the two types of surveys was in accord with the recommendations of the Joint Committee (Archives).

In two highly important respects, however, recommendations of the Joint Committee were not acted upon. The recommended increases in direct appropriations to the Bureau

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45. The other two federal members of the Joint Committee were J.L. Boatman of the Extension Service and M.L. Nichols (acting for Bennett) of the Service. The three representatives of the Land-Grant College Association were Richard Bradfield of Cornell University, Chairman, W.H. Pierre of Iowa State College, and L.D. Baver of North Carolina Agricultural Experiment Station (217):2.

and the states for soil survey work were not forthcoming; as a result, the orderly replacement of individual farm planning surveys by the expansion of basic soil survey coverage did not materialize. Secondly, the placement of the survey programs under research administrators, already in effect in the Bureau and in the states, did not occur in the Service; its Division of Soil Conservation Surveys remained under the Chief of Operations rather than the Chief of Research, and technical personnel of the soils conservation survey staff reported to regular line officers (soil conservationists) in the operations program of the Service (105):15.

The *entente* of September 4, 1945, marked the beginning of a period of semi-independent and regionally divergent relations between the programs of basic soil surveys and of soil conservation surveys. In administrative regions of the Service where some degree of coordination had been achieved previously, most soil conservation surveys continued to apply soil series and soil type classifications in field mapping and, as noted, Service personnel participated in a number of basic soil surveys which were fully acceptable to all concerned. In other regions, however, coordination deteriorated. Field personnel making soil conservation surveys lost contact with the personnel and with the basic research of the Soil Survey; the use of soil series and soil type classifications was abandoned; and some soil conservation survey maps and legends, most of which were locally considered fully adequate for the immediate, but limited, needs and objectives of local Service operations, were developed in accord neither with the correlation standards of the Soil Survey nor with efforts by the Chief of the Conservation Surveys Division to maintain uniform national standards in the survey work of the Service. Throughout the country, “State Soil Scientist” positions were established by the Service (as noted in chapter 3.441), and, in States where the Bureau had no facilities, most soil conservation surveys were carried on under two-way memoranda of understanding with the state agencies.

Meanwhile, in the postwar years, there were renewed efforts to reorganize the activities of the Department of Agriculture, particularly as they involved the relations between the major action agencies and the Extension Service. Among the first of these efforts was that undertaken by a series of committees within the Department itself under the leadership of Assistant Secretary Charles F. Brannan in 1947 (110):169. Most of Brannan's committees dealt with problems far more important than that of the soil survey controversy, but the Soil Survey figured in specific recommendations of the subcommittee on "Conservation Policy." This subcommittee, chaired by Oris V. Wells, Chief of the Bureau of Agricultural Economics, and including officials of the Soil Conservation Service, dealt with the technical aspects of the various means for improving technical assistance in soil conservation and land-use planning at the farm level. The subcommittee proposed and defined the development, at the farm level, of a "basic appraisal" upon which to base farm planning. The "basic appraisal" concept included many elements of existing inventory procedures for farm planning purposes, particularly those in use by the Service, but the subcommittee recommended that

> The physical appraisal and development of conservation recommendations should be carried forward by technicians or adequately trained persons who have proved themselves competent. And recommendations relating to land-use and soil practices should be based upon information supplied by the National Cooperative Soil Survey and other research materials relating specifically to the land type or specific area concerned, wherever such information is available (39):23.

The proposals of Brannan's various subcommittees were presented to Congress in October of 1947, but were not acted upon. The recommendation by economist Wells' group is noted here, however, since it was representative of most professional economic opinion at the time, regarding soil survey interpretation. In the economic analysis of land-use alternatives, an essential step in any approach to complete farm planning or budgeting, agricultural economists were able to make much more use of soil survey interpretations expressed in the input-output terms of yield estimates and production functions than of interpretations showing "Land-Use Capability," in which productivity was a secondary criterion (110):61, (292):49, (213):131, (301), (327).

Nonetheless, Wells' specification of the use of data from the National Cooperative Soil Survey was qualified by the clause "...wherever such information is available." At the time it was not available for very much of the United States.

Despite the continuing administrative schism between the mapping program of the Service and that of the Soil Survey, both survey agencies began to receive increased support in the late forties and early fifties. Federal appropriations and, to a lesser extent, state soil survey funds were increased; ever wider use was made of soil survey results; and Congressional interest picked up. On the latter point, legislative proposals such as the Hope Bill of 1948 (favorable to the Service) and the Peterson Bill of 1950 (favorable to the Soil Survey), are noted in chapter 4.1. Expanded cartographic facilities of the Division of Soil Survey, shortly to be canceled out by the military map-making demands of the Korean War, began to reduce the backlog of unpublished soil survey reports. In 1950, funds appropriated for the Soil Survey amounted to about a million dollars for the federal division with an additional estimated $750,000 contributed by the cooperating states. At the same time, federal funds devoted to the soil conservation survey work of the Service totaled between four and five million dollars.

The ratio of financial resources of the two survey programs was thus narrowed to two or three to one. The ratio of actual mapping coverage per year, however, was very much higher in favor of the soil conservation surveys because of fundamental differences between the two programs. In the mapping work of the Service, conservation surveyors were constantly under pressure from farm planning technicians for mapping and more mapping; the surveys were limited essentially to an inventory of the specific soil and land features considered to be significant in conservation farm planning operations. In the program of the Soil Survey, there was less urgent pressure for mapping coverage and more emphasis upon the associated research; basic soil surveys were supported by, and were an integral part of, the total research program of the Soil Survey which included the scientific investigations essential for soil characterization, classification, correlation, and interpretation, and publication of the completed surveys.

Shortly before 1950, the Service presented a most serious challenge to the Soil Survey in the proposal of a "National Land-Capability Inventory," to be based upon soil conservation surveys (see chapter 3.441). In 1951, Bennett wrote,

> We are confronted with a grave national emergency. It may last many years. If our land is

> called on for all-out production of food, feed, fiber, it will surely suffer from overcropping and resultant erosion, unless necessary protection is provided. We need to examine the situation, take a careful, searching look at the land all over the country in order to arm ourselves with precise knowledge about the condition of the land and what we must do to keep it productive.
>
> To do this we must, as speedily as possible, complete the land-capability inventory now underway. We must have the land facts this inventory will reveal, for purposes of blueprinting our farms and ranches for soil and water conservation accurately, and on a well-balanced basis (259).

Support for the "Inventory" from beyond the ranks of the Soil Conservation Service was a reflection both of the wide coverage and proven value of soil conservation surveys and land-capability maps as applied in field operations of the Service and of the solid success and popularity achieved by the total Service program. Further, though indirect, support for the Service proposal was supplied by Secretary's Memorandum No. 1278, of February 16, 1951. Memorandum 1278, although it dealt with issues far afield from the soil survey controversy, provided added impetus to the "National Land-Capability Inventory" in that it defined, as the

> ..basic physical objective of soil conservation activities by Department agencies..the..use of each acre of agricultural land within its capabilities and the treatment of each acre of agricultural land in accordance with its needs for protection and improvement.

In advocating recognition of the Inventory, Service spokesmen cited the many broad uses to which land-capability maps might be put; use of the terms "soil survey" and "soil surveyor" were discouraged in the mapping program of the Service, and distinctions between that program and the other, the National Cooperative Soil Survey, were accentuated (130), (283), (132).

To deal with the growing competition between the two survey programs, Departmental efforts to effect better coordination, after a lapse of several years, were renewed in 1950 and 1951 by Secretary Brannan. These efforts, initially conducted through Research Coordinator C. P. Barnes of the Office of the Agricultural Research Administrator, provided a means for mutual review of the differences, and of the similarities, between the two programs. By 1951, however, the political and administrative heaving and pulling had tended to place the soil survey controversy on an “either/or” basis, and the attempts at coordination were largely forestalled as the three proponents, the Service, the Bureau, and the Land-Grant College Association, reaffirmed even more strongly their earlier positions on the issue (225).

The impasse continued through 1951, but the entire situation was altered by a sudden event late in the year. By Secretary’s Memorandum No. 1301 of November 5, 1951, Brannan appointed Bennett to a position of Special Assistant to the Secretary. To Bennett’s former position as Chief of the Soil Conservation Service, Brannan appointed Robert M. Salter, theretofore Chief of the Bureau of Plant Industry, Soils, and Agricultural Engineering (105):16. Salter was directed by Brannan to settle the soil survey controversy.

Salter’s established association with both state and Bureau participants in the National Cooperative Soil Survey, when carried over into his new position as Chief of the Service, produced an environment within which traditional interagency rivalry could be minimized, while the technical and scientific phases of the controversy were reviewed with more objectivity than was previously possible. During 1952, with the cooperation of Byron T. Shaw, Agricultural Research Administrator, Salter and Kellogg carried out a field study of soil mapping and the use of soil maps in order to define the area of technical agreement. The results of this study served to verify what already had been demonstrated in the scattered Service-Bureau-State joint soil surveys dating from the late ‘thirties. In terms of technical requirements, the immediate needs of the action program of the Service as well as the broader practical and research applications sought by the Bureau and the states, could best be served with a single type of basic soil survey (226), (291).

With the technical phases of the controversy seemingly resolved, there remained the administrative problem of setting up an organizational structure for the Soil Survey which would be acceptable to the Colleges as well as to the two federal agencies. Although Service-College relations had markedly improved following the change in Service leadership, the increasingly evident rapprochement between the two formerly hostile federal agencies in the soil survey field was viewed with caution by a number of state college participants in the Soil Survey.

On the basis of the field studies of 1952, the agreement on the substantive content for the Soil Survey, and the attitude of the states regarding the possibility of Service domination of the federal share of the program, Salter and Kellogg represented a tentative plan in July which would provide for technical integration of the soil survey work of the two federal agencies, under coordinate-but separate-administrative control. Neither extensive reorganization nor transfer of personnel between the two agencies was proposed.

Charles Brannan, however, had different ideas. No stranger to tough organizational problems, Brannan rejected the proposed coordination of the two federal agencies involved, and ordered instead, direct integration. He thus terminated the soil survey controversy which, for nearly twenty years, had seemingly borne out the opinion of Arthur Maass that, "...where two agencies do the same job in the same area, coordination cannot succeed." (167):254. As Gauss and Wolcott have pointed out, "Coordination is the reciprocal of control (102):290," and throughout the long controversy, no unified authority had ever had sufficient control over the soil survey activities of the Department to effect coordination of the work. Brannan's action provided such authority and control.

By Secretary's Memorandum No. 1318 of October 14, 1952 (effective November 15, 1952), Brannan transferred all personnel and funds of the Bureau's Division of Soil Survey to the Soil Conservation Service, and designated the Service as the single agency responsible for all soil survey activities in the Department of Agriculture (279). At the same time, certain personnel, laboratory facilities, and funds of the Bureau's Division of Soil Management and Irrigation were transferred to the newly integrated soil survey unit within the Service. All research projects of the Service dealing with soil and crop management and with water management on farms related to crop production were transferred to the Agricultural Research Administration (279).

In a memorandum to all personnel of the Division of Soil Survey (issued simultaneously with the Secretary's Memorandum of October 14th, Kellogg wrote,

> ...without suggestion or opposition from either Dr. Salter or me, it was determined that the soil survey program could develop best if administered within the Soil Conservation Service. Although we did not ourselves propose this consolidation and transfer of the Division of Soil Survey, both Dr. Salter and I firmly believe that such a move will lead to the mutual advantage of all concerned in the future development and use of the soil survey work. We believe that it will be helpful in the soil mapping, soil research, soil classification, publication, and interpretation and use of the results.

Within the Service, Kellogg was named Assistant Chief with responsibility both for the integrated soil survey work and for the remaining research projects. The pooled resources of the integrated federal soil survey work included approximately 900 soil scientists and a budget of five or six million dollars. Additional resources available through State cooperation included about 75 soil scientists and funds of perhaps $750,000.

Also pooled as a result of the federal integration were two parallel, but administratively distinct, sets of regional field offices for correlation and inspection of combined surveys. Transferred intact from the old Division of Soil Survey were the personnel of the four “Regional Soil Correlator” offices; these were line officers, reporting directly to Kellogg. Retained intact from the existing Service organization were the seven “Regional Soil Scientists” in each of the seven administrative regions of the Service; these were staff officers reporting to the Service’s ranking line officer, the Regional Director, in each case.

Democrat Brannan ordered integration of the Department’s soil survey activities on October 14, 1952; the effective date for the actual transfers, however, was November 15th, after the national election, and as it happened, after the Republican victory. Thus the subsequent elaboration of a fully integrated soil survey program within the Department occurred under the administration of Brannan’s successor, Ezra Taft Benson.

Even before the inauguration of the incoming national administration, however, there were some sharp reactions to Brannan’s reorganization. In December, the retired-but highly vocal-creator of the Soil Conservation Service got off a lusty blast to the effect that “They’re Wrecking Soil Conservation.” Bennett’s principal target was the action by Brannan in transferring certain research projects out of the Service, but he also declared that the reorganization

> ...would load down the S.C.S. with responsibility for the national soil survey... The S.C.S. evolved a unique kind of land survey-the land capability survey-a relatively simple, streamlined survey designed for one purpose. To show the farmer how his land is classed from a conservation standpoint. Now, to divert the S.C.S. to the job of gathering the great amount of technical data wanted by soil scientists for purely classification purposes is bound to slow down practical soil conservation (36):52.

The views of Hugh Bennett, still tremendously influential, were shared by many others in the Soil Conservation Service.

Equally vehement criticism, though inspired by totally different motives, arose also from many of the individual land-grant college participants in the Soil Survey. Before issuing Memorandum No. 1318, Brannan had secured the tacit approval of the Land-Grant College Association, which had insisted upon the continuity of Kellogg's leadership and upon the maintenance of scientific standards established by the Soil Survey for the proposed integrated program, and the Association collectively did not thereafter formally oppose his action (226):11. Antipathy remained, however, on the part of individual college spokesmen. Their concern was with the possibility of a relaxation of scientific standards in the reconstituted Soil Survey if Kellogg and his numerically inferior staff transferred from the old Division were submerged in the much larger organization of the Soil Conservation Service; on another level, they were concerned with the seemingly inevitable diminution of College influence and representation in the emerging program of the Soil Survey.

Immediately following the integration, the new Soil Survey Staff of the Service prepared, and Salter issued, a statement on the "Suggested Program for a National Cooperative Soil Survey." Favorable reaction to the "Suggested Program" on the part of the Colleges was something short of unanimous, but the latent concern of college spokesmen regarding the possibility of Service domination of the Soil Survey was in part allayed through the preparation of new memoranda of understanding which provided for full and continued college participation in the new program. These new memoranda generally reaffirmed the cooperative nature of the Soil Survey, stipulated the use of the established nationwide system of soil classification, provided for mutual approval of all soil survey legends and field work, and specified that incumbents in the Service's State Soil Scientist positions be mutually acceptable also to the colleges concerned (226):12.

Meanwhile, the advent of a new national administration and the immediate or impending reorganizations throughout the Executive Branch created a brief period of uncertainty regarding the organizational status of the Service, and of the soil survey activities within the department. In the interval, the Soil Survey staff within the Service began the development of standards for a single integrated national soil survey to be carried on with the states. For some months, however, the two distinct systems of regional field offices for soil surveys, noted, were maintained.

On November 2, 1953, by Secretary's Memorandum No. 1320, Supplement 4, Benson carried out a sweeping reorganization of a number of activities of the Department of Agriculture. Within the Service, the seven administrative regional offices were abolished, and their administrative and technical functions transferred partly to the Washington office, and partly to the Service's state offices, which thus gained in discretionary authority. [46/] All remaining research projects in the Service were transferred to the Agricultural Research Administration with the sole exception of "...investigations required for the national soil survey of the Soil Conservation Service (280):1."

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46. As noted in chapter 4.3, the elimination of the Service's regional offices by Benson's reorganization of November 2, 1953, was a reflection of the relatively greater influence of the Land-Grant College Association in the new administration.

Chapter 5   The National Cooperative Soil Survey Since 1952

At the present writing (1957), the development of the integrated program growing out of the reorganizations of 1952 and 1953 is still taking place. Any serious appraisal of the emerging Soil Survey would clearly be premature; a few points regarding the present status of the program, however, should be noted.

Federal appropriations for the Soil Survey have been appreciably increased since the integration. For fiscal year 1957, federal funds for soil surveys totaled about $8,500,000. One important result of the additional funds has been the final elimination of the burdensome backlog of unpublished soil survey reports. Publication is now on a current basis. Upon recommendation of the President's Advisory Committee on Water Resources Policy in 1955, and approval by President Eisenhower in 1956, the Service prepared a proposed schedule for greatly accelerating the progress of the Soil Survey so as to complete the mapping of the United States in fifteen years with an additional five years allowed for publication and distribution of the results (282):53. Ironically, the current proposal, which is still pending, has the backing of the Bureau of the Budget; this same Bureau disapproved a similar plan to accelerate the production of desperately needed soil surveys twenty years before (Archives). The Service has already accelerated soil surveys in connection with the "Great Plains" program, and, whether or not the fifteen-year plan is realized, it seems clear that increasing use will be made of soil survey data in many of the Department's programs (282):52. These include, in addition to the Service's continuing program of assistance to soil conservation districts, the Department's Agricultural Conservation Program and Soil Bank, the Service's Small Watersheds program, as well as many state and local programs with direct relationship to the use and conservation of soil and water resources.

Administratively, within the Service, federal responsibility for the Soil Survey is carried by Kellogg, who, as Assistant Administrator, has a higher rank than that of any former leaders of the Service's soil conservation surveys program. [47/] He is assisted by

47. This refers only to technical responsibility and delegated operating authority. Ultimate administrative responsibility for the federal share of the Soil Survey rests with the ranking officer of the Soil Conservation Service, Administrator Donald A. Williams.

senior staff members with specialized technical responsibility for the functions of Soil Survey Operations, Soil Survey Investigations, Soil Classifications and Correlation, Soil Survey Interpretation, and Cartography. The Assistant Administrator and this senior Soil Survey Staff provide technical and scientific guidance to the soil survey work of the Service through a decentralized staff of Soil Correlators several of whom are headquartered in each of the five “Groups of States” under five “Principal Soil Correlators.” The field correlation staff makes period reviews of all soil survey work to determine technical and scientific quality and to maintain uniformity of national standards across state lines. Soil correlators (jointly with representatives of the land-grant colleges or other designated state agencies) exercise field approval authority over all soil survey legends, soil survey report manuscripts, and other technical and scientific phases of the work within their assigned territories. In the Service table of organization, soil correlators report directly to Kellogg. In the maintenance of national standards, the Washington office of the Soil Survey further exercises approval authority over all soil survey work plans, initial and final field reviews, soil correlation and classification, and projects of basic soil investigations (246). General standards for soil survey personnel are promulgated by the Washington office.

In the field organization of the Service, the soil surveys themselves are made by soil scientists headquartered at the various state, area, and work unit offices. They are, in all cases, staff officers reporting administratively to line officers (area conservationists) in the Service program. Technical guidance is provided by the soil correlation staff, noted above, and by a state soil scientist who is a staff officer reporting to the senior line officer in the state (state conservationist) (246).

Thus the federal field force of the Soil Survey, as presently organized, retained elements both of the straight-line structure of the old Division of Soil Survey, as represented by the field correlation staff, and of the line-and-staff structure of the old Division of Soil Conservation Surveys, as represented by the field soil scientists doing the mapping. The interstate responsibilities of the soil correlators, however, and the approval authority and increased rank of the Washington Soil Survey staff provide a means to establish and to maintain national standards. And the large number of soil scientists in the Service program provide the means to carry on a large scale program of field mapping. The present coverage of the Soil Survey, including the contribution of the states, is about 35 million acres annually, mostly in detail (282):52. Total professional personnel of the Soil Survey include about 900 soil scientists in the Service and about 100 soil scientists employed by the cooperating states.

Cooperative, within the structure of the Soil Survey, participation by the states through the land-grant colleges or other designated agencies has been fully maintained although, as before the extent of such participation varies widely among the several states. Total contributions of state funds to the Soil Survey, estimated in 1956 to be at about the same level of $750,000 as in 1950, have not kept pace with the increases in federal appropriations for the work (190):4, (282):53. Opportunity for state participation in the field operation is assured in the joint memoranda of understanding providing for mutual approval of soil survey work plans, legends, maps, and reports, and of individual incumbents in State Soil Scientists positions. At the broader level of technical and scientific standards for the national program, state soil survey leaders participate in the Annual Technical Work Planning Conference of the National Cooperative Soil Survey, and, since 1955, in similar conferences held annually in the five Groups of States. In less explicit, but highly important contributions, some of the land-grant colleges have expanded both undergraduate and graduate programs in soil science, including those phases of particular pertinence to the work of the Soil Survey. The continuing need for such expansion of educational facilities is clearly indicated. In addition to the established cooperative relations with the States, the Soil Survey (through the Service) has cooperative work underway with a number of other federal agencies including the Agricultural Research Service, agencies of the Defense Department, Geological Survey, Office of Experiment Stations, Bureau of Standards, Bureau of Indian Affairs, Bureau of Reclamation, and others. In recent years, governmental bodies at various levels have drawn upon soil survey data for use in broad appraisals of the extent and significance of the encroachment of urban and industrial developments, highways, airports, etc., on to areas of agricultural land.

Technically, the development of a single national soil survey from the previously separate programs of basic soil surveys and soil conservation surveys has been and is being carried out through intensive training of soil scientists and through the establishment of technical and scientific standards to which all soil surveys, within reasonable time, are to be converted. This standard soil survey, comparable to the basic soil survey of before, is made under a closed descriptive legend, with the mapping units described in detail and identified in terms of the nationwide system of soil classification; the scale and detail of mapping, as well as the interpretations of the soil survey data, are to be adequate, not only for the immediate needs of the Service program, but for the broader purposes of the diverse uses and users of the National Cooperative Soil Survey. Pending conversion to standard soil survey, existing surveys are referred to as soil conservation surveys. For each conversion of a soil conservation survey to a standard soil survey, the soil survey work plan and legend are to be approved by the land-grant college concerned, the State Conservationist of the Service, and the Assistant Administrator in Washington. In a directive of June 10, 1954, the Administrator of the Service specified

> All soil scientists will be trained as rapidly as possible in the careful observation of soil characteristics, preparation of soil descriptions using standards terminology, and preparation of descriptive legends (246):14.
>
> Because of their importance, immediate steps should be taken to obtain complete up-to-date descriptions of all soil units listed in mapping legends for all areas as rapidly as possible (246):15.
>
> Soil conservation surveys still in progress are to be converted as rapidly as possible to standard soil.... A standard soil survey may be conducted either progressively, that is by mapping in blocks of area, or by individual farms or groups of farms. The policy of the Service is to map in blocks wherever the operating program permits (246):10.

By the end of 1956, with soil surveys underway in about 2,000 counties throughout the country, about 400 had been converted to standard soil surveys, of which about 200 were being mapped on a progressive basis. All new soil surveys initiated are to be only standard soil survey, and all standard soil surveys are scheduled for publication (282):52.

As it affected the conservation operations program of the Service, the training of soil scientists in techniques of soil description and interpretation, and their continuing responsibilities in these fields in standard soil surveys resulted in an initial reduction in total mapping production. This reduction has since been regained, in large part; because of the absence of so many insignificant mapping unit boundaries under the closed legends of the standard soil surveys, they are, in some respects, made more rapidly than the open legend soil conservation surveys, even with the addition of the supporting investigational work required. More significantly, the increased attention by soil scientists to soil morphology and classification has been reflected in more accurate mapping as well as in sounder and more diverse interpretations for the Service program and for others. These interpretations include the Land-Use Capability System-currently under thoroughgoing review-and many specific interpretive groupings for application to specific purposes such as engineering predictions in soil mechanics, irrigation, drainage, etc., forest site indices and other predictions for forest planting and management, range site predictions, and many others (247):11. To provide additional basic data for agricultural interpretations, there has been increased activity in the mapping and correlation of soils of experimental plots of agronomic research. In addition to eliminating the backlog of unpublished soil surveys, the Soil Survey has introduced a new format, including printing of the soil maps against an airphoto mosaic background, for publication of new soil survey reports.

The points noted above represent considerable technical progress in the Soil Survey since 1952; the great need for training of soil scientists and for conversion of soil surveys continues, however, and the demand for soil survey coverage in the conservation operations program of the Service is still such that only about ten percent of the soil surveys currently underway are being made on a block-mapping or progressive basis (282):52.

Scientific activities of the Soil Survey have expanded, particularly since the transfer to the Service in 1952, of certain personnel and projects previously in the old Division of Soil Management and Irrigation (279). Since the reorganization of 1953, the only authorized research projects in the Service are those associated with the Soil Survey (280). In addition to the Service's activities in soil survey investigations, and in cooperation with them, basic scientific research in soil science is underway at a number of land-grant colleges and experiment stations. In connection with continuing studies of soil correlation and classification, perhaps the most significant recent development has been the preparation and the repeated testing and revision of the new comprehensive natural system of soil classification. This system is now at the stage of the "fifth approximation." Field mapping of the Soil Survey has benefited from laboratory studies by the Service, the Colleges, and by a few other agencies such as the Bureau of Public Roads. In the soil survey laboratories of the Service during fiscal year 1955, laboratory determinations for soil characterization were done on 2,300 samples representing 357 different soil profiles from 146 countries in 37 states and Alaska (247):7. More specialized investigations have dealt with clay mineralogy and geomorphology as related to soils, the relation of soil conditions to the absorption by plants of the residual materials from radioactive fallout, the influence upon plant and animal nutrition of certain micronutrients in the soil, the influence of climatic changes and geological processes upon soils and others. Professional contact with soil scientists throughout much of the world has been maintained through American participation in recent Congresses of the International Soil Science Society, through the investigations of the World Soil Map Unit of the Service, and through continuing work on the new system of soil classification. In preparation for the Seventh International Soil Science Congress, to be held in this country in 1960, soil scientists of the American Soil Survey are selecting sites and laying out tours and demonstrations to illustrate not only the recent achievements toward gaining an understanding of the soil, but also the vastness of the nature of soil about which they lack such understanding.

Chapter 6 Conclusions

If there is one incontrovertible conclusion to be drawn from a serious study of the evolution of the National Cooperative Soil Survey, perhaps it is simply that, as a nation, we are still learning how to make, and use, soil surveys. There is a great deal yet to be learned, and there always will be. There is also the distilled experience of the more than half-century of operations of the Soil Survey, the respectfully critical consideration of which has been the subject matter of the present study. From this, some inferences may be drawn.

If it were possible to express such inferences in a single sentence, it might be said that the need has been demonstrated for a Soil Survey that is national in scope, cooperative in structure, scientific in outlook, versatile in application, and professional in composition. Conclusions regarding these general attributes, and the relations among them, are noted briefly below.

A national soil survey. The application of the results of research and experience with soils, and the full realization of the potential uses of soil surveys presupposes uniformity in standards of soil classification and correlation wherever the soils may occur. This necessarily federal responsibility for interstate soil correlation, a federal responsibility freely acknowledged and defended by all but a very few of the states since the Soil Survey began, will become yet more essential with the expanding coverage and use of soil surveys and with the further elaboration of research results. In terms of regional public programs, the maintenance of technical control of interstate soil survey work is implicit in the large-scale planning and developmental activities underway in major watersheds and other multi-state regions. At the national level, the maintenance of nationwide standards for soil classification, mapping, and interpretation is a determining factor in the growing recognition of the need for relating long-range national agricultural policies and programs more closely to the nature and distribution of soil resources as determined by the Soil Survey. Previously, major agricultural programs such as that of the Agricultural Adjustment Administration made relatively limited use of soil surveys because of lack of available coverage. More recently and more specifically, the Soil Bank Act of 1956 would have been written and administered differently had there been a complete or nearly complete soil survey of the nation. Increased application of the data of the Soil Survey to future national agricultural policies and programs is indicated by Departmental and Budget Bureau support of current plans for accelerating soil surveys.

Such a national Soil Survey, even as it applied only to the programs of the states themselves, cannot be administered by the states alone. The state of Illinois conducted a completely independent soil survey program of its own for nearly forty years, without regard to concurrent developments of a nationwide system of soil classification and of interstate soil correlation by the national Soil Survey. As it gradually became apparent that the state thus had no means for full utilization of, and exchange of data on, the body of research knowledge relating to specific soil types that it shared with many other states, Illinois ultimately, and completely voluntarily, rejoined the National Cooperative Soil Survey.

Nor can such a national Soil Survey be administered solely through a system of regionally autonomous soil survey operations. The experience of the soil conservation surveys of the Soil Conservation Service demonstrates that such an administrative structure produces not a national program, but a number of uncoordinated regional programs. If there is to be a national Soil Survey, there must be a means to correlate the correlators. In this respect, the present organizational structure of the federal portion of the Soil Survey represents a compromise, in that, while the field mapping of soil surveys is carried on under a line-and-staff structure with soil surveyors reporting administratively to line officers (soil conservationists), the functions of interstate and interregional soil correlation are performed by soil correlators reporting directly to the head of the national Soil Survey, the Assistant Administrator of the Service. The Assistant Administrator, however, is himself in a staff position in that he reports to the Administrator of the entire Service, who thus has ultimate responsibility for the federal share of the Soil Survey.

If it is to serve the many and diverse purposes of which it is capable, a national soil survey cannot be administered exclusively as an auxiliary of service function within the program of another action agency. The data from such auxiliary service programs as those of the Bureau of Reclamation, Indian Service, and, more specifically, of the former soil conservation surveys of the Soil Conservation Service, have only limited application to purposes beyond the specific needs of the parent agencies. In this respect, again, the present organization of the Soil Survey represents a compromise, in that funds and ultimate responsibility for the federal share, which is the major share, are assigned to the Administrator of the Service, while, in the actual operations of the Soil Survey program, provisions for the broad multipurpose applications of soil surveys, as promulgated by the Assistant Administrator, are assured as a matter of Service policy through the administrative authority of the Administrator.

A cooperative Soil Survey: In the current operations of the Soil Survey, with federal activities integrated within the Soil Conservation Service, the ratio of federal appropriations for the program to the total funds contributed by the states is more than ten to one. This is the widest disparity between the two in the history of the Soil Survey. Moreover, since state contributions have not kept pace with recent increases in federal funds provided, which may be increased further, the ratio is likely to go higher.

Such a simple quantitative comparison of dollar inputs, however, is an inadequate measure of the contribution by, or the need for cooperation with, the states. A relatively greater proportion of the state activities in the Soil Survey involve basic soil investigations, the results of which serve to strengthen the scientific basis of soil surveys well beyond the state borders. In a broader sense, state participation in the Soil Survey affects the national program in a manner that cannot be duplicated by the federal agency.

Within the boundaries of the nation, there are extreme variations, locally and regionally, among the many different kinds of soil; there are equally great differences from place to place in cultural and economic conditions and in types of farming. Within the technical and scientific standards established nationally for soil classification and correlation, soil surveys and soil survey reports are adapted locally in accord with the nature of the soils and needs for soil survey data. The total national program of the soil thus requires the services both of soil scientists with broad ranges of knowledge and experience (for the national and interstate correlations), and of soil scientists with intensive knowledge of local soils and types of agriculture (for the local adaptations of soil surveys and reports). If there were no soil survey staffs maintained by the states, the above need of the national soil survey for specialized local knowledge would have to be met exclusively, as it has now partially, by federal soil scientists assigned and headquartered locally. As it happens, most of the states do maintain soil survey staffs and, most significantly, the soil scientists on these state staffs are in close contact with the related state programs of the Extension Service, experiment stations, etc. In participating in the national Soil Survey, soil scientists affiliated with the states thus provide not only the knowledge of the local soils and agriculture, but also the entree to current research work and to the many state agencies that use soil surveys. Through such participation, the states, in turn, are assured of a higher level of soil survey activity within their border, wider understanding of, and use of, soil surveys by individuals and agencies in the State, and greater opportunity for representation of state interests and needs in the making of soil surveys.

This history of the Soil Survey provides ample evidence of the consequence of the breakdown of cooperative relations; these range the half-century from the secession of Illinois from the national Soil Survey, to the more recent disputes among the Soil Survey, the Soil Conservation Service, and the states. Mention should also be made of the consequences of maintenance of such cooperative relations. If there is to be a cooperative Soil Survey, inevitable there will be differences of opinion between federal and state participants; in the simultaneously technical and administrative function of resolving such differences, a major problem for the Soil Survey leadership is to distinguish between what may be scientific and technical points at issue on the one hand, and differences of viewpoint arising from agency affiliation (federal or state), on the other. To the extent that this distinction is understood and acknowledged, cooperative relations in soil survey work can flourish.

A scientific Soil Survey: The experience of the Soil Survey has repeatedly demonstrated that the soundness of all phases of the work, soil classification, soil mapping, and soil survey interpretation, are dependent upon the state of knowledge about the soil, and that such knowledge can be expanded only through investigations in basic and applied soil science. One of the most essential of all steps in making a soil survey, the identification and classification of soil units so that they might be mapped, and such maps interpreted, is based entirely upon the data of basic soil science, of pedology.

With respect to the place of soil science in the administration of the Soil Survey, the history of the program includes some additional evidence. During the nineteen-twenties, preoccupation with the basic science aspects of the work on the part of the Soil Survey leadership engineered (together with tremendous progress in such aspects), an unbalanced program with confused objectives and with underdeveloped potentials for practical application. On the other hand, the virtual abandonment of scientific concern for soil classification in the former soil conservation surveys program of the Soil Conservation Service resulted in the development of various kinds of pragmatic surveys in which there was adequate provision neither for the application of soil science in the operations program of the Service through use of the surveys nor for the surveys themselves to contribute significantly to the body of knowledge of basic soil science. And finally, the record of Congress clearly demonstrates an unwillingness to provide the funds necessary for support of a national Soil Survey considered as a separate scientific program.

The Soil Survey thus must maintain a cautious middle course between scientific purism on the one hand, and expedient pragmatism on the other. Under the present organization of the federal portion, scientific work, such as the development of the new natural system of soil classification, and other investigations, are at an all-time high; relatively little headway has been made, however, in reversing the former service policy and in gaining recognition of soil investigations as one of the normal and necessary functions of field soil scientists.

A Soil Survey versatile in application: Manifestly, no one single kind of soil survey can be made that would serve all the possible needs of all the possible users of soil survey data. The great majority of such needs, however, can be met with a single soil survey if the soils are classified in terms of intrinsic soil characteristics and their combinations, and if the soil survey data are applied to each specific purpose by means of an interpretive system or technical grouping designed specifically for that purpose.

Attempts to interpret and to use soil surveys in which the soils were not classified in terms of significant combinations of characteristics have led to some anomalous results. Early in the century, in the Soil Survey of Milton Whitney, attempts to correlate crop production with soil types failed completely because the soil types were classified in terms of only a single soil characteristic, soil texture, without regard to the significance of soil texture in relation to the combination of the other soil characteristics. The same type of error was made in the early surveys of the Soil Conservation Service, in which soil slope and extent of past erosion were considered as independent variables; interpretation of such surveys was confused because the boundaries drawn did not, in many cases, separate significantly different areas of soil.

With respect to the second "if" specified above, the need to interpret soil surveys for a particular purpose only by means of an interpretive system or grouping designed specifically for that purpose, the experience of the Soil Survey is again instructive. Some of the soil surveys of the early 'thirties were interpreted by means of grouping soils in terms of "inherent" or "natural" productivity, in the absence of fertilization, irrigation, etc.; when applied to actual areas in cultivated agriculture, where the soils were fertilized, or drained, or irrigated, etc., the interpretive soil groupings based upon inherent productivity were frequently meaningless. Similarly, in the program of the Soil Conservation Service in the late 'forties, the interpretive device of the land-capability classification was applied to other purposes, including land appraisal for rural tax assessment. Such application failed because the capability system had been specifically designed for a particular purpose, conservation farm planning with emphasis on control of erosion, and it could not be applied to another interpretative use which involved consideration of other sets of soil conditions.

In the present Soil Survey program, although the land-capability classification remains in wide use for its proper purpose of soil survey interpretation for conservation farm planning, a great many other technical groupings have been developed for use in the interpretation of soil surveys for purposes of engineering, forestry, irrigation, range management, etc. One of the most significant changes in the Service program wrought since the integration of 1952 is the recognition that the land-capability classification is a system, not the system for interpretation of the basic data of soil surveys.

A professional Soil Survey: The making and the interpreting of soil surveys involves complex and difficult functions. It can be carried on adequately only with experienced, well-trained soil scientists. The rate and intensity of coverage can be, and should be, varied locally according to complexity of soil conditions and potential intensity of land-use. The total program, however, cannot be doubled or trebled on short notice to meet the sudden needs of new emergencies or new programs, regardless of the availability of funds. Such crash programs of soil surveys in the past, on anything but a local basis, have been uniformly unsuccessful. With available financial resources for soil surveys at an all-time high, and with the likelihood of additional funds for acceleration of the program, selective recruitment and continuing intensive in-Service professional training for soil scientists are the essential conditions concomitant with any large-scale expansion of the operations of the Soil Survey. Otherwise, the accelerated soil surveys will simply have to be soil surveyed all over again.

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