Soil Survey in Indiana: Past, Present and Future

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Soil survey activity in Indiana began in 1902 with publication of the map and report for Posey County and continues to the most recent report, for Orange County, in 1984. An earlier review (18) traced development of this program from 1902 through 1976. Surveys, made originally to help agriculturalists extrapolate results of field experiments from the plots to other locales, have adapted to the changing needs in successive periods. Since World War II rapid land use changes in housing, industry, retail marketing and recreational developments and the expansion of agricultural and forestry operations as well as environmental concerns of a rapidly expanding population have all stimulated interest in using soils surveys. Equitable farm land taxation has been another stimulus. Land qualities which soil surveys describe has made them of inestimable value to Indiana citizens.

This paper reviews important historic phases of soil survey progress during the past 82 years. The first phase spanned 57 years and included growth of knowledge about soils and improvement in survey techniques. A total of 64 surveys were published, all having colored line maps. These surveys will eventually be replaced by newer ones. In the second phase, which spanned 24 years in the decades of the 1960s, 70s and 80s, the survey program expanded dramatically and surveys were published, or will be published, for each county of the state. These surveys have detailed maps published on air-photo base maps and greatly expanded reports tailored to the needs of users in a greatly expanded audience for soil information. The third phase, beginning now, will emphasize use of the surveys.

Phase 1. Early Growth of Indiana's Soil Survey: 1902-1959

Early soil mapping was done by the Bureau of Soils and later by the Bureau of Chemistry and Soils of the U.S. Department of Agriculture (USDA) cooperatively at first with the State of Indiana Department of Geology and after 1920 with the Purdue University Agricultural Experiment Station (AES). Later, progress continued with Bureau of Plant Industry, Soils and Agricultural Engineering of USDA cooperating with AES.

Field mapping was done early on plane tables at a scale of 1 inch per mile and later 2 inches per mile. Many of the earlier workers had more training in geology than in soils. Little was known about soil morphology but the geologic nature of soil parent materials was better understood. Reports included only general observations of crop growth and cropping systems followed on various soils and little reference was made to research on crop production or how it could be adapted locally. Reports improved greatly after 1922 when soil management chapters written by Purdue AES workers were added to survey reports.

Two Important Advances

In 1922 Thomas M. Bushnell began his long career as head of the soil survey activities for AES at Purdue University. His early work with the Bureau of Soils in Lake County and elsewhere and with aerial observation and photographs in World War I helped him to later pioneer the use of air-photos in soil mapping, which had a very lasting effect on later survey program development.

Bushnell obtained air photos from the Army and from highway engineers for experimental use in early surveys (2). He later ordered a complete set for Jennings County and used these as field base maps for the soil survey. Jennings was the first county to be mapped entirely on air photos (3). In 1936 he summarized the influence of photos on the soil survey program (4). Air photos allowed better visualization of important landscape features by soil mappers and aided them to see greater detail and locate the observed soil features more accurately in relation to buildings, roads, streams, cropland, pasture and wooded area boundaries.

As knowledge about soil-landscape relations increased, Bushnell and his colleagues began to appreciate the "catena" concepts used by Milne (30) in Africa to explain the nature of groups of soils formed from similar parent materials. He applied "catena" ideas to Indiana soil relationships to aid development of the taxonomy of Indiana soils in 1938 (5) and in 1939 (6) and 1942 (7). He further refined the system and put it into a key form in the Story of Indiana Soils in 1944 (8), a work termed "a classic of organization" by Kohnke et al. (28).

Early Improvements Set Stage for Better Surveys Later

With increasing knowledge of soils, greater accuracy in mapping with air-photos, and increasing studies from which to draw interpretations of soil behavior under different uses, a slow revolution occurred in the soil survey program. Soil mapping was done in more detail and reports became more comprehensive so that county survey publication time increased from 1 or 2 years in early surveys to 5 years by 1930, and to 6 years by 1940 (18).

Emphasis on making soil surveys for farm planning increased as soil conservation programs got under way with the Soil Conservation Service (SCS) in 1935. Conservation demonstration farms were established and the Soil Conservation District (SCD) work with individual farmers started after 1938 and expanded rapidly. These changes and diversion of mappers into other pursuits during World War II resulted in a drastic increase in time between completion of the mapping of a county and publication of the survey. The interval was 10 years in the early 1950s (18).

The SCS benefitted from knowledge gained in past surveys and developed a system of soil conservation surveys made for individuals farms or groups of cooperating farms as owners requested technical assistance. Beginning around 1950, symbols on soil map units included slope range in one of seven classes, and, effects of past erosion in one of three classes, both important in use and management (56). Such surveys preceded any farm planning assistance. Maps enabled use of a land capability classification system to help farmers understand the restrictions imposed by features like wetness, erodibility, and low water holding capacity on the soils of their farms. In counties with SCDs and active soil conservation programs, there was more interest in developing farm plans than in concentrating on soil survey publication.

In 1951 Herbert P. Ulrich became the second soil survey leader responsible for the operations of the soils survey for AES. Prior mapping experience in 12 or more Indiana counties made him particularly capable of expanding knowledge about soil parent materials (48, 49) useful to field soil scientists in succeeding years. He also assisted in support of other studies about loess distribution and soil mineralogy begun by White (51, 52), Bailey (1), Post (33, 34), and others. T.C. Bass became SCS State Soil Scientist in 1945 after serving in that capacity in Wisconsin. Bass and Ulrich capably led the survey for many years.

Ulrich assisted greatly in improving soil survey report usefulness. In the 1943 survey of Knox County, he introduced the first general soil association map of Knox County which led to the small-scale, colored maps in the standard soil reports of 1960 and later. He first added estimated crop yields at two levels of management in the

Vanderburgh County Survey of 1944. They provided economic background for selecting farm practice combinations. These innovations were used in a number of publications delayed by World War II up to Carroll and Tippecanoe counties in 1959. In these he introduced block diagrams relating soils and topography, tables suggesting use and management, including rotations for soils of similar management groups, and the first tie-in with the land capability classification system used widely by SCS in farm planning.

Soil Survey Functions Combined Under Soil Conservation Service

In 1952 the soil survey publication functions in the USDA Bureau of Plant Industry were combined with the soil conservation surveys made by SCS. Cooperation with the AES at Purdue continued. Soil conservation surveys, which were available to be used immediately in farm planting, were improved in nature and quality to make them adaptable to later publication as part of a county soil survey.

Phase 2. Era of Standard Soil Surveys for Publication 1960-1987

Mapping for farms of SCD, later named Soil and Water Conservation District (SWCD), cooperators still look priority in planning survey progress but it became an integral part of a complete county survey. Air-photos at a scale of 4.0 inches (a few 3.2) per mile were selected as base maps.

Standard soil survey reports included soil descriptions designed for lay people and more technical and detailed ones for soil scientists. Reports also provided a colored general soil map showing the broad soil associations with brief descriptions of the soils and land uses as described by Zachary and others (57). They included a glossary of technical terms and tabular presentations of soil properties and of interpretations relative to using the soil map units for agricultural, forestry and engineering uses. The first publication of this kind in Indiana was for Fayette and Union counties in 1960.

Tables of test data useful to highway engineers and a section on wildlife were added in 1962 in Owen County; soil series classified according to the U.S. Soil Taxonomy (of most interest to scientists) was first added in 1967 in Parke County. Tables of soils and outdoor recreation potential and of trees and shrubs for wildlife planting came in 1969 in Allen County, while soil limitations for six common classes of outdoor recreation came in 1971 in Howard County. A chapter on town and country planning rating soils for homesites, septic disposal systems, local roads and streets, sewage lagoons, landfills and species for landscape planting emerged in 1972 in Lake County. The reports showed a continuous improvement in meeting the needs of the user.

Other Materials Support Use of Published Soil Surveys

Management recommendations must be revised frequently. Thus, specific ones were omitted from soil survey reports and are presented in several extension publications usually prepared by Cooperative Extension Service, AES, and SCS people. Fertilization is recommended in line with soil test reports. Guides to economic productivity levels for all soils are updated periodically (17, 50). Available soil water capacity studies by Wiersma (53, 54) aid productivity estimates. Drainage needs refer to a farm drainage guide (29), irrigation potential to another guide (25), and adaptation of tillage-planting systems to yet another (20).

A highly valuable guide to conservation planning resulted from work of Wischmeier and others (55) in developing the universal soil loss equation. With it farm planners can predict long-time average soil losses from specific tracts of land under various cropping and management systems. No advance has helped make soil survey maps more useful to farm planners and landowners in agricultural programs!

For those needing to relate to soils on a broader basis than single farms other publications are supportive. A series of general soil maps and a users guide were updated in 1975 (19) and a guide to properties of soil series (24) was published in 1977. They reflected some of Harry M. Galloway's depth of experience in helping farmers and others use their soils while preserving them for future generations. A 1977 colored map of soil associations (41) and a 1982 key relating soils to each other and to their environments (14)are useful to agency program planning, planning commissions and others. To help persons understand and judge Indiana soil properties, the high school soil judging program manual (50) was expanded in 1978 to be used by a wider audience.

Donald P. Franzmeier became the third and present state soil survey leader responsible for soil survey operations in 1970. He recognized the potential for learning more about the soils being mapped as surveys progressed. He organized a soil characterization laboratory at Purdue to perform analyses of soil samples taken by field soil scientists of SCS and IDNR during survey operations. Results are in a series of AES station bulletins from 1977 to 1984 (41). Field and laboratory procedures were described in a 1977 bulletin (13).

Field soil scientists also measured water table depths and crop yields, especially as affected by erosion. With assistance of SCS soil scientists, especially Frank Sanders, papers were published about soil moisture regimes (12, 15), organic soils (37), history of the Miami series in Indiana (38), and dark-colored northern Indiana soils (36). Graduate students working with Franzmeier studied various aspects of soil genesis and many of them worked on soil survey parties during summers to gain experience and gather field research data. Included were studies on soil water regimes, Harlan (22); remote-sensing, Steinhardt (44) and Cipra (9); micromorphology, Steinhardt (43); manganese minerals in soils, Ross (35); soil formation and fragipan development in loess-derived soils, Harlan (23), Norton (32), and Steinhardt (45, 47); eolian processes, Franzmeier (11) and Miles (31); hydraulic conductivity and morphology of Clermont soils, King (26, 27); and plant nutrients in trees, Crum (10). Data relating the organic matter content and color of silt loam soils were summarized by Steinhardt (46).

County and State Sources Help Finance Surveys

In the mid 1960s, because of rapid land use changes, various counties supplied funds to obtain soil survey information to help with land use decisions. Lake County, in cooperation with Purdue, supported a soils extension specialist; Howard County provided funds for extra assistance from SCS in preparing reports for its planning commission; Elkhart and Clay counties were the first to supply funds to get their surveys completed sooner; and in Miami, Marion, Johnson, and Kosciusko counties state and county funds supported half the cost of field mapping.

In 1968, Ray Dideriksen became State Soil Scientist when T.C. Bass retired, and in 1972 H. Raymond Sinclair was appointed to that position. With Franzmeier, they directed the survey through this period of expansion.

Accelerated Soil Survey 1974-1987

The 1973 Indiana legislature passed a bill requiring that soil survey information be used to evaluate farmland for tax assessment. At that time less than 40 of the standard surveys suitable for such use had been completed. In 1974 additional state money was provided through the Indiana Department of Natural Resources (IDNR) to match county and federal money to complete the field work of the standard survey in 1984. At that time SCS employed 28 field soil scientists. To complete the survey in 10 years it was projected that this number would remain constant and that IDNR, through the State Soil and Water Conservation Committee, would employ a number of soil scientists, increasing to 31 around 1980 and decreasing to none by the end of 1984. This projected schedule for total number of soil scientists was followed fairly well except that now, toward the end of the program, more are employed by IDNR and fewer by SCS (Figure 1). State and county funds supported IDNR employees and federal

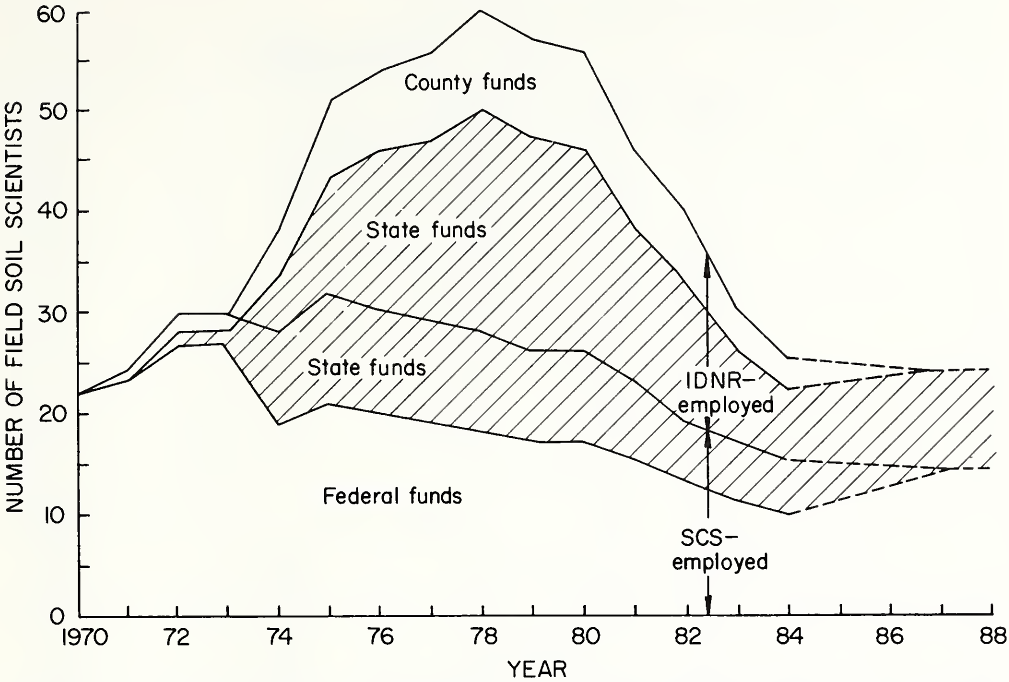

FIGURE 1. Number of field soil scientists in the Cooperative Soil Survey of Indiana, their employing agency, and source of funds.

and state funds supported SCS employees. Also, three counties with surveys started in the 40s and published in the late 50s were added, extending the program. By 1987 all field soil mapping should be completed and by 1990 all surveys should be published. Surveys for 53 counties will be completed through this program (Table 1). In 1974 the estimated cost of the program was $15,700,000 with 48% from state funds, 31% from federal funds, and 21% from county funds.

TABLE 1. Dates or projected dates (> 1984) of completion of field mapping and publication of soil surveys of Indiana.

County	Mapping Completed	Published	County	Mapping Completed	Published
Adams*	1982	1985	Madison	1961	1967
Allen	1961	1969	Marion	1974	1978
Bartholomew	1971	1976	Marshall*	1978	1980
Benton*	1983	1986	Martin*	1982	1986
Blackford & Jay*	1982	1985	Miami	1976	1979
Boone	1970	1975	Monroe*	1977	1981
Brown*	1984	1986	Montgomery*	1982	1986
Carroll*	1986	1989	Morgan*	1978	1981
Cass*	1978	1981	Newton*	1986	1989
Clark & Floyd	1967	1974	Noble	1973	1978
Clay*	1979	1982	Ohio* (with Dearborn)	1977	1981
Clinton*	1977	1980	Orange*	1980	1984
Crawford	1968	1975	Owen	1959	1964
Daviess	1968	1974	Parke	1959	1967
Dearborn & Ohio*	1977	1981	Perry	1963	1969
Decatur*	1979	1983	Pike*	1982	1986
Dekalb*	1979	1982	Porter*	1977	1981
Delaware	1967	1972	Posey	1977	1979

TABLE 1.—Continued

Dubois*	1977	1980	Pulaski	1964	1968
Elkhart	1967	1974	Putnam*	1978	1981
Fayette & Union	1952	1960	Randolph*	1981	1986
Floyd (with Clark)	1967	1974	Ripley*	1981	1985
Fountain	1961	1966	Rush*	1981	1985
Franklin*	1983	1987	Scott	1958	1962
Fulton*	1982	1986	Shelby	1967	1974
Gibson*	1984	1987	Spencer	1966	1973
Grant*	1983	1986	St. Joseph	1973	1977
Greene*	1983	1986	Starke*	1979	1982
Hamilton	1975	1979	Steuben*	1977	1981
Hancock	1974	1978	Sullivan	1962	1971
Harrison	1969	1975	Switzerland*	1983	1986
Hendricks	1970	1974	Tippecanoe*	1987	1990
Henry*	1981	1986	Tipton*	1984	1987
Howard	1965	1971	Union (with Fayette)	1952	1960
Huntington*	1979	1983	Vanderburgh	1971	1976
Jackson*	1983	1986	Vermillion	1976	1978
Jasper*	1982	1986	Vigo	1970	1974
Jay* (with Blackford)	1982	1985	Wabash*	1979	1983
Jefferson*	1980	1984	Warren*	1985	1988
Jennings	1971	1976	Warrick	1975	1979
Johnson	1974	1979	Washington*	1983	1986
Knox*	1978	1981	Wayne*	1981	1986
Kosciusko*	1983	1987	Wells*	1986	1989
LaGrange	1977	1980	White*	1978	1982
Lake	1966	1972	Whitley*	1983	1987
LaPorte*	1977	1982			
Lawrence*	1981	1984			

*In accelerated soil survey program.

The employees trained during the program are benefitting Indiana in many ways. Some continued as soil scientists or conservationists with SCS. Many continued with IDNR in the Department of Reclamation while others took positions with agencies like ASCS, PA, FHA or coal companies, or went on to graduate school. In all cases their soil training is of great benefit to people in Indiana and in other states where they are employed.

Computer Storage and Interpretation of Surveys

Joseph E. Yahner realized the advantage of storing soil maps in computers and using the system to make various kinds of soil interpretations (42). Early systems, using computer cards and the Purdue main computer, were tried in Elkhart, Dubois, and Miami counties. They utilized a 2.5-acre grid-cell. Then a system was developed for storing attributes (properties) of soil map units and soil and land owner maps by 1 1/3-acre grid-cells on the county FACTS terminals (39). This system was designed largely to provide average productivity values for specific tracts of land. Although initial computerization was to accommodate land evaluation for tax assessment, experience in the pioneering counties has shown that people other than tax assessors make extensive use of the system. For example, in Miami County, many rural appraisers and realtors furnish a computer-printout of a soils grid-cell map and a summary of soil productivity information to their clients (personal communication Jack Hart, Cooperative Extension Service). The survey has been processed by computer in 19 counties to date (Figure 2).

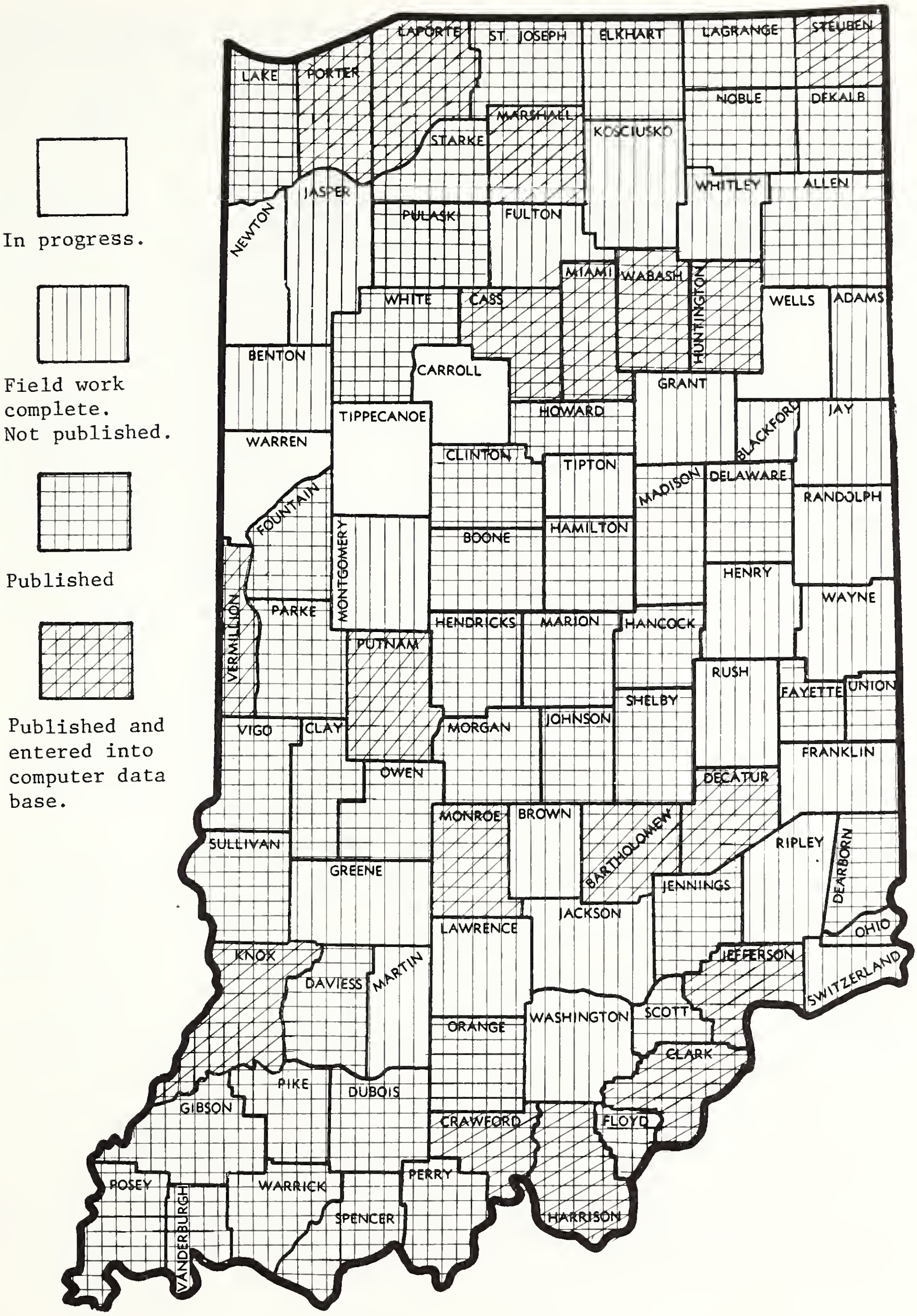

Figure 2. Status of soil surveys and computer storage of surveys in Indiana as of November 1984.

Phase 3. Future Plans for Soil Survey

Future Soil Survey After 1987

In the first two phases of the soil survey the goal was to produce published soil surveys of each county of the state. After more than 80 years of making soil surveys the procedures for describing and classifying soils and conducting surveys were described in detail in handbooks and manuals. The process of making and publishing a soil survey became so tightly prescribed that there was little allowance for creativity and innovation by the soil scientists.

In the future, however, the situation will change dramatically. For the third phase of the soil survey, which begins now as soil scientists complete their assignments in the second phase, the goals and tasks are not as well defined as they were in the two earlier periods. There are very few guidelines for the survey. Individual soil scientists will have to develop new ideas. Indiana will be the first state in the midwest, and one of the earliest in the country, to complete the standard soil survey mapping.

In proposing the goals and objectives of future phases of the soil survey we have made two assumptions: that detailed surveys of entire counties will not be produced in the immediate future, and that the major goal of the program will be to help people use soil information, much of which is in published soil surveys. This will continue and expand the survey extension education programs that began in 1958 (21). In examining these goals we realize that some of the information needed to serve the public is not available. Over the years the mapping goals were so demanding that soil scientists had little time to measure the properties of the soils they were mapping. Also, some of the field work of the "modern" detailed surveys will be 40 years old when the last survey is published. Thus a major effort will be to collect and update information and make it available to assist users of the survey.

Over the years the major use of soil surveys has been for planning farming operations and this will continue to be an important application of the information. In the future, however, two new programs will be major users of soil information—using the computer to store and interpret soil surveys, and evaluating soils for on-site home waste disposal.

In much of Indiana a large percentage of the soils are not suited to conventional septic-tank systems for home waste disposal because they have high water tables or are too slowly permeable. Innovative systems can be used successfully on many of these soils as demonstrated in the On-Site Waste Disposal Project led by J.E. Yahner at Purdue. One is the mound system, in which effluent absorption lines are placed in a mound of sand built on the undisturbed soil in order to create a zone of unsaturated soil above the water table to effect purification of the effluent. Another is the pressure distribution system, in which effluent is pumped into the drainage lines for even distribution. Accurate soil information is essential for the successful operation of these systems. It is necessary to decide if a system can be installed and, if it can, where it should be located and how it should be designed. Contractors must also be taught to construct the system without damaging the soil.

With this background, we will outline the major tasks of the future of the soil survey as we perceive them. We realize that this transition phase must remain flexible to adjust to changing needs. Five major objectives are suggested.

Objectives of Program

Integrating and Updating Surveys

Some work is needed to bring older surveys up to the standards of the most recent surveys. This is especially true for interpretations because now many more are made than were made in earlier surveys. Also, individual county surveys were made by different people at different stages of knowledge of the soils, so adjoining county surveys do not match very well in some places. To help those who use surveys across county lines we need to define mapping units state-wide and show how these units fit the landscape. This might be done by defining soil-landscape units and mapping them on U.S. Geological Survey topographic maps.

Soil Investigations

During the course of the survey practically all of the efforts were directed to mapping soils and developing reports. In addition, laboratory characterization data were obtained for many counties. Now we need to learn more about the properties of the soils themselves, especially properties not measured in the laboratory. Many of the interpretations we are now making are based largely on *estimated* properties and some of these estimates were made from little factual information. In the future we need to obtain laboratory characterization of soils in counties mapped before the soil characterization laboratory was started. We especially need to measure *field* properties such as hydraulic conductivity (permeability), seasonal water table depths, available water capacity, and bulk density (to characterize compaction) which are necessary for designing farm drainage systems, on-site waste disposal systems, predicting the water storage in soil profiles, and recommending suitable tillage systems. We also need to measure crop yields, especially on sloping and eroded soils, to support yield estimates made for land evaluation and tax assessments.

On-site Investigations

Soil maps can be used for many interpretations, but for some soil uses a soil scientist must investigate specific conditions of the site. This is especially important for on-site waste disposal—whether or not a system can be installed and, if it can, where it should be located, how it should be designed, and when and how it should be constructed. The nature of these investigations and the relation of soil properties to the kinds of recommendations made are not well established. They need to be determined in conjunction with the On-Site Waste Disposal Project. In agriculture, on-site investigations will continue to be needed for installing drainage systems, constructing erosion control and water detention structures, and planning other farm operations. Increasingly, soil scientists will be called on to identify soil compaction problems and advise how to prevent compaction and improve compacted soils. These investigations and interpretations also are not established.

Soil Mapping

Detailed soil maps and reports need to be prepared for special areas, such as research farms, developing areas, reservoirs and other high-intensity uses. They will draw on experience gained in the survey program.

It will be necessary to map land use and flood hazards during the growing season, which are necessary for land assessment, and store this geographic information in the computer. Soil scientists will be called on to assist with this mapping. Experience has shown that soil scientists learn about soil properties and how they relate to using the soil by mapping them. When phase 3 of the soil survey program begins a large group of soil scientists with this background will be available, but this storehouse of knowledge will not last forever. Some mapping programs will be necessary to provide training and experience for future generations of soil scientists.

Education

Education is a two-way street. Soil scientists need to be educated themselves as well as educate others. Many of the programs are new and the nature of the job will be determined by those in the position, in contrast to the previous soil survey program in which the nature of the job was well established before an individual soil scientist filled a position.

In this kind of innovative program, mistakes will be made, but to learn from them will require frequent interchanges between soil scientists and researchers, and among the soil scientists. To be effective in their work soil scientists must have a keen interest in maintaining and improving their skills. In the process many will obtain advanced degrees. They will also participate in short training sessions in Indiana or elsewhere. They must also be interested in teaching others such as conservationists, contractors, engineers, and sanitarians. They will continue some education programs in place since 1958 (21) and develop others as needs arise. How well these great information resources are utilized to better the patterns of land uses by Indiana citizens will depend on the ingenuity of workers training themselves for the future.

Summary

In 1902 the first soil survey in Indiana, for Posey County, was published. Beginning then, we have identified three phases of the survey. In the first phase, colored line maps were published for 64 counties between 1902 and 1959, mostly at a scale of 1 in:1 mi. (1: 63, 360). Jennings County, mapped in the early 1930s was the first county in the U.S. to be mapped entirely on air photos. Very little mapping was done during and immediately after World War II.

Our "modern" published surveys were produced, or are being produced in the second phase of the survey in which the mapping began about 1952 and the report was published in 1960. The surveys were all made and published on air photo base maps, mostly at a scale of 1:15, 840 (4 in.: 1 mi.) with some at 1:20,000 (3.2 in.:1 mi.). Now, (November, 1984) the field work is finished in 87 counties and 5 county surveys are in progress; surveys are published for 60 counties. The field work is scheduled to be finished in 1987.

The third phase of the survey, which begins as soil scientists complete their regular soil mapping assignments, will emphasize learning more about the soils mapped and helping people use soil information. Also, some "modern" surveys, made during a 35-year span, will need to be brought up-to-date and integrated with other surveys. The challenge is to protect one of the state's most precious resources for future generations.

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