The Creation of the Vermont State Data Base

A Program of Work
April 1983

School of Natural Resources
University of Vermont

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ABSTRACT

Recent technological advances in computer technology, data handling, manipulation and display have made the concept of a statewide geographically-related information system a reality. Generally referred to as a geographic information system or simply GIS, it not only provides an efficient data storage and retrieval system, it can also be used to model various events. Properly built and maintained, a geographic information system can often replace traditional point sampling methods with a complete population enumeration. Through cooperative efforts involving state, federal, University and private agencies and organizations, very detailed information can be efficiently collected, entered into a system and used fully by all parties. Failure to take such action will result in the needless waste of time and money collecting often duplicate information sets and being unable to properly analyze and use the information to its maximum value.

Until very recently data entry was a major stumbling block to the creation and maintenance of a state data base. Information layers such as landcover and use were very time consuming to enter into the system and to keep current. Current satellite imaging capabilities from space have now made yearly statewide updates in land cover a reality. In addition, the time involved to enter very detailed polygon and topographic information has also been reduced with the development of raster scanning and laser line following devices.

With proper planning, coordination and funding a statewide data base for Vermont can be in place by 1990. Sections of this information system will be available even sooner providing spatially located information to resource planners, decisionmakers, and administrators.

BACKGROUND

The concept of a Vermont resource data base was considered as early as 1979. At that time representatives from the Vermont State Planning Office worked on the idea, discussing it with The Soil Conservation Service (SCS) and other organizations. From this preliminary work it became apparent that a great many data sources were available but that their existence was not well known outside the collecting agencies. Often this has led to a duplication of effort with an associated expenditure of funds and personnel time that might better have been used in other areas.

By 1980 there was a general consensus that a statewide data base would be a great benefit to resource planning. The intent at that time was to establish a register or cataloguing system which would reference the different data bases by type, location, availability, reliability, and agency or group responsible for collection and maintenance. Unfortunately, this concept was never realized because of two main factors. First, no one agency or group had the expertise, funds, or time to dedicate towards its completion. Second, was the realization that no suitable framework or methodology was available to begin this massive task.

During this same time frame, the University of Vermont's School of Natural Resources began to explore the uses of a computerized geographic information system (GIS) to spatially store and subsequently analyze geographically referenced data. This work ultimately led to the acquisition in late 1980 of a commercially available GIS and host computer at the School of Natural Resources. This system was made possible by grants from the U.S. Forest Service, Digital Equipment Corporation and monies from the University of Vermont. This geographic information system is capable of providing the necessary framework to begin the establishment of a statewide data base that was envisioned back in 1979 and 1980.

The SCS in Vermont began to discuss the concept of a GIS in 1981. It was becoming increasingly evident to the agency that it needed a system to tie data bases together in order to facilitate resource planning at the town, regional, and state level. It was also evident that much time and money could be saved during watershed planning activities if a system existed to integrate different data bases. Because of these factors a GIS appeared to be a comprehensive approach.

In June 1982, a meeting was held at the Vermont SCS state office to discuss further the concept of creating a statewide resource data base. The SCS invited several individuals to attend. Persons attending this meeting included representatives from the SCS National Headquarters, Vermont SCS state staff, School of Natural Resources - UVM, NASA - Goddard Space Flight Center, and the Vermont Agency of Environmental Conservation. Several major points came out of the meeting. These included:

- Several agencies and groups share common data needs.
- Each agency has specific expertise in its resource areas and different data collection techniques.
- Interagency cooperation would be helpful in fulfilling total data needs.
- A state resource data base should be a major goal.
- A state data base would provide greater resource information for all data users within the state.
- Current technology to initiate a state resource data base is available in the School of Natural Resources, UVM.

A second meeting was held in June 1982. Persons attending this meeting included representatives from state and federal agencies and the private sector. Attendees expressed strong support for a state resource data base.

A four-member committee, representing SCS, UVM School of Natural Resources, Vermont State Planning Office, and the private sector, was established to investigate the requirements of creating a state resource data base. This committee met and developed a draft framework plan for the data base creation.

OBJECTIVE

The principal objective of creating a statewide data base using a GIS is to facilitate resource planning through the integration of multiple information sources and expertise of several state and federal agencies, the University of Vermont, and various private groups.

Using a GIS will address multi-agency needs and take full advantage of multi-agency expertise as outlined in the June 1982 development meeting. Numerous data bases will be integrated and the system will have flexibility to incorporate future information sources.

The GIS will have application in many resource areas and can revolutionize the entire area of data collection, analysis, and storage. In addition to registering existing data bases for tabular and graphic display, the GIS will generate new data by interfacing initial data layers. This capability will allow more rapid, accurate, and cost-effective resource analysis.

APPLICATIONS

Present

The GIS will be used in numerous ways to fill data needs of state and federal agencies and private groups. Some of the uses to fill current data needs are as follows.

Watersheds - Provide acceleration to planning. Information to be gained includes:

Land Use

Cropland characteristics by:

- soil types and productivity
- flooding
- erodibility (K factor, percent slope, slope length)
- etc.

Critical eroding areas

The GIS will provide the capability to rapidly quantify these parameters at the watershed and subwatershed level. For ongoing watershed projects in the St. Albans Bay and Laplatte River regions the system will provide the capability to rapidly monitor and quantify land use changes. This information is needed to evaluate land use change as it relates to project activity and water quality.

Resource Planning - Provide rapid quantification and graphic display of current and changing land use by soils at town and regional levels. This will provide invaluable data to evaluate the use of prime farmland soils (SCS national definition) and primary agricultural soils as defined in Vermont's Land Use and Development Law, Act 250. Digitized soils information will provide the capability to produce numerous interpretive maps. These kinds of information are essential to local and regional land use planning as it relates to policy making. By integrating such information with other data sources, the SCS will be able to provide current, accurate, and comprehensive information to decisionmakers. Such information will also be helpful in implementing the Agricultural Land Evaluation and Site Viability Assessment Program.

Spatial location and graphic display of installed septic systems, waste storage facilities, and sanitary landfills relative to streams, waterbodies, springs, wells, and ground water recharge areas will provide invaluable information useful in correcting and preventing water quality problems.

All of the foregoing analyses will be useful in the Resource Conservation Act (RCA) Appraisal Process.

Future

Although the above uses are already known, it is anticipated that additional uses will occur as the system is developed and expanded. Because of this, the GIS is viewed as a nonending source of resource data storage, analysis, and display. It will continue to fill ongoing and new data needs for years to come. Some potential future uses are as follows.

National Resource Inventory (NRI) - Evaluate the capabilities of the GIS to fill data requirements of the NRI, thereby reducing SCS staff time to conduct NRI field work. If this process proves to be technically and economically feasible, an evaluation should be done to link the data with data derived by the U.S. Forest Service during Continuous Forest Surveys. Such integration will provide current and comprehensive resource data for decisionmakers at regional and state levels. Such data will also serve decisionmakers in the RCA and Resources Planning Act (RPA) appraisals.

Resource Planning - The GIS has potential for use in conservation planning with individuals, groups, and units of government. Data layers needed in conservation planning can be integrated and reproduced on an available orthophoto base with a scale of 1:5,000.

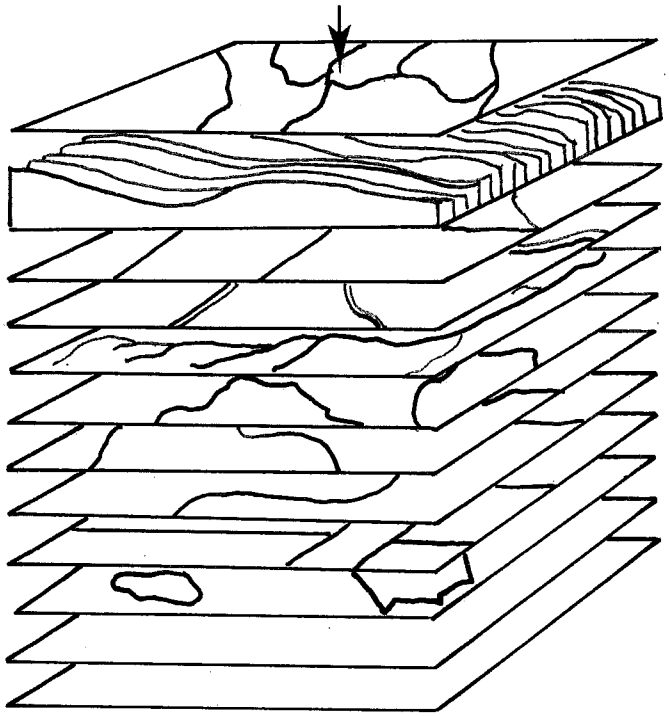
PROGRAM OF WORK

Overview

The creation of a computerized geographic information system entails the spatial referencing of various data sources in what are commonly called "data layers." Until very recently these systems were severely hampered by the time consuming task of data entry. As a result, detailed analysis has been limited to relatively small geographic areas, often 50,000 acres or less in size. Analyzing large areas usually involved working with grid cells between 10 and 40 acres in size. For these large grid cells the dominant feature would be assigned to represent the entire area. Statistics from this large grid cell data base were adequate for statewide statistics but were not suited for county, town or watershed analysis. Recent technological advances have now made the possibility of creating a very detailed data base for a state a reality. The July 1982 launch of LANDSAT 4 with its 30 meter resolution Thematic Mapper has made efficient, detailed large area land cover mapping a reality. Not only can this imagery be used to create the initial land cover layer, it can also be used to provide timely updates to the data base. Another significant aid in creating a statewide data base is the increased availability of pre-digitized data on computer compatible tape. Digital Terrain Tapes (DTT) and the Digital Elevation Model (DEM) tapes may be input to a system to provide topographic detail. One of the biggest aids to the data entry process is the development of raster scanning and laser line following digitizing systems. These systems greatly decrease the data entry time and expense to enter detailed polygon maps, such as detailed soil survey maps.

Figure 1 is the flow chart diagram for the Vermont geographic information system. This figure shows the initial data layers to be included in the system. Additional layers will be added as needed.

A GEOGRAPHIC INFORMATION SYSTEM for VERMONT



SOILS

TOPOGRAPHY
slope, aspect, elevation

POLITICAL BOUNDARIES

TRANSPORTATION

STREAM COURSES, WATERSHEDS

LAND COVER/USE

GROUND WATER

GEOLOGY

SOCIO-ECONOMIC FACTORS

HISTORICAL/ARCHAEOLOGY

FUTURE EXPANSION

FUTURE EXPANSION

DATA ENTRY

MANUAL DIGITIZING

VIDEO or LASER DIGITIZING

SATELLITE or DIGITAL AERIAL PHOTOGRAPHY

AVAILABLE COMPUTER DATA

COMPUTER STORAGE

ANALYSIS

MAP OUTPUT
1. composite maps
2. perspective maps
3. route analysis
4. enlarged maps
5. reduced maps

TABULAR or STATISTICAL INFORMATION

The creation of the geographic information system for Vermont will be conducted in three phases. The areas of coverage for each phase are shown in Figure 2. The establishment of these areas was primarily driven by the availability or projected availability of both detailed soil survey maps and state orthophoto basemaps. Within each phase the project is further broken down by county priorities. The priority for county one is shown in Figure 3. The priority ratings for phases two and three are shown in Figures 4 and 5 respectively.

This project will concentrate its efforts in Franklin County during the first year. This county has been assigned the highest priority within the first phase of the project. Serving as a pilot area, Franklin County will be used to thoroughly test the methodology, information quality and data entry procedures that will be employed to complete the entire state. It will also assist the ongoing SCS/UVM "St. Albans Bay Watershed Rural Clean Water Project Comprehensive Monitoring and Evaluation Program" by providing composite maps of spatially referenced information. At the conclusion of this first year an evaluation of the system will be conducted to define problems and correct methodologies prior to starting the succeeding year's work in Chittenden and Addison Counties.

The Geographic Information System at the University of Vermont

The geographic information system at the University of Vermont is located within the School of Natural Resources. This sophisticated system is commercially available and distributed by the Environemntal Systems Research Institute of Redlands, California and functions in both grid and polygon format. Its analysis capabilities include, but are not limited to, polygon overlays, slope and aspect calculations, boolean algebraic functions, suitability analysis and route selection. Currently this GIS is installed on a Digital Equipment Corporation VAX 11/750 computer. Peripheral support

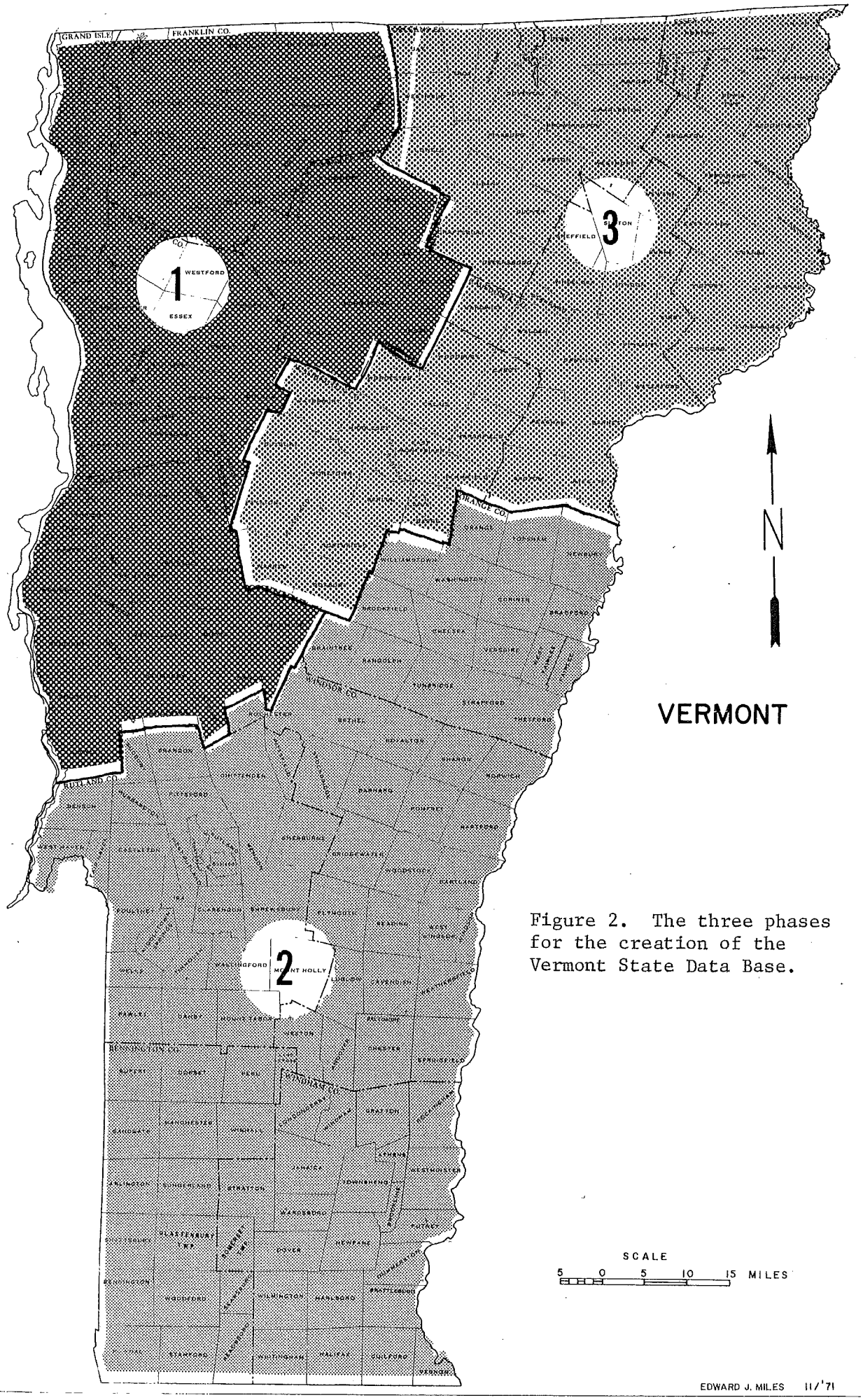


Figure 2. The three phases for the creation of the Vermont State Data Base.

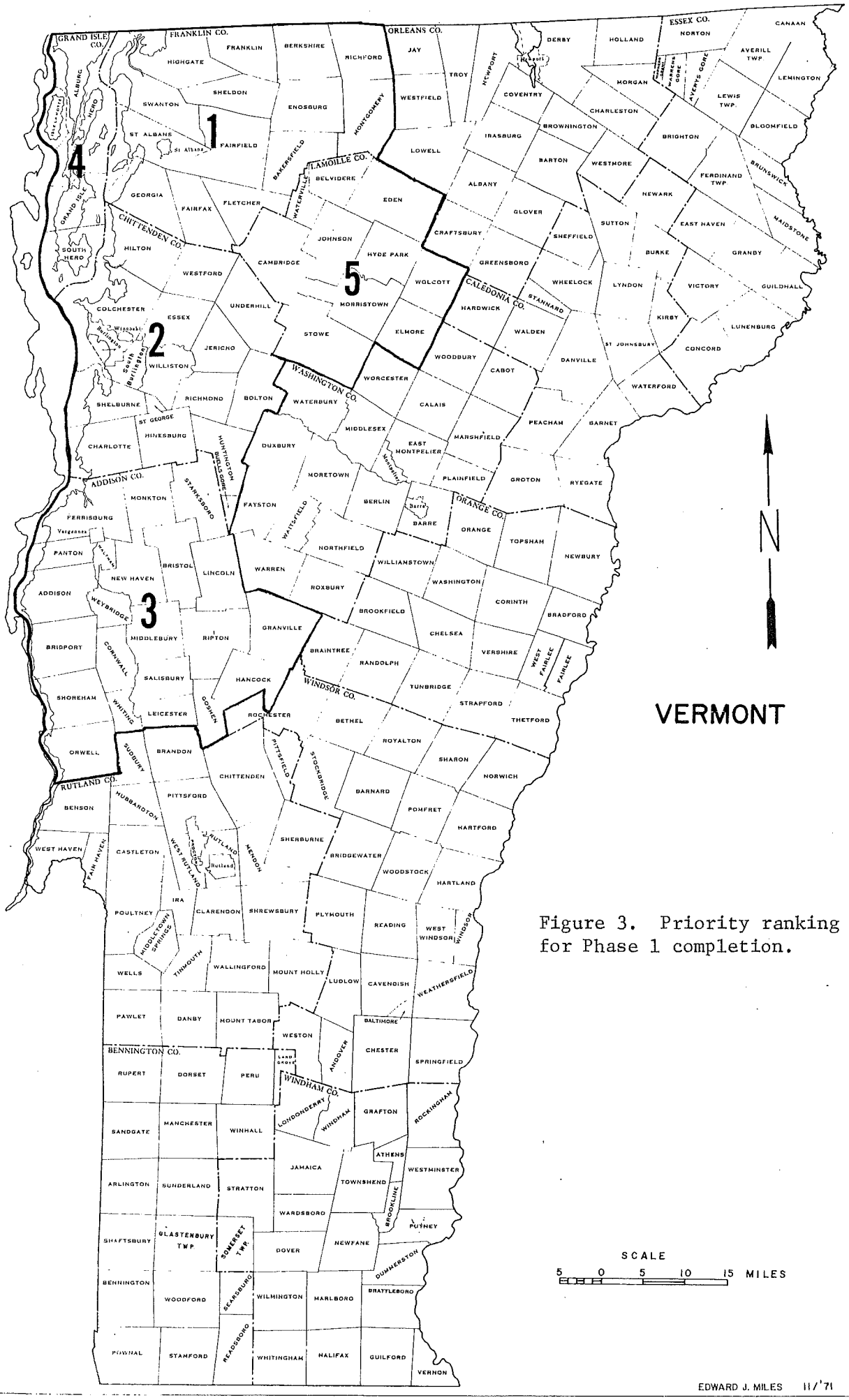


Figure 3. Priority ranking for Phase 1 completion.

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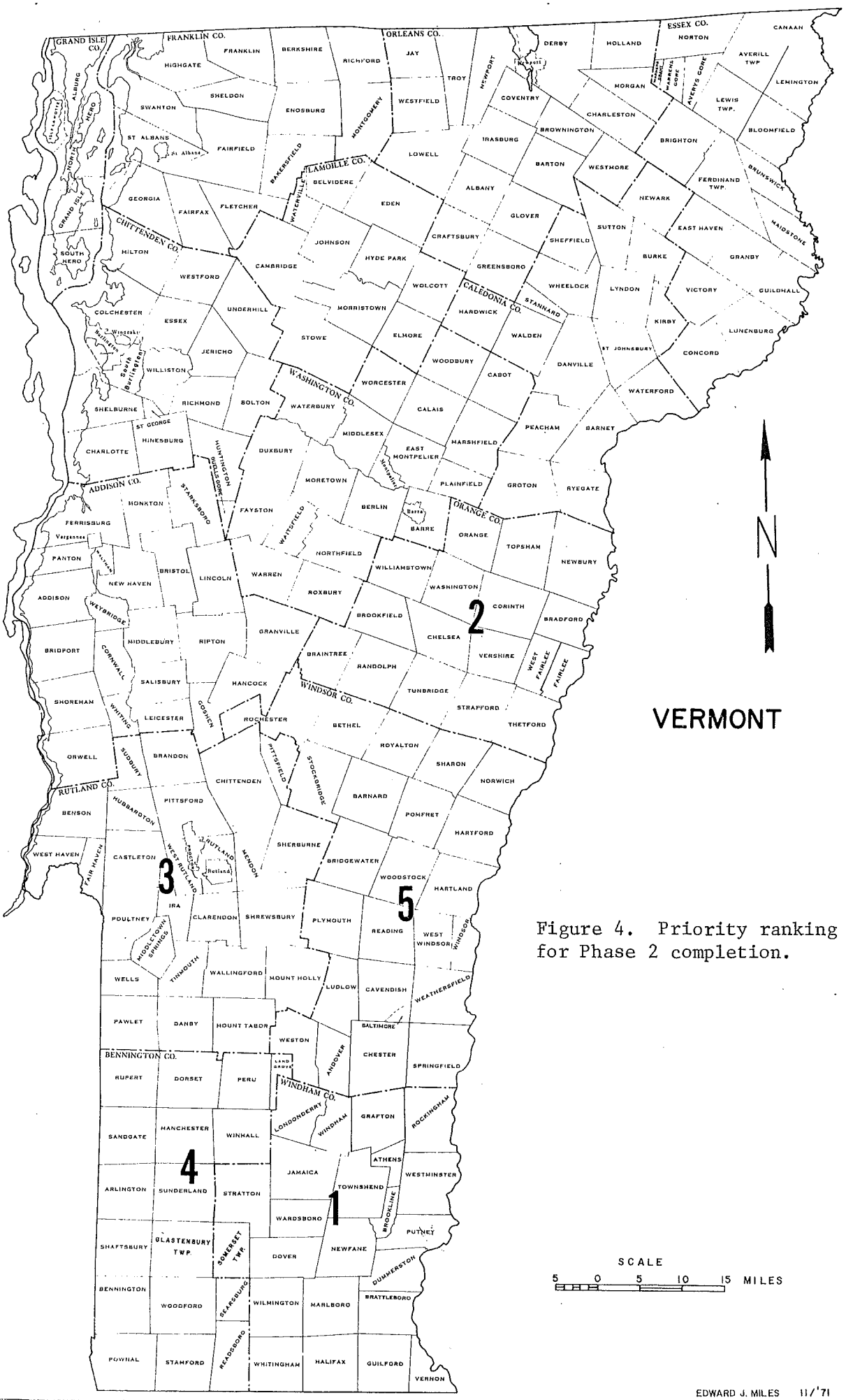

Figure 4. Priority ranking for Phase 2 completion.

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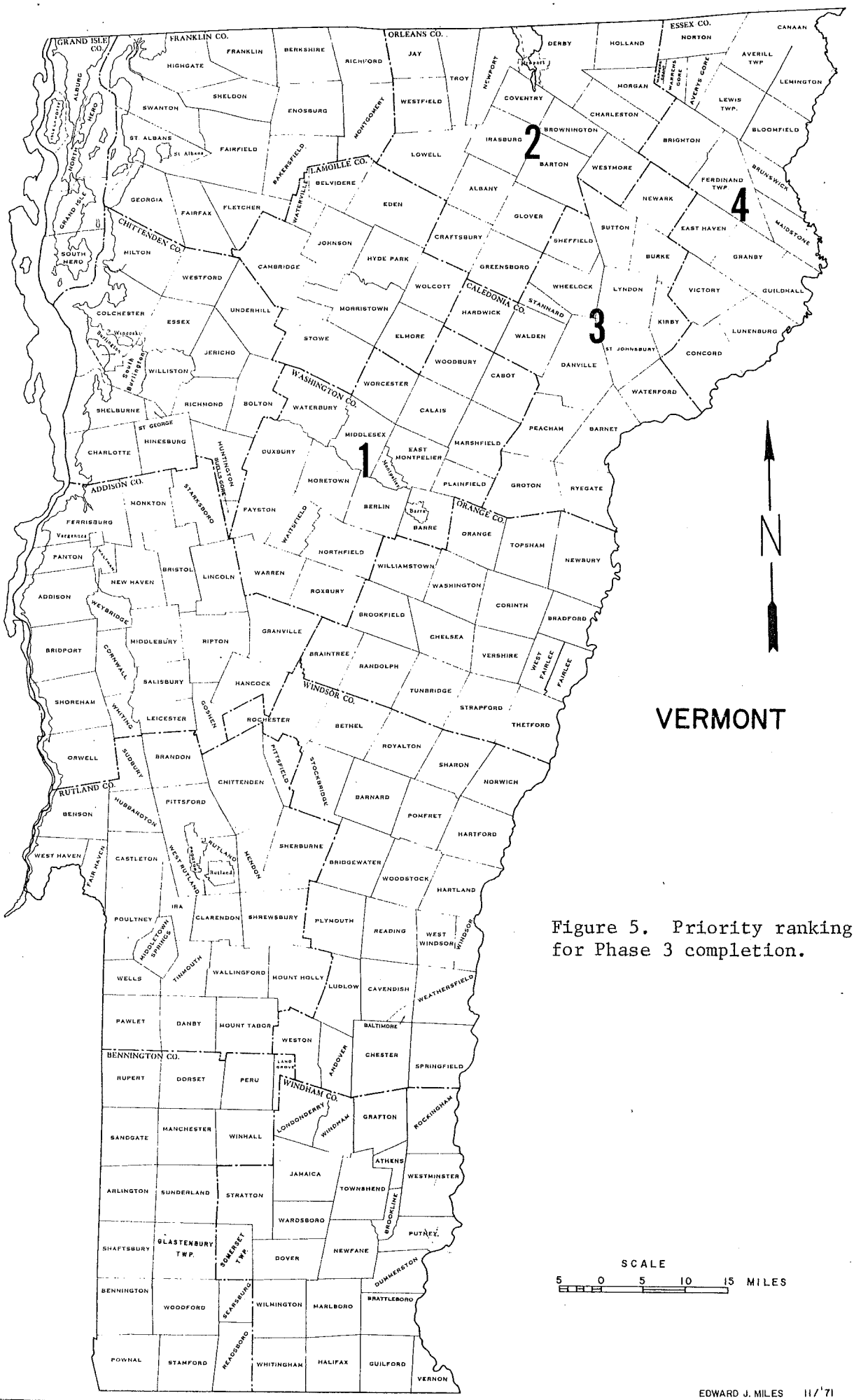


Figure 5. Priority ranking for Phase 3 completion.

equipment includes a 127 megabyte disk drive, an 800/1600 BPI tape drive, line printer, 36" four-color Houston Instruments drum plotter, 6 video terminals, 2 printing terminals and a large Talos digitizing table, coupled with a DEC 11/03 micro computer serving as the principal data entry mechanism. Other means of data insertion include reading from computer tape and direct keyboard entry.

The VAX computer at the School of Natural Resources is linked to the University's main computer, a DEC 2060 by a commercially known system, "DECNET". This system makes remote access to the GIS possible to anyone able to reach the DEC 2060. Direct access to the VAX could also be possible with the addition of appropriate communications equipment.

Data Layers and Entry Procedures

The data layers to be included in the initial work within Franklin County include the following:

1. Soils
2. Topography
3. Political Boundaries (Towns)
4. Transportation Networks
5. Stream Courses, Watersheds
6. Land Cover/Use
7. Ground Water

These data layers will form the nucleus of the system and will provide the opportunity to evaluate various data sources and entry procedures. It is anticipated that additional counties will be completed more efficiently due to techniques learned in Franklin County.

The State of Vermont's orthophoto base maps produced at a scale of 1:20,000 will be the base map from which much of the information will be digitized. Each of these maps are approximately 30" square. It will take 13 map sheets to cover all of Franklin County. The orthophoto base map will be used because it is the most accurate available map source and can be obtained at the same scale throughout the state. The scale of 1:20,000 was selected for two principal reasons. First, it provided the opportunity to include enough detail to be useful at the town and watershed level. Second, all of the current and planned detailed soils mapping in the state is accomplished at this scale. Because the soils information is currently the most complex data layer to be entered into the GIS, working at this scale will greatly simplify the data entry process and cost of including this information.

For the actual data entry process, political boundaries, transportation networks, stream courses, watershed boundaries and ground water points will be identified on overlays to the orthophoto base maps. The desired information will be digitized from these overlays. This will reduce the possibility of introducing errors in relative spatial position into the data base. Specific information and details on its entry procedure into the data base is contained in the following text.

SOILS The soils data layer is the most complex and time consuming part of the proposed system. The current detailed soils mapping for Franklin County was completed at 1:20,000 scale aerial photography. Soil boundaries will be transferred to an overlay of the orthophoto base map from either copies of the archived prints of the annotated photography or negatives of the published prints. Current plans call for these overlays to be digitized with automated scanning equipment. The output product will be a vector formatted computer tape that will be read into the geographic information system. Once it is

within the GIS each soils polygon will be annotated with the appropriate descriptive information.

TOPOGRAPHY Topographic information will be entered directly from the Digital Terrain Tapes (DTT) available from the U.S. Department of Interior, Geological Survey's National Cartographic Information Center. This information was derived from the 1:250,000 scale series of maps by the Defense Mapping Agency Topographic Center (DMATC). DMATC developed the Digital Topographic Data Collection System which records two types of data; elevations as contour lines and points, and stream and ridge lines. This information is sorted, matched and resorted to obtain a grid of elevation values for every 0.01 inches on the map (approximately 200 feet on the ground). Undefined points on this grid are found by either linear or planar interpolation. Once this information has been entered into the GIS, slope and aspect variables can be derived. Since this information is taken from such a small scale map, there is some concern about the spatial accuracy of this data. An evaluation of this information will be completed to determine the desirability of this data for inclusion in the rest of the state.

POLITICAL BOUNDARIES This information includes the boundary of Franklin County and all of the 15 towns within the county. Current plans call for the boundaries to be transferred to an overlay of the orthophoto base map from the USGS topographic maps. This line information will be hand digitized on a digitizing table and entered into the data base.

TRANSPORTATION NETWORKS Transportation networks such as highways, railroads, power and pipe lines will be digitized from overlays of the orthophoto base maps. This information will display the actual right-of-way and have associated with it supplemental information of ownership, class, and type of surface.

STREAM COURSES, WATERSHEDS This information will also be identified and digitized from overlays of the orthophotos. Where difficulty is encountered in identifying the course on the orthophoto, other sources such as aerial photography and the topographic maps will be used to assist the mapping process.

LAND COVER/USE The initial Land Cover/Use data layer for Franklin County will come from the digital image processing of a LANDSAT 4 Thematic Mapper image recorded on October 26, 1982. Work on the processing of this scene has already begun at and with the assistance of personnel at NASA's Goddard Space Flight Center. Once the classification process is complete, the categorized data will be put onto a computer tape in a format that can be read directly into the GIS at the University of Vermont.

GROUND WATER The first step required for this data layer is the spatial location on the orthophoto base maps of the approximate 1,500 well logs that have been recorded by the State of Vermont's Department of Water Resources. Associated with each of these points are variables of depth, flow rate and depth to bed rock. The number of wells to be added is dependent upon funding and the availability of Water Resources personnel. From this information it is hoped that major aquifers can be identified through an interpolation process.

Expected Results

The principal result of this work will be the completion of an efficient, multi-purposed data base that can provide resource planners and managers with the proper information to make critical decisions that have far-reaching, long-term impacts. As Figure 1 shows, the information contained in this geographically referenced data structure can be portrayed in both map and

tabular form. The uses of the state data base go beyond the obvious basic acreage summary of a particular land use or graphical display of all prime agricultural lands in a particular town. It can be used to model various events, such as converting all forest land currently occupying prime soils to agricultural uses. It may be able to predict potential contamination to ground water systems by superimposing the location of hazardous waste sites over derived aquifer locations. Simply stated, the Vermont Geographic Information System has no defined limits on the results or information it will be able to provide.

Not only will this system reduce or eliminate duplicate data set collection by various groups and agencies, it will provide a common framework or data structure for future surveys. The ultimate goal will be superior information at a greatly reduced cost to all users of the system.

Definition of Roles and Responsibilities

This comprehensive multi-year project to establish a Vermont Geographic Information System will be initiated by the U.S. Department of Agriculture's Soil Conservation Service and the University of Vermont's School of Natural Resources. After the first year's pilot work, additional cooperating parties, specifically the State of Vermont, will be sought to assist in the project.

Specific roles for the initial two participants are outlined below.

Soil Conservation Service-USDA

The Soil Conservation Service will:

- provide federal funding as funding allocations permit
- provide original field soil survey field sheets and negatives of the Atlas sheets for data input
- provide for quality control check of soil data transfer and input

- provide leadership in defining attributes to be used for soil interpretations
- conduct certain field surveys and ground truthing as needed to supplement the GIS development
- compile and provide those additional data bases that are of interest to the agency
- analyze NRI data at MLRA level as it relates to GIS capabilities to help determine feasibility of replacing part of NRI work with GIS functions
- provide technical consultation and assistance as appropriate

School of Natural Resources-UVM

The School of Natural Resources will:

- provide nonfederal cost-share funds as negotiated annually
- provide computer resources, personnel and laboratory facilities
- provide leadership, coordination, and technical support throughout the project
- collect, analyze, and prepare data sources for entry into the geographic information system
- identify and use the most efficient, cost effective method of data entry for each data layer
- conduct surveys and ground reference checks as required to supplement system development and assure quality control
- provide SCS with plotted soils information for quality control
- make data immediately available to other parties to the agreement as needed
- provide educational opportunities for students

- provide administrative and budget control and required final reporting to SCS
- formulate annual plans in consultation with participating parties
- actively present results to appropriate technical meetings, symposiums, etc.

Reporting Requirements and First Year Time Table

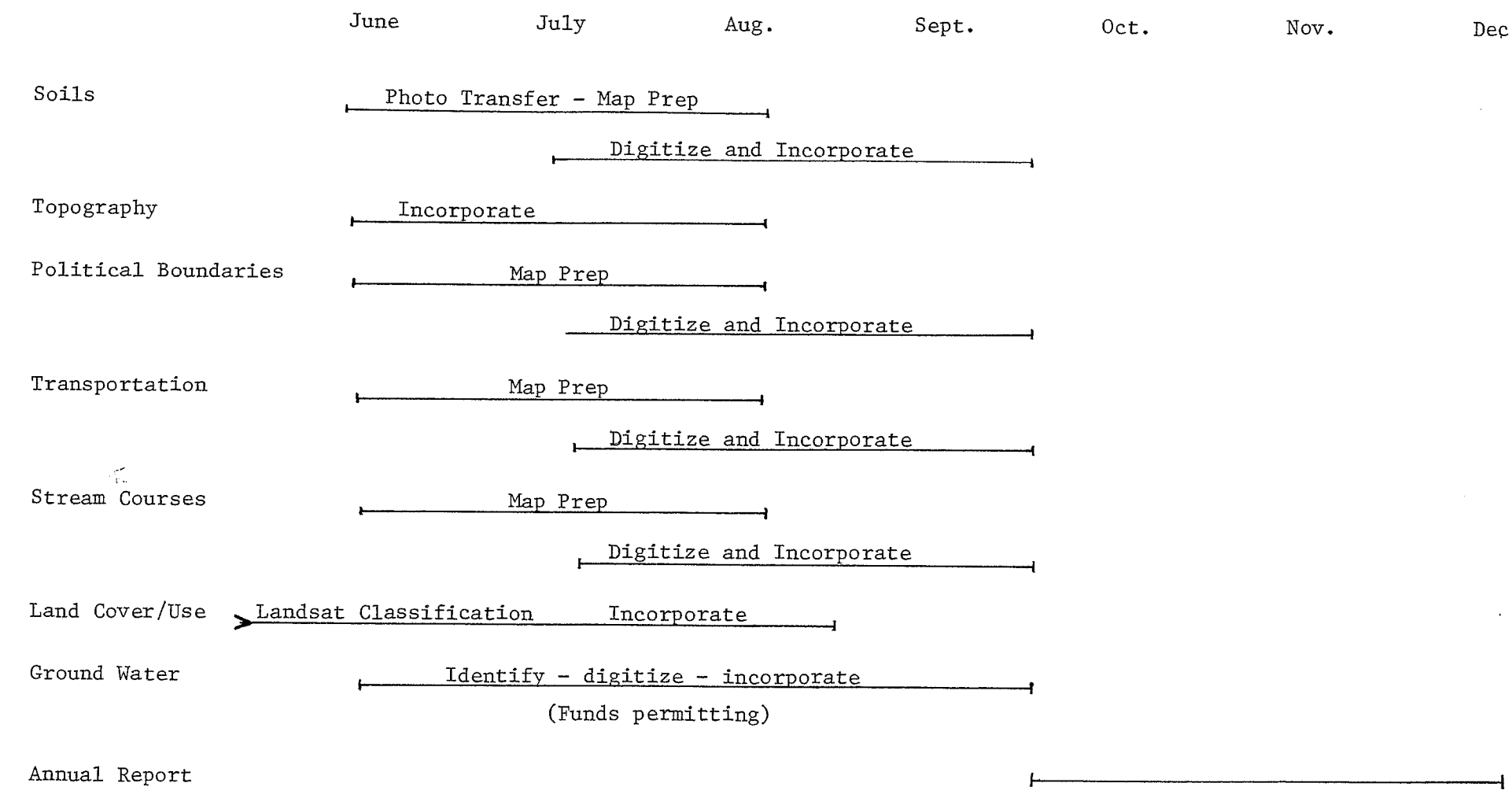
The University of Vermont, School of Natural Resources, through its principal investigator shall have the ultimate responsibility for evaluating all data layers included in the state geographic information system and for preparing all written reports. During the first year of this project, the principal investigator will meet with the SCS on a monthly basis to review progress to date and to adjust as necessary the time table shown in Table 1.

Annually, a written progress report will be prepared and submitted to the Soil Conservation Service. This report shall include, but not be limited to:

1. A narrative description of the Vermont Geographic Information System with supplemental maps and tables as needed for clarity.
2. A narrative description of all findings to include data layers entered, source of information used, and data entry procedures.
3. A summary of all the data by geographic area that has been entered into the system.
4. A summary of the various uses and users of the data base.
5. A projected program of work for the next two years.

At the conclusion of the project the principal investigator will submit a comprehensive final report describing the data base. This report will follow the same format for the first 4 items that are included in the annual report.

Table 1. Time Table 1983



Program Budget

A. Total Program Budget — Years 1983 through 1990 (1983 dollars)

	Estimated Cost
Phase 1	
Franklin	87,500
Chittenden	87,500
Addison	75,000
Grand Isle	50,000
Lamoille	75,000
Phase 2	
Windham	75,000
Orange	75,000
Rutland	75,000
Bennington	75,000
Windsor	75,000
Phase 3	
Washington	75,000
Orleans	75,000
Caledonia	75,000
Essex	75,000
	1,050,000

B. Total Program Budget Summary (1983 dollars)

Project Year	Fiscal Year	Budget
1	1983	87,500
2	1984	125,000
3	1985	139,584
4	1986	139,584
5	1987	139,584
6	1988	139,584
7	1989	139,584
8	1990	139,584