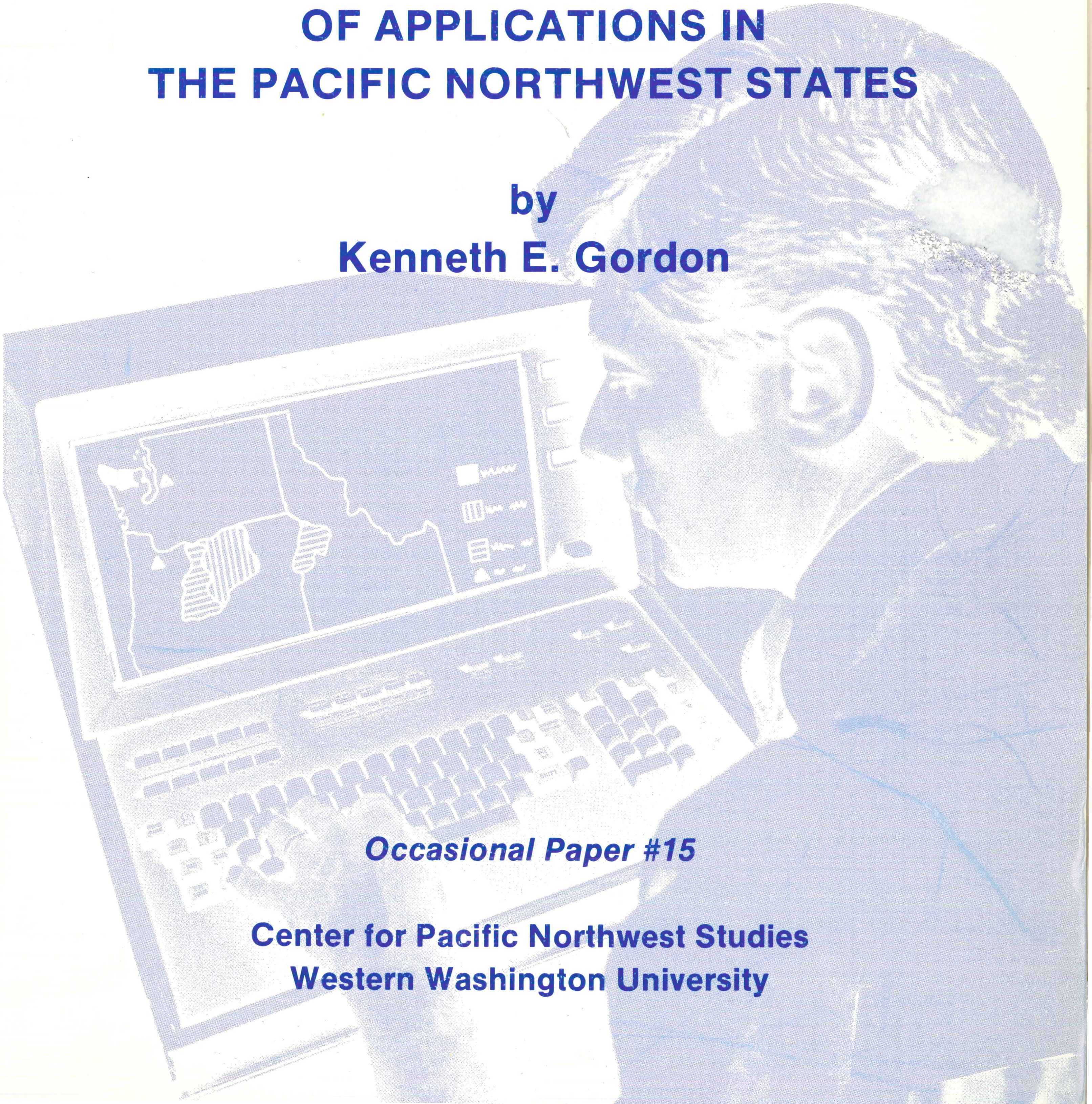
ENVIRONMENTAL DATA USE IN COMPUTER-ASSISTED DATA HANDLING SYSTEMS:

THE RESULTS OF A SURVEY OF APPLICATIONS IN THE PACIFIC NORTHWEST STATES

by

Kenneth E. Gordon



Occasional Paper #15

Center for Pacific Northwest Studies
Western Washington University

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PREFACE

Research on the topic covered in this volume was begun five years ago when the author was a graduate student in the Department of Geography and Regional Planning, Western Washington University. His M.S. thesis provided a basis for further research undertaken as a result of two NASA--Ames University Consortium Agreements--NCA2-OR862-801 (completed December 1978) and NCA2-OR862-001 (completed July 1980). The first of these was an investigation of data use and data processing practices of agencies and firms in the Pacific Northwest, the second an analysis of environmental data handling in geographic information systems in the Pacific Northwest.

The present publication, included in the *Occasional Papers* series of the Center for Pacific Northwest Studies, is an edited version of the report submitted to the NASA-Ames Research Center in July 1980.

Apart from a number of minor editorial changes, some reorganization of the material has been undertaken. However, the findings of the report and the mass of factual information that was gleaned and sorted from the questionnaires remain intact.

It is a pleasure to include in the series a volume we hope will be a useful reference work in the social and environmental sciences.

James W. Scott
Director

February 1981

ACKNOWLEDGMENTS

Acknowledgment is due the many persons who have aided this investigation: Dr. James Scott and Eugene Hoerauf of the Department of Geography at Western Washington University; NASA-Ames staff and affiliates, especially Don Wilson and Frank Westerlund; the Technology Transfer Task Force; the reviewers of the draft of this report including: Kristina Brooks of the Department of Geography, Oregon State University, Doris Steingraber of the Computing Service Center, Washington State University, and William Todd of Technicolor Graphic Services, James Scott and Don Wilson; and the many individuals within agencies who took time to respond to the questionnaire.

The editor would like to acknowledge the help given in the preparation of the manuscript by Mary Rudd, Department of Geography and Regional Planning and by Florence Preder of the Bureau for Faculty Research, who typed the final version of the manuscript.

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I. INTRODUCTION

The report on which this publication is based was prompted by significant interest in computer-assisted methods for the storage, manipulation, analysis, and display of spatial data. Many public agencies, research institutions, and private corporations have found computer-assisted methods for handling data to be cost-effective. This is especially true if the volume of data is great, if many types of data are to be analyzed, if diverse output products are desired, or if time is a factor. Many generators of primary data at the federal and state levels have recognized efficiencies in the collection and storage of spatial data in digital form, in addition to conventional mapped form. Nationally, many states and various resource management, planning, and environmental protection agencies within states, as well as municipalities and their agencies have developed--or are in the process of developing--land and natural resource information systems.

The specific purpose of the study is to investigate issues of environmental data use and data handling practice in these particular data processing systems, and the problems that may arise for the ultimate users of these systems and the data they provide. Recognizing the present trends toward computer storage of environmental data bases, and the increased interest in and use of computer-assisted methods for spatial data handling, this report seeks to provide users of environmental data with additional information upon which to base data management decisions. The report is therefore directed at users of primary and secondary environmental data but more specifically the persons within agencies who make data management and information use decisions. A basic familiarity with computer terminology and issues of spatial data handling is assumed.[1]

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[1] A glossary of terms is provided at the end of the volume on page 147.

NARROWING THE FOCUS

Content

The primary concern of this investigation is spatial data handling, which encompasses the following operations: 1) data acquisition; 2) changing the data to useful formats; 3) storing the data in or on some medium; and 4) retrieving and manipulating the data for display and analysis (I. Calkins and Tomlinson, 1977, p. 35).[2] Spatial data handling systems vary greatly depending upon the functions they serve, although each in some way performs all of the above mentioned operations. The spatial data collected will include observations, statistics, modeling results and like information concerning geographic features, locations, distributions, and areas represented as points, lines, or area coverages. Spatial data handling systems include data base management systems, map production (cartographic) systems, geographic information systems, and various special hardware and software configurations. The term system is used loosely to refer to techniques and equipment to perform operations on data.

The spatial data with which this study is particularly concerned are such natural resource and environmental data as soils, geology, hydrology, and climate. The study focuses on the characteristics of the systems which handle these data with computer assistance, and the experience of the users of these systems. These systems and the agencies which use them are of particular importance because they represent attempts to standardize data handling procedures and practices, and demonstrate the utility of computer-assisted data handling techniques.

The Region

The Pacific Northwest, for the purpose of this study, refers to the states of Idaho, Washington, and Oregon. The choice of the Pacific Northwest as the study region, though determined in large part by geographical proximity, is especially appropriate due to the existence of an innovative program of data and technology application that involves federal, state, and local agencies. The program is administered by a task force of the

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[2] The reference notation refers to entries in the bibliography, which is divided by subject. The Roman numeral refers to the subject heading in which the reference may be found.

Pacific Northwest Regional Commission. The task force is comprised of representatives of data users, and it includes also representatives from NASA and the United States Geological Survey. The program, now called the Landsat Applications Program, began with a series of demonstration projects which were to evaluate the use of Landsat imagery for various disciplines. One phase of the project was an investigation of the feasibility of an operational land resource information system for the region. Within each of the three states, various state agencies are developing information systems to serve statewide data needs, while municipal governments and corporations are in various stages of system design. There are thus many practical applications for which this study is directed.

Need

Computer-assisted spatial data handling is possible due to many recent technological advances and, as the technology continues to change, new applications are made possible. Because of the many recent developments, there is an acknowledged need to know "who is doing what?" "what is available from where?" and "what is possible when?" The inventory of what exists, what problems may arise, and what is desired are basic preliminary steps for information system design. When the Technology Applications Task Force was approached to endorse a study of computer-assisted spatial data handling in the region, it was recognized that increased knowledge of the characteristics and needs of spatial data users, and also insights into the present state of application of computer-assisted techniques could be very useful for technology transfer decisions, as well as providing an excellent reference work for participating agencies and interested individuals.

The Task Force had previously sponsored a study of user need for an operational Landsat data analysis system in the region (III. Westerlund and Wilson, 1977), but that study was limited with respect to the purpose of the present investigation in the following ways:

1. The agencies surveyed were limited to selected agencies participating in the resources inventory demonstration project;
2. The focus of the study was upon the use and investigation of Landsat and related data provided by remote sensing.

It was thus recognized that this research would complement and enhance the information gathered under the previous User Needs Study and provide, by association, added insights about computer-assisted spatial data handling in this country.

OBJECTIVES

Following a review of the literature on spatial data management, in particular that concerning information system design and evaluation models, [I. Calkins 1972; I. Dueker and Horton (undated); I. Shelton and Hardy 1974; I. Calkins and Tomlinson 1977; and I. Tschanz and Kennedy 1975] four objectives were identified for the present study, and a series of questions formulated. The four objects are as follows:

1) to study the issues of data selection and use in an information system design context;
2) to develop a preliminary directory of geocoded environmental data and geoprocessing systems in the region;
3) to determine which type of applications, geographic data parameters, and data processing capabilities are most prevalent and preferred for the various types of geoprocessing systems and for the types of agencies for which the use of environmental data is routine;
4) to comment upon the status of geoprocessing in the region; and
5) to evaluate the appropriateness of the research technique for the inventory and analysis of spatial data handling needs and practices.

And the nine questions:

1. What are the implications of the choice of various data-handling options upon systems design?

2. What systems are now in use in the region? What tvpes of agencies have them, what are their principal characteristics, and what are they used for?

3. What categorical types, hardware/software configurations, and data handing capabilities of systems are characteristic of different types of users, and what are the characteristics of different types of systems?

4. What are the perceived data and geographic referencing needs and system use objectives of different types of users?

5. What types of editing, spatial analysis, and display functions are the most prevalent and preferred by different types of users, and performed by different types of systems?
6. What is the present availability of computerized spatial data? What types of data are in the systems, and what are the characteristics of these data?
7. What are the principal sources of spatial data for information systems?
8. Are geocoded data and the software programs which transform the data into usable form transferable and available for use by other agencies?
9. What factors limit the expanded use of the information systems?

It should be noted, however, that the purpose of this study is not to evaluate the limitations or potentials of any particular systems, but rather to gain knowledge of the ways computer-assisted spatial data handling systems and techniques facilitate the handling of environmental data, and to learn about the data handling, spatial analysis, and data requirements and practices of different user groups, and the potential applications and limitations of groups of systems.

DEFINITIONS AND DELINEATIONS

Systems[3] which store or process spatial data, with computer assistance, in such a manner that both the data and a geographic identifier are a part of the same data record--and can therefore be retrieved together for display and analysis--are called *geographic information systems*, *automated spatial data handling systems*, *geobased systems* or *geoprocessing systems*. The series of requisite operations is called *digital spatial data handling* or *geoprocessing*, and the data which form the spatially defined computerized record are called *digitized, geocoded, and georeferenced*, or *geoprocessed data*. All of the systems evaluated in this study consist of computer hardware and software which store and process spatial data, and georeferenced data records, often a maintained data base, which contain spatially distributed observations, events, or features. The sophistication of these varies greatly.

The terms "data" and "information" are used interchangeably to mean elements of description, even though there is a recognized distinction.

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[3] The term "system" is often used as a shortened form of computerized or computer-assisted spatial data handling system.

Data is normally defined by the particular users according to their purposes. For the purpose of this report, the term "data" is considered to be "facts, statistics, maps, observations, modeling results, etc., collected, processed, stored, analyzed, or otherwise manipulated during the course of a program to produce information." The term "information" refers to data which are deliberately acquired and formatted to be of some use. Any reference to "data" or "information" also assumes a spatial reference.

"User need" is implied to mean any product, characteristic, or capability requested (e.g., desired) by a user. A user may be an individual, agency, or division, for which interest in the use of spatial data is implied.[4]

Environmental data are considered to be that subset of all spatial data which define naturally-occurring phenomena and their characteristics. Another term to substitute for environmental in this context might be physical geographic or natural resources. Examples are the characteristics and nominal representations of features of the atmosphere, geologic phenomena, soils, physiographic phenomena, vegetation, and hydrologic phenomena that have discrete spatial boundaries. Such data may also include, by virtue of spatial generalization and interpretation, characteristics of zones of air quality, climate, habitat, visual quality, natural resource availability, etc. Specifically excluded are those entities which change their location quickly in time, move about in space, or have a separation in real distance less than the resolution (I. Kennedy and Meyers, 1977, p. 6).

THE SURVEY

The survey which provided data for the present study was performed between June and December 1978. The record of the survey is contained in a previous report prepared for the NASA-Ames Research Center (III. Gordon, 1978). The latter describes the purpose and origin of the survey, the content and conduct of the survey, and a preliminary record of response. A mailed questionnaire, followed by in-person or phone interview, was the method chosen to conduct the survey.

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[4] The characterization of the terms "data," "information," and "user need" is paraphrased from: I. Power, 1975, p. 9.

The Survey Population

The survey population consisted primarily of planning, natural resource, and environmental agencies, and the spatial data processing systems maintained by these. Data were acquired from thirty-nine federal systems, ten state systems, five regional systems, four municipal systems, and six corporate systems. Of these, the fifty most complete and representative responses were chosen for analysis in this report.[5] The sample was quite diverse. Among the agencies and systems included in the survey were the following: Environmental Protection Agency - STORET; Soil Conservation Service - Advanced Mapping System and Natural Resources Data System; Geological Survey - Digital Mapping Systems, Computerized Resources Information System (CRIB), Geographic Information Retrieval and Analysis System (GIRAS), Digital Image Processing System, and WATSTORE: Forest Service, Region 6 - TRI; Washington State Department of Natural Resources - Gridded Inventory Data Systems (GRIDS) and Calma Mapping System; Oregon Department of Revenue - Computer Assisted Mapping System (CAMS); and many municipal government and corporate systems - Puget Sound Council of Governments, Lane County, Oregon, City of Tacoma, Battelle Northwest Laboratories, Boeing Computer Services, and Weyerhaeuser Corporation.

Analysis Procedures

Various models for geographic information system design were consulted to select the key issues and information requirements that should be addressed in the process of the deliberate creation of a computer-assisted spatial data handling system. The questionnaire was designed to collect this information from the respondents.

The data from the questionnaires were coded, and then tabulated to provide an analytical examination of each of the research questions based upon the collective experience and perception of system users. More than thirty individual characteristics of the systems, the data, and the agencies' use of the systems were recorded from the questionnaire response. The

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[5] All of the questionnaires were sent to NASA for reference as a preliminary directory of systems and geocoded data. Available from the Technology Applications Branch, NASA-Ames Research Center, MS-242, Moffett Field, California.

responses were coded and keypunched and then tabulated, using the CROSSTABS option of the Statistical Package for Social Sciences (V. Nie, et al., 1970). Gathered primarily to create a directory of data systems, the information is used in this study to profile groups of systems and groups of data users. Such profiling assumes the existence of categories into which each response can be placed. The procedure developed is discussed in detail in Chapter II.

A Note to the Reader

The data handling issues discussed herein are selected from concerns normally associated with geographic information system design. The reader who is familiar with these issues and their implications will derive most benefit from this investigation. The findings can be used most effectively if applied within a systems development context.

Several design and evaluation schemes for geographic information systems have been developed to guide the system designer (I. Calkins, 1972; I. Tschanz and Kennedy, 1975; I. Kennedy and Meyers, 1977; I. Dueker and Horton, undated; I. Shelton and Hardy, 1974). The suggested procedures have been advanced to insure that all relevant issues are investigated, that the system components support each other, and that the working system meets the needs of the data users. These schemes offer step-by-step directions for the evaluation and selection of systems. Fundamentally, three types of issues are of concern to the system designer: issues relating to the data base--the characteristics of the data itself; issues relating to data retrieval and processing--including graphic and quantitative operations performed on the data; and system support--the resources (staff, buildings, equipment), operational and maintenance procedures, and formal arrangements necessary to implement and continuously operate the system (I. Tschanz and Kennedy, 1975, pp. 23, 24).

Throughout the process of system design, many choices must be made within the categories mentioned above. Issues of data specification such as scale, geographic referencing, classification detail, method of acquisition, etc., and issues of system specification including choices of hardware and software, response time and various operational policies must be addressed. These issues are called decision variables and each implies an ultimate choice from among selection options. For example; scale connotes choices of scale intervals and ranges; method of data acquisition connotes choices of various mechanical and survey techniques or the use of primary of secondary data; hardware connotes choices of preferred equipment options, makes and models. The ultimate design of a system is based upon the selection of appropriate options from the decision variables--options which meet user needs and are compatible with each other (I. Calkins, 1972, I. Calkins and Tomlinson, 1977). The design decisions may be divided into two types: 1) data decision variables referring to the choices of the types and characteristics of the data to be maintained in the system's data base, and 2) system decision variables referring to other choices of system design such as storage medium, degree of automation, equipment, response time, and user access.

The types of decision variables from which options may be selected are generally the same for any type of spatial data handling system. This is logical because each system has common elements of data, data handling equipment and operations, and the need to reference data spatially. Automated systems will have hardware and software options exclusive of manual systems, but the basic requirements are similar. Agencies with similar purposes and data handling needs should pick similar options within each decision variable, because their data handling requirements are similar. Each decision variable is linked to the rest of the system. Each option selected within each decision variable will influence other decision variables and options. For example, choice of scale will affect data accuracy requirements and data storage requirements.

The research questions imply that the questionnaire responses provide information on how certain types of systems and system users have resolved decision variables, and whether key considerations of effective system design and operation are being followed.

Another motive underlying the construction of the research questions is the feasibility of spatial data integration. Spatial data integration is the process of combining multiple spatial data types and providing for their mutual storage, retrieval, analysis, and display. Spatial data integration is one capability of geographic information systems which demonstrates their utility to the applied data user. The ability to perform spatial data integration, with computer assistance, is also dependent upon many factors of system design and application. Features of the data base and the data processing capability determine the feasibility and ease of spatial data integration in any system. The compatibility of data, and the utility of data for particular applications is determined by such features as scale, classification detail, precision, resolution, location identifier, and coordinate reference. The issue is whether data exist in the form desired or whether they can be transformed or otherwise interpreted to be useful. The transformation implies data processing capability (software) to perform the necessary functions of editing, storage, retrieval, format change, graphic and statistical analysis, measurement, and output. The ability of any system to integrate data is usually a function of the software available to perform these necessary operations.

The understanding of these spatial data processing capabilities, data characteristics, other decision variables, and their composite influence on system design and operation is, therefore, imperative. Explanation of the options and implications of each system design feature examined in this study, however, would be a separate treatise. In lieu of this, the reader is directed to the following:

1. The bibliography which is divided into three sections.
2. An appendix which introduces concepts of computer-assisted spatial data handling and examines two of the more basic and critical issues of spatial data handling: software options and geocoding options.
3. References that provide a broad, nontechnical overview of issues of spatial data handling and spatial data integration (I. Calkins and Tomlinson, 1977; I. Gordon, 1979; I. Honeycutt et al., 1980; I. Kennedy and Guinn, 1975; I. Kennedy and Meyers, 1975; I. Schneider and Amanullah, 1979; I. Tzchanz and Kennedy, 1975; II. Computer Sciences Corporation, 1979; II. Dueker, 1975).[6]

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[6] This is a representative listing from the bibliography and does not indicate an endorsement by NASA or by this author.

Chapter II. RESEARCH METHODS AND ANALYSIS TECHNIQUES

In this chapter a survey is described which sought information about the data handling activities and needs of a special group of data users and data suppliers in the Pacific Northwest. The special group of data users are the agencies and firms which have, or are anticipating the use of computer-assisted methods for the storage and retrieval of environmental data. The group of data suppliers are those which: 1) generate or maintain data which is georeferenced; 2) have programs to supply digital spatial data to data users; 3) have developed novel computer-assisted spatial data handling practices; 4) demonstrate any combination of the above. Endorsement for the survey was obtained from the Pacific Northwest Regional Commission's Technology Transfer Task Force[1] and funding to conduct the survey was granted by the NASA/Ames Research Center under a University Consortium Agreement.

The 1978 survey previously noted provided the data for the empirical examination of the issues of spatial data handling dealt with in this publication (III. Gordon, 1978). The remainder of the chapter describes the survey and the methods which are used to extract and analyze the data for this study.

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[1] In 1974, a Land Resources Inventory Demonstration Project was initated by the Pacific Northwest Regional Commission. A Land Resources Inventory TaskForce was established to pursue projects, and provide coordination. The task force consisted of state representatives and representatives from NASA and U.S.G.S. A five-phase program was developed, leading to the creation of an operational resource inventory system within the region. Over twenty individual remote sensing demonstration projects have been sponsored by the task force since its inception and though the operational information system is not yet realized, it is an active project in the ongoing, follow-on stages of the original regional demonstration. The Land Resource Inventory Task Force's name has been changed to the Technology Transfer Task Force, and the original Land Resources Inventory Demonstration is now referred to as the Pacific Northwest Applications Program. Further information on the activities of this project can be directed to the task force Chairman Wallace Hedrick, Resources Northwest, Inc., 775 N. 8th St., Boise, Idaho, or to Don Wilson, M/S 242-4, NASA/Ames Research Center, Moffett Field, California.

However, while the questionnaire provided the empirical data for this study, it should be noted that the purpose and scope of the questionnaire is not the same as that for this study. The original questionnaire was designed to be descriptive. It had to be explicit enough to provide information on the specific data handling practices and needs, as well as the data coverage and data characteristics of each respondent. In the present study, the primary concerns are regional patterns and the analytical focus is on representative groups of data users. It is necessary, nevertheless, to deal briefly with the original questionnaire in that all the data used in this study are derived from it.

PREPARATION OF THE QUESTIONNAIRE

Although the questions for the questionnaire were gleaned from many sources, an attempt was made to ask many questions similar to those in other studies so that comparison could be made (I. Calkins and Tomlinson, 1977; I. Comarc Design Systems, 1976; I. Tomlinson, ed., 1970; I. Tomlinson, ed., 1972; III. Mutter and Nez, 1977; III. Salmen et al., 1977a and b). The final format decided upon for the questionnaire was the result of collaboration between the author and NASA cooperators. Compaction was achieved by placing many of the questions in tabular form and structuring the questions in a manner which allowed simple checking from multiple response options or filling in a blank with a short statement.

THE SURVEY

Included in the survey were all public and private agencies and corporations in the Pacific Northwest region which collect, store, process, publish or utilize their own geocoded data files, as well as agencies that maintain data for the Northwest though situated outside the region made known to this author by practicing professionals, met the study criteria, and responded to the mailed questionnaires.

The recipients of the questionnaire have been divided into two groups. Group One consists of agencies located in the Pacific Northwest. Group Two consists of those agencies that have their headquarters or maintain their facilities outside the region, including many federal agencies.

Group One agencies were contacted by phone prior to the mailing of the questionnaire to determine whether they met the study criteria, whether they were willing to participate, and to whom the survey should be sent. A cover letter explaining the purpose of the questionnaire and directions for its completion, and a letter of sanction from the Pacific Northwest Regional Commission's Technology Transfer Task Force were attached to the questionnaire. A stamped, preaddressed mailer was also included.

On its return each questionnaire was checked to evaluate the adequacy of the response. In those cases where clarification was called for a telephone or in-person interview was conducted. Because of monetary limitations, only Group One agencies could be included in such follow-up procedures.

A list of questionnaire recipients is included as an appendix to the 1978 report (III. Gordon, 1978). Those agencies from which a completed or partially completed questionnaire was received are noted in Appendix 3.

THE QUESTIONNAIRE

The questionnaire was arranged in five main sections:

1. General systems description--including the stage of development, use environment, hardware, frequency of use, and extent of documentation.
2. Geographic information system software--including operating, planned or desired data handling capabilities, and an indication of their transferability and frequency of use.
3. Directory of geocoded data coverage--including the area of data coverage, type and characteristics of data, and purpose for which the data is coded.
4. Data collection and preference--including a list of natural resource data categories and space to indicate the characteristics of that data type which are representative of the data coverage, or are preferred were that data to be made available.
5. Information system/data use--including a list of applications for which the use of natural resource data is routine and space to indicate the characteristics of the data used for that purpose, or the characteristics of the data preferred for that purpose.

Table 2-1 details some of the information which could be gleaned from analysis of the completed questionnaires.

Table 2-1

Information Which May Be Obtained from Analysis of the Questionnaires

	Question Number
I. Documentation of the present stage of development and use of information systems in this region.	
1. For what purposes are geographic information systems used?	20.III.P, O. 22
2. How frequently is the demand for the use of the system inside and outside the agency?	12, 13
3. What is the geographic coverage of geocoded data?	20.II.
4. What are the perceived limitations for expanded system use?	15
5. How often is software in-house programmed vs. vendor supplied?	5
II. Data and system compatibility.	
1. Hardware	
a. owner status?	4
b. computer make and model?	6.a.
c. peripherals?	6.c.
2. Software	
a. programming language?	5.c.
b. is the system user friendly (query language)?	11
c. are programs transferable?	19
3. Data	
a. geographic coverage?	20.II.
b. appropriate data type?	20.III.N, O. 21
c. are the characteristics of the data in the system compatible (e.g., map projection, coordinate reference, scale, precision)?	H. J. L.
4. Records and Documentation	
a. is sufficient information available to verify the data?	14
b. is sufficient information available to learn about the system and its use?	16
III. Technology transfer (desire for data and software).	
1. Software What types of data handling routines are perceived to be valuable to enhance systems use (e.g., digitizing, format change, spatial rectification, measurement, sorting/merging, comparison, graphic output, and remote sensing)?	19

Table 2-1--continued

	Question Number
2. Data types and characteristics	
a. what types of data are desired by each respondent?	21
b. what are the geographic characteristics of the data which are desired by each respondent (e.g., frequency of update, scale, precision, coordinate reference)?	21, 22
c. what sources of data provide appropriate data for each respondent and for general categories of data use?	21, 22
IV. User profile	
1. What types of data are used for each general type of system use?	3, 7, 20, 21
2. What geographic characteristics of the data are most prevalent and preferred for each type of application?	3, 20, 22
3. What types of spatial analysis and editing functions (software) are most prevalent and preferred for each type of application?	3, 19
4. What equipment is characteristic of different types of agencies?	3, 6
5. How can the original data be manipulated and/or composited to facilitate a particular purpose?	20.III.0, 22 Interview

Used in combination, inferences about the data handling practices and needs of groups of users, about system applications, or about data coverage can be made.

ANALYSIS OF THE QUESTIONNAIRES

Because the questionnaire was not constructed to provide explict answers to the research questions of this report, data from the questionnaires had to be evaluated for their descriptive content, selectively interpreted to provide the most illustrative information, extracted from the questionnaire and placed in an organized fashion, and then analyzed to answer the research questions.

Selection of Appropriate Responses

Ninety-one questionnaires were distributed. Of these, sixty-five were received and fifty used as the sample for this investigation[2] The questionnaires which were deleted from this survey were excluded because the systems which were described:

1. did not use computers;
2. did not contain data coverage of the Northwest, nor were expected to do so;
3. did not contain land-based data;
4. did not contain spatial data;
5. were not sufficiently developed.

Some questions were not sufficiently complete to extract useful data, and were therefore excluded from the population. In many others certain questions were not answered by the respondent, although the questionnaire was sufficiently informative to be included in the survey population.

Table 2-2 lists the agencies whose response makes up the survey population. It also records some of the significant characteristics of the systems which are reported.

Selection of Representative and Descriptive Groups of Systems

Useful interpretation of the aggregated results of the survey presupposes the grouping of the responses in meaningful ways. The evaluation of the responses from the total survey population is representative of a cross-section of spatial data handling in general. Further evaluation is required to provide a more distinctive profile of representative groups of respondents. Three groupings are used to provide this evaluation. These are:

1. functional groups of users;
2. types of systems;
3. sponsorship.

Although other studies have described individual systems in various degrees of detail,[3] no other attempts appear to have been made to provide

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[2] The two additional agencies reported to NASA represented surveys from agencies which indicated desire for systems but were not yet committed. Thus, it was appropriate to report these as representative of user need, but not system description.

[3] See Section III of bibliography.

Table 2-2

Profile of the Survey Population

I.D. No.	AGENCY	BASIC RESPONSIBILITY[a]	SYSTEM NAME	TYPE OF SYSTEM[b]	STAGE OF DEVELOPMENT	COMPLETENESS OF RESPONSE
State Agencies						
01	State of Washington Department of Ecology	Environmental Protection	Coastal Zone Atlas and Information System	Integrated Output Mapping - Image Production	Operational and still being developed	Complete
12	State of Washington Department of Natural Resources	Land Management	Gridded Resource Inventory Data System (GRIDS)	Resources Information Retrieval - Fixed Grid	Operational	Complete
13	State of Washington Department of Natural Resources	Mapping	CALMA Mapping System	Graphics Output Mapping - Image Production	Operational	Complete
09	State of Oregon Forestry Department	Resource Planning and Management		Resources Integrated - General Purpose	System being designed	Incomplete
14	State of Oregon Department of Revenue	Mapping	Computer Assisted Mapping System (CAMS)	Graphics Output Mapping - Image Production	Operational and still being developed	Partially complete
10	State of Idaho Transportation Department	Special Area Planning	Unnamed	Geocoding Information Retrieval - GBF/DIME	System being developed	Partially complete
07	State of Idaho Department of Lands	Land Management		Resources Information Retrieval - Fixed Grid	System being developed	Partially complete
02	State of Idaho Department of Water Resources	Resource Planning and Management		Resources Information Retrieval - Fixed Grid	System being designed	Complete
Regional Governmental Agencies						
16	Puget Sound Council of Governments	Regional Planning	Map Model	Integrated Integrated - Map Overlay	Was developed, no longer operating	Complete
17	Puget Sound Council of Governments	Regional Planning	'EMPIRIC' Activity Allocation Model and associated data files, software and hardware	Integrated Information Retrieval - Combined	Operational and still being developed	Complete
25	Mid-Willamette Valley Council of Governments	Regional Planning	Oregon Planning System	Resources Information Retrieval - Fixed Grid	Operational and still being developed	Complete
15	Lane County Council of Governments	Metropolitan Planning	Unnamed	Integrated Integrated - Map Overlay	Operational and still being developed	Nearly complete

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(a) Responsibility of agency or division for which geoprocessing system operates.
(b) Upper classification is according to Peucker; lower classification is an adaptation guided by Tomlinson.

Table 2-2--continued

I.D. No.	AGENCY	BASIC RESPONSIBILITY	SYSTEM NAME	TYPE OF SYSTEM	STAGE OF DEVELOPMENT	COMPLETENESS OF RESPONSE
Municipal Agencies						
20	Spokane County Planning Department	Metropolitan Planning	Unnamed	Geocoding Information Retrieval - GBF/DIME	Operational and still being developed	Partially complete
21	Snohomish County Planning Department	Regional Planning	Unnamed	Resources Information Retrieval - Fixed Grid	Operational and still being developed	Complete
04	City of Tacoma Planning Department	Metropolitan Planning	Geographic Base System	Integrated Information Retrieval - Combined	Portions operational and still being developed	Complete
24	City of Salem	Metropolitan Planning	Computer Assisted Map Information System (CAMIS)	Integrated Other	System being developed	Nearly complete
Corporations						
27	Puget Power and Light	Other	Electric Plant Data Base	Integrated Information Retrieval - Combined	Portions operational, comprehensive system being designed	Complete
31	Battelle Northwest Laboratories	Resource Planning and Management	Water and Land Resources Computer Facility	Integrated Integrated - General Purpose	Operational and still being developed	Partially complete
33	Boeing Computer Services	Other	Natural Resources Information System	Resources Integrated - Map Overlay	Operational	Partially complete
30	Weyerhaeuser Corporation	Resource Planning and Management	Forest Inventory and Regeneration Data System	Resources Integrated - Map Overlay	Operational	Complete, but confidential
Other						
99	Huxley College	Other	Huxley System	Integrated Information Retrieval - Combined	Operational and still being developed	Nearly complete
Federal Agencies Situated in the Northwest						
34	Bureau of Indian Affairs and Colville Confederated Tribes	Land Management	Natural Resources Information System (NARIS)	Resources Integrated - Map Overlay	Operational and still being developed	Nearly complete
36	U.S. Department of the Interior, Bureau of Land Management	Resource Planning and Management	Map-Model	Resources Integrated - Map Overlay	Was developed, no longer operating	Partially complete

Table 2-2 --continued

I.D. No.	AGENCY	BASIC RESPONSIBILITY	SYSTEM NAME	TYPE OF SYSTEM	STAGE OF DEVELOPMENT	COMPLETENESS OF RESPONSE
Federal Agencies Situated in the Northwest -- continued						
35	Bureau of Transmission Engineering Bonneville Power Administration	Special Area Planning	PERMITS	Resources Information Retrieval - Fixed Grid	Operational and still being developed	Nearly complete
92	U.S. Army Corps of Engineers, North Pacific Division	Resource Planning and Management	CROHMS	Other Information Retrieval - Point	Was developed, no longer operating	Nearly complete
52	USDA Forest Service, Region 6	Land Management	TRI	Resources Other	Operational and still being developed	Complete
44	USDA Agriculture Research Service	Resource Planning and Management	Hydrological Data Bank	Resources Information Retrieval - Fixed Grid	Operational and still being developed	Nearly complete
Federal Agencies Outside the Northwest						
59	U.S. Geological Survey Topographic Division Digital Applications Team	Mapping	UCLGES - DLG-3 CONEDIT DCDI	Graphics Output Mapping - Image Production	Operational and still being developed	Complete
60	U.S. Geological Survey Western Mapping Center	Mapping	Digital Elevation Models (DEM)	Digital Terrain Model Digital Terrain Model	Operational and still being developed	Complete
61	U.S. Geological Survey Western Mapping Center	Mapping	Digital Line Graph (DLG)	Graphics Output Mapping - Image Production	Operational and still being developed	Nearly complete
63	U.S. Geological Survey Mineral Resources Division	Resource Planning and Management	Computerized Resources Information Bank (CRIB)	Geocoded Data Base Data Base Maintenance	Operational	Partially complete
66	U.S. Geological Survey Branch of Isotope Geology	Other	Radiometric Age Data Bank	Geocoded Data Base Information Retrieval - Point	Operational	Nearly complete
70	U.S. Geological Survey EROS Data Center Digital Applications Laboratory	Other	LANDSAT System and associated data analysis subsystems	Integrated Other	Operational and still being developed	Complete
64	U.S. Geological Survey Geography Program	Regional Planning	Geographic Information Retrieval and Analysis System (GIRAS)	Integrated Information Retrieval - Variable Boundary	Operational and still being developed	Partially complete
74	U.S. Geological Survey Geologic Division	Other	Digital Image Processing System	Other Other	Operational and still being developed	Nearly complete

Table 2-2--continued

I.D. No.	AGENCY	BASIC RESPONSIBILITY	SYSTEM NAME	TYPE OF SYSTEM	STAGE OF DEVELOPMENT	COMPLETENESS OF RESPONSE
Federal Agencies Outside the Northwest -- continued						
76	U.S. Geological Survey Geologic Division Seismic Engineering Branch	Other	Earthquake Strong Motion Data System	Other Other	Partially operational, still being developed	Nearly complete
80	U.S. Geological Survey Geologic Division	Resource Planning and Management	Rock Analysis Storage System (RASS)	Geocoded Data Base Data Base Maintenance	Operational	Nearly complete
83	U.S. Geological Survey Conservation Division	Resource Planning and Management	Geophysical Interpretive Aid System (GIAP)	Integrated Information Retrieval - Combined	Operational and still being developed	Complete
84	U.S. Geological Survey Geologic Division	Other	Well History Control System	Integrated Information Retrieval - Combined	Operational	Partially complete
85	U.S. Geological Survey Geologic Division	Other	Petroleum Data System	Integrated Information Retrieval - Combined	Operational	Partially complete
87	U.S. Geological Survey Geologic Division	Resource Planning and Management	WATSTORE	Integrated Information Retrieval - Point	Operational and still being developed	Partially complete
88	U.S. Geological Survey Water Resources Division	Other	National Water Data Exchange Hydrologic Unit Map Base	Integrated Information Retrieval - Combined	Operational and still being developed	Nearly complete
38	U.S. Environmental Protection Agency	Environmental Protection	STORET	Integrated Information Retrieval - Point	Operational	Nearly complete
39	U.S. Environmental Protection Agency	Environmental Protection	Storage and Retrieval of Aerometric Data (SAROAD)	Geocoded Data Base Information Retrieval - Point	Operational and still being developed	Nearly complete
40	USDA Soil Conservation Service	Land Management	Conservation Needs Inventory	Geocoded Data Base Data Base Maintenance	Operational	Partially complete
41	USDA Soil Conservation Service	Mapping	Advanced Mapping System	Graphics Output Mapping - Image Production	Operational	Partially complete
47	USDA Soil Conservation Service	Land Management	Natural Resources Data System	Geocoded Data Base Data Base Maintenance	Operational and still being developed	Nearly complete
42	Brookhaven National Laboratory, Atmospheric Sciences Division	Other	Point and Area Source Emissions Inventory	Integrated Information Retrieval - Point	System being developed	Partially complete

Table 2-2--continued

I.D. No.	AGENCY	BASIC RESPONSIBILITY	SYSTEM NAME	TYPE OF SYSTEM	STAGE OF DEVELOPMENT	COMPLETENESS OF RESPONSE
Federal Agencies Outside the Northwest -- continued						
43	USDA Forest Service	Resource Planning and Management	Timber Management	Geocoded Data Base Data Base Maintenance	Operational	Nearly complete
49	U.S. Water Resources Council	Resource Planning and Management	Second National Water Assessment	Geocoded Data Base Information Retrieval - Variable Boundary	Operational and still being developed	Nearly complete

profiles of representative groups of systems. In addition to providing new information for the literature, it was thought that a profile would assist agencies with similar needs to narrow the choices for system and data specification based upon the observed characteristics of systems fulfilling similar data processing and data analysis objectives.

The desire to select representative groups of systems led the author to place all responses into mutually exclusive categories. This proved difficult due to the lack of an accepted typology in the field, the lack of universally accepted terminology, the multiple uses of some systems, and the non-uniform functional level of the responses. The latter is evidenced by the receipt of some questionnaires describing hardware and software configurations, and others describing the activities of a department or program utilizing a geoprocessing system to support some of its data handling requirements.

The explanation of the categories follows. Table 2-2 notes the groups in which each agency and each system are placed for evaluation.

Groups of System Users. The basic responsibility of the agency or division for which the geoprocessing system operates is chosen to reflect the function of the user. It is used for grouping responses because it is a meaningful term to potential system users, is not dependent upon the very characteristics of the systems described, and is not dependent upon undue subjective interpretation.

Question three concerns the function (responsibility) of the agency or department of the agency which uses geocoded information. Thus, the category in which each agency respondent placed itself is used to determine the grouping. Some judgment had to be exercised where an agency indicated more than one functional area of responsibility for, in order to maintain exclusiveness, each questionnaire was placed in a single category which best represents the functional responsibilities of the respondent. The research category was deleted from the list because it was not representative of a particular functional area of responsibility or data use, while the automated cartography and cadastral mapping categories were combined to comprise the mapping group. The resultant grouping, and a brief explanation of each is as follows:

1. *Metropolitan Land Use Planning:* strategic, administrative, regulatory, or monitoring activities commonly carried out by municipal (city, county) planning departments and other planning bodies which carry out planning for nonrural (metropolitan areas).
2. *Regional Land Use Planning:* comprehensive long-range planning, coordination, and monitoring functions of regional governmental entities (including counties) planning for both rural and metropolitan areas. Differentiated from metropolitan planning by the size and diversity of the area (territory) of responsibility.
3. *Land Management:* agencies with broad management responsibilities for multiple use of lands and for the regulation, extraction, and planning for renewable and nonrenewable resources on those lands.
4. *Resource Planning and Management:* same as above, but oriented to the optimization, utilization, monitoring, etc., of a single resource (air, water, timber, mineral, etc.)
5. *Mapping:* concerned with the creation, maintenance, or storage of maps and the maintenance of map-related information.
6. *Environmental Protection:* monitoring and regulation of ambient and/or point source pollutants, and the enforcement of environmental protection laws and regulations.
7. *Special Area Planning:* any of the specialty functional areas of planning other than land use planning. Examples are: health, transportation, public utility, etc.
8. *Other:* Respondents not fitting into the above groups or too diverse in responsibility to place into a particular group.

Groups of System Types. The responses were also grouped into mutually exclusive categories based upon system type. The classification system follows the basic form proposed by Tomlinson and others (I. Tomlinson, ed., 1970, pp. 35-41). This scheme constitutes a hierarchy of three major classifications and several minor classifications. The major classifications are:

1. Image Systems designed to display data in various forms and usually not restricted for use with any particular data base.
2. Information Retrieval Systems which have data storage and manipulation capability and in most cases some form of output capability. These systems, which are likely to be associated with a data base and designed to provide the user with particular types of analysis and display, are classified by the spatial format of the encoded data (i.e., point, line, grid, etc.).[4]

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[4] Format has many implications for data handling. Some of these are discussed in Appendix 1.

3. Integrated Information Systems which combine image mapping capability with data storage and data manipulation capability. Data manipulation which necessitates line and polygon data performance require more sophisticated data structures, analysis capability, and software than information retrieval systems.

The capabilities and degree of integration of geocoded data are the basis for the classification. To these are added two other groups recognized by Peucker (Personal Communication). The resulting grouping, with brief explanation of each, is therefore:

1. *Data Base Maintenance:* Systems whose principal purpose is data storage and retrieval. Input, output, and editing routines are common, but no data analysis or sophisticated display capabilities are associated with the basic input and output functions.
2. *Output Mapping-Image Production:* Systems whose principal purpose is map (or graphic) image production and reproduction. These systems are usually not data base dependent. They usually include peripheral equipment and software for digitizing, editing, and graphic output.
3. *Information Retrieval System - Point:* Systems that handle data where spatial reference (geographic location identifer) is a point. The system stores, retrieves, analyzes, and displays data aggregated as points.
4. *Information Retrieval System - Fixed Grid:* Systems that handle data whose spatial reference is a fixed grid cell. The system stores, retrieves, analyzes and displays data aggregated into cells.
5. *Information Retrieval System - Variable Boundary:* Systems that aggregate data into variable size and shape units. The original data may be of point, grid or polygon format, but computer storage and resultant tabulations are for the aggregated unit, often a census district or other special taxing district. The system stores, manipulates and outputs these aggregated data for the area described within its boundaries.
6. *Information Retrieval System - GBF/DIME:* Systems that contain data about blocks, street segments, and nodal points within an urban spatial framework modeled after the reporting units of the census. Information is assigned to and retrieved in aggregates of nodes, street segments, and blocks.
7. *Information Retrieval System - Combined:* Systems which can store and manipulate data in formats combining any two or more of the above.

8. *Integrated Map Overlay System:* System which can accommodate data in point, line or area format, edit it for storage in a common data structure, and perform various types of manipulation. The distinction between this and other systems is that different coverages can be compared logically and graphically using union or intersection overlay techniques.
9. *Integrated General Purpose Systems:* Systems with more versatile data manipulation capability than the map-overlay systems. They may include data analysis and modeling capabilities with various image data manipulation and output capabilities.
10. *Digital Terrain Models:* Systems which store height values in their data banks, and can perform various spatial analysis and display functions on the height data (e.g., contouring, slope calculations, intervisibility, perspective drawing).
11. *Other:* Systems not fitting into the above categories, too diverse to classify, or for which not enough data were collected to make a determination.

Federal and Nonfederal System Users. The third profile segregated the federally sponsored systems from the nonfederal systems. The intent is to evaluate the similarity and difference of response for the purpose of assessing opportunities for data integration and for determining whether perceptions about data handling are similar between these groups. The federal systems, having predominantly national coverage and containing predominantly primary data in their data banks are a potential source of digital data to other data users. The nonfederal systems, conversely, normally contain data from multiple sources and have more localized coverage. They are the candidate data users.

Selection of Descriptive Variables and Options

The selection of the system and data attributes which are used for profiling the systems (agencies) and the characteristics of the spatial data used by these data users has been guided by the research questions. The questions required either a descriptive or comparative response. Descriptive questions such as 'What are the principal sources of spatial data used in systems?' only required direct recording of observations from the questionnaire. The comparative questions required that different sets of answers be compared to other sets of answers, or that individual responses be aggregated into representative groupings. The questionnaire provides the universe of potential descriptive information. From it, the descriptors which are used for description or comparison are deliberately chosen to enchance the information content of the analysis.

The descriptive and analytical system and data characteristics which are recorded are noted below in outline form.[5]

A. Characteristics of the Responding Agency

1. Basic responsibility(ies)
2. Residency
3. Sponsorship (federal, state, corporate, etc.)
4. Applications performed by/with system
5. Limitations for expanded use of geoprocessing in agency

B. System Characteristics

1. Classification of type of system
2. Stage of development
3. Whether there is an integral data base
4. Computer mapping capability
5. Graphic line reproduction capability
6. Conversationally directed query (user friendly)
7. Vendor supplied
8. Transferable software
9. Sophistication of data processing
   a. Software
   b. Derived analysis
10. Encoding format

C. Characteristics of the Digital Data Base

1. Data types
2. Location identifier
3. Scale
4. Precision
5. Resolution
6. Map projection
7. Coordinate reference
8. Size of coverage
9. Location of coverage
10. Source of data

Each of the above characteristics connotes options which may be used to describe the agency, system, or data base descriptors. Some of the descriptors are best described by nominal or interval classification. Data type connotes an infinite number of different choices. Precision connotes scalar values that for ease of interpretation may be expressed as interval ranges. Some descriptors such as computer mapping capability may be expressed by the simple binary classification of 'yes' or 'no.' The creation of appropriate nominal classifications and intervals is guided, as much as

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[5] See the Glossary for definition of terms.

is practical, by previous example. The list of research variables (descriptors) and options is given in Appendix 4.

Some of the description which is required can be transcribed directly from the questionnaire. In these cases, there is a one-to-one correspondence between the question asked and the response recorded on the questionnaire. Other descriptors for which there is no corresponding question on the questionnaire are assigned based upon knowledge of other system characteristics. An example is the assignment of a system classification category to each system reported.

Due to the large number of descriptors and options, the size of the sample, and the analytical procedures required for the answering of the research questions, the descriptive data were placed in computer-readable form, and the sorting accomplished with computer assistance. The coding of the data required that coding variables be assigned to each descriptor and option, and an encoding format be established. Once the descriptive categories and encoding format were devised, each questionnaire was reviewed and the attributes of each system were recorded on computer coding forms using numerical representation. Appendix 4 also provides the key to the coding of the questionnaires. It provides the reader with a list of the descriptive characteristics, the options chosen to be descriptive of each response, the position of each variable on the coding form, and the numerical symbol which denotes each variable's definition.

Description of Analytical Procedures

The analysis of the questionnaires was accomplished using the CROSSTABS[6] option of the Statistical Package for the Social Sciences (V. Nie, et al., 1970). The CROSSTABS option creates two-way to 'n'-way cross-tabulation contingency tables. The software enables the computer to count the number of pairwise comparisons recorded between selected variables describing the population and then print out a table of the frequency and percentage of pairwise comparisons. Thus, for example, the number of times respondents report both aerial photography as a data source and a particular area of coverage can be tabulated. Another example is the sorting of the sample by

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[6] CROSSTABS performs cross-tabulation, which is defined as a joint frequency distribution of cases according to two or more classification variables.

any descriptor such as agency responsibility. It is possible to record in this manner the number of times the land management agencies report having data of particular types, at particular scales, with particular location identifiers, etc. Cross-tabulations with the highest frequencies connote the greatest correspondence between the selected variables. It is thus possible to develop from the sample the desired profile of the most frequent and lesser frequency attributes of the population, and to imply correspondence between selected variables. The descriptors which are compared to one another using the CROSSTABS program are noted in Figure 2-1. The profile of federal versus nonfederal responses was tabulated without computer assistance.

Simple user programs were written to perform the desired cross-tabulations in accordance with the programming requirements for the Statistical Package for the Social Sciences. Two representative cross-tabulations are included for inspection by the reader as Figure 2-2. The numerical frequencies from the printouts were then transcribed onto the tables in the next chapter and as Appendix 5. These tables provide the data from which the research questions can be answered.

The techniques of data transcription and interpretation for each section of the report are described in the corresponding section.

		Agency and System Characteristics														Data Base Characteristics													Other		
		Responsibility of Respondents	Type of Geoprocessing System	Stage of System Development	System Applications	Geodefinition	Conversationally Directed Query	Vendor Supplied System	Transferable Software	Derived Maps and Analysis	Integration of Environmental and Cultural Data	Graphic Line Reproduction Capability	Form of Geocoding	Integral Data Base	Computer Mapping	Map Projection	Coordinate Reference	Location Identifier	Scale	Precision	Resolution	Units of Coverage	Units of Composite	Data Source	Data Type - General	Data Type - Environmental	Size of Coverage	State of Residence	Software	Derived Maps and Analysis	Limiting Factors
Agency and System Characteristics	Responsibility of Respondents		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Type of Geoprocessing System	x			x																								x	x	
	Stage of System Development	x	x																												
	System Applications	x																													
	Geodefinition	x																													
	Conversationally Directed Query	x																													
	Vendor Supplied System	x																													
	Transferable Software	x																													
	Derived Maps and Analysis	x																													
	Integration of Environmental and Cultural Data	x																													
	Graphic Line Reproduction Capability	x																													
	Form of Geocoding	x																													
	Integral Data Base	x																													
	Computer Mapping	x																													

Figure 2-1. Descriptive characteristics which are compared, using the 'CROSSTABS' Option.

		Agency and System Characteristics														Data Base Characteristics													Other		
		Responsibility of Respondent	Type of Geoprocessing System	Stage of System Development	System Applications	Geodefinition	Conversationally Directed Query	Vendor Supplied System	Transferable Software	Derived Maps and Analysis	Integration of Environmental and Cultural Data	Graphic Line Reproduction Capability	Form of Geocoding	Integral Data Base	Computer Mapping	Map Projection	Coordinate Reference	Location Identifier	Scale	Precision	Resolution	Units of Coverage	Units of Composite	Data Source	Data Type - General	Data Type - Environmental	Size of Coverage	State of Residence	Software	Derived Maps and Analysis	Limiting Factors
Data Base Characteristics	Map Projection	x																									x	x			
	Coordinate Reference	x																									x	x			
	Location Identifier	x																		x	x					x	x				
	Scale	x																		x	x						x				
	Precision	x																x	x					x			x				
	Resolution	x																x	x					x			x				
	Units of Coverage	x																													
	Units of Composite	x																													
	Data Source	x																		x	x					x	x				
	Data Type - General	x																													
	Data Type - Environmental	x																x						x							
	Size of Coverage	x														x	x	x	x	x	x			x							
	State of Residence	x														x	x														
Other	Software	x	x		x																										
	Derived Maps and Analysis	x	x																												
	Limiting Factors	x																													

Figure 2-1—continued

AGRESP	Count Tot Pct	Stage					Row Total
		1	2	3	4	6	
	1	0 0.0	3 6.0	0 0.0	1 2.0	0 0.0	4 8.0
	2	0 0.0	4 8.0	0 0.0	0 0.0	1 2.0	5 10.5
	3	1 2.0	3 6.0	0 0.0	1 2.0	0 0.0	5 10.0
	4	2 4.0	4 8.0	0 0.0	0 0.0	0 0.0	6 12.0
	5	1 2.0	2 4.0	0 0.0	0 0.0	0 0.0	3 6.0
	7	4 8.0	5 10.0	3 6.0	0 0.0	2 4.0	14 28.0
	8	0 0.0	1 2.0	0 0.0	1 2.0	0 0.0	2 4.0
	9	5 10.0	6 12.0	0 0.0	0 0.0	0 0.0	11 22.0
	Totals	13 26.0	28 56.0	3 6.0	3 6.0	3 6.0	50 100.0

AGRESP	Count Tot Pct	Scale 03		Row Total
		1	2	
	3	1 10.0	0 0.0	1 10.0
	4	3 30.0	0 0.0	3 30.0
	7	4 40.0	1 10.0	5 50.0
	8	1 10.0	0 0.0	1 10.0
	Totals	9 90.0	1 10.0	10 100.0

Number of missing observations = 40

Figure 2-2. Representative cross-tabulation samples. The numbers on the axis represent individual variables, the key to which may be found in Appendix 4.

Chapter III. A PROFILE OF SYSTEMS AND SYSTEM USERS

Examined in this chapter are the characteristics and applications of different types of geoprocessing systems, and profiles of the needs of the system user. Though not recommended as a sole course upon which system design decisions should be based, the report of the characteristics and desires of the survey population provides insight based upon the collective experience and perception of different sectors of the survey population.

The chapter is divided into three parts:

1. An overview of the characteristics of the sample.
2. A profile of the prevalent and preferred system operating characteristics, data and data processing needs, and representative applications of systems and system users.
3. A selective comparison between federal and nonfederal systems.

DISTINGUISHING CHARACTERISTICS OF THE SAMPLE

The sample population consists of fifty questionnaire responses from a diverse group of respondents. The diversity influences the nature of the responses, and the lack of homogeneity precludes the making of all but gross assumptions at the level of description of the total population. There are certain characteristics which, when described, further characterize the sample, and thereby assist the interpretation of the numerical tabulation. These distinguishing characteristics are chosen to orient the reader to the nature of the systems so that there may be awareness of their influence on the data handling and data use characteristics examined in the latter portion of this chapter. The distinguishing characteristics are the user classification, system classification, sponsorship, stage of development, and the following special characteristics: whether the system and applications are designed around a particular data base; whether there are derived products resulting from the use of the system; whether the system is user oriented, i.e., has conversationally directed query; whether the systems are vendor supplied; whether the software is transferable; whether the system produces computer mapped output; and whether environmental data are integrated with nonenvironmental data.

User Classification

Table 2-2 listed each respondent's basic responsibility and is indicative of distinct user orientation. The user orientation is important as a guide for interpretation of the survey results. Each user group will be interested in the system characteristics and preferences from its own group.[1] The groups and the agencies in them are briefly identified here.

Municipal Planning: Four agencies are included in the municipal planning category. Lane County Council of Governments maintains an integrated land parcel based system which is used extensively by the City of Eugene. The City of Tacoma maintains several systems for which data are interchangeable. A parcel based system is the core. Other systems are a grid based environmental data system and a variable boundary polygon system which is used primarily for data aggregation. Spokane County maintains a GBF/DIME file for the metropolitan area around Spokane and has begun to record land cover characteristics interpreted from satellite imagery. The City of Salem is developing a very fine resolution graphics system with the parcel as the principal identifier. The City of Bellevue has a similar system, but did not complete the questionnaire.

Regional Planning: Five agencies are placed in the regional planning category, four of them still operating, the other no longer operating. Three of the operating systems maintain data in grid format. Two have a variable sized grid and the other is a fixed grid system. All are encoded manually. The system no longer operating was a polygon system which did not have the editing capability to make it time and cost effective. The U.S.G.S. Geography Program maintains one variable polygon system which is used in the digital display and analysis of data from the 1:250,000 scale map quadrangles.

Land Management: There are five land management systems. Their characteristis are quite diverse, representing the unique needs and management responsibilities of each. The State of Idaho Department of Lands is developing a system modeled after the system at the Washington State Department of Natural Resources. This is a grid formatted system for which the

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[1] Documentation exists for many of the systems described in this survey. Because the purpose of this study is to report aggregated characteristics rather than individual system characteristics, no references other than the questionnaire are used or noted in this section.

recorded data are interpreted from evenly spaced sampling points (660 feet apart) by aerial photograph interpretation and field checking. Changes recorded at the sampling sites are extrapolated to the surrounding grid. Data attributes are retrieved statistically or are printer plotted. The Bureau of Indian Affairs developed a polygon system for reservation lands for the Colville Confederated Tribes which is maintained by Washington State University. The U.S. Forest Service, Pacific Northwest Region, maintains a polygon system which stores attribute acreages on the computer and is geographically coordinated to Polygon overlays drawn upon orthophoto maps and stored on microfiche. Digitizing and computer-assisted polygon and grid mapping and analysis systems are available for special projects. The Soil Conservation Service maintains two automated land management systems, reported herein. One records attributes of randomly selected sample sites and thereby provides data for localized management problems. Another is used to store descriptive and analytical data representing the characteristics of individual soil types, and is used primarily to update technical guides.

Mappings: The six mapping systems are quite similar to one another. Four are used solely for the computer-assisted production of line maps, two producing soil maps, one producing cadastral maps, and the other assisting in the production of U.S.G.S. quad maps. A fifth system reported is a digital terrain model and digital terrain mapping system, and the final questionnaire response reported three separate systems, recorded here as one survey record--two of them planimetric systems and the third a terrain mapping system.

Environmental Protection: Three environmental protection systems are reported. Two of these systems--primarily engaged in maintaining sampling records, but with associated analytical and display capabilitiy--are both maintained by the Federal Environmental Protection Agency. The remaining one, developed for the Department of Ecology, is the Coastal Zone Atlas and Information Sytem for the State of Washington. Graphic polygon records of many coastal area features are the basic data units. Though not yet operational, selective interactive retrieval of the polygon records will be provided to assist the environmental review and permit granting staff of the agency.

Resource Planning and Development: This category includes fourteen systems used in the evaluation or the management of a single type of natural resource. The system configurations and the function of the sample are quite diverse. Four are forestry systems, five water resource systems, three mineral systems, and one a resource analysis laboratory. Three of the forestry systems maintain data in polygon format and store many layers of forest vegetation and forest land related data. The other is a system for statistical reporting of production records. Two of the water resource systems maintain data in point format; one of which records flows, the other water sample data. One is a regional statistical reporting system. Two others are grid systems which record many attributes of the coverage. Two of the mineral systems record sampling data, the other assists in the interpretation of geophysical records. The resource laboratory operates many types of systems ranging from Landsat to computer-assisted mapping and also accesses data from many other data storage systems.

Special Area Planning: Two special area planning systems are described. One is a GBF/DIME type system maintained by a transportation authority used to aggregate data to project traffic flows. The other is a grid system used to select alternative routes for power transmission lines based upon a very sophisticated attribute weighting scheme.

Others: The 'other' category covers eleven different types of agencies and systems. These are too diverse to provide representative profiles. Two systems are used for the analysis, interpretation and storage of Landsat imagery for a variety of different applications. One agency is a computer service bureau which markets geoprocessing capability to clients on a project basis, but also provides other computer services. The geoprocessing system of this agency manipulates data in polygon and grid format but no data are maintained as a data base. One system is used by a private utility to maintain data on its generating facilities and transmission lines. Another system is maintained at a university and is used for instruction and on many types of grant-supported geoprocessing projects. Three of the systems are used for pure and applied research. Another two are used to record and interpret data on wells and petrochemical transmission facilities.

System Classification

Each of the fifty responses is additionally classified according to system type. The sophistication of the systems varies widely. Table 3-1 notes the number of responses assigned to each category. It is useful to distinguish between systems used primarily for data storage and retrieval, true geographic information systems, and specialty systems. Data storage and retrieval systems lack sophisticated data manipulation software, normally store data in a consistent format, and maintain single or very closely related data types. Information systems are more sophisticated, handle a wider variety of data types and formats, and normally accommodate ad hoc inquiry. Specialty application systems used for mapping, Landsat data analysis, etc., are specially configured for unique data handling applications.

Table 3-1

Numerical Classification of Systems[2]

System Type	Number Classified
Data Base Maintenance	5
Output Mapping - Image Production	6
Information Retrieval - Point	6
Information Retrieval - Fixed Grid	7
Information Retrieval - Variable Boundary	2
Information Retrieval - GBF/DIME	2
Information Retrieval - Combined	8
Integrated - Map Overlay	6
Integrated - General Purpose	2
Digital Terrain Model	1
Other	5

Other Distinguishing Characteristics

The sample is further described by eleven other characteristics gleaned from the questionnaire. These are reported as the totals on Tables 3-2 and 3-3. Each characteristic imparts a unique set of values which influence deductions about the sample. A few examples are noted:

---

[2] For explanation, see Chapter 2.

1. Stage of development: Influences the degree to which the system meets the needs for which it was designed. An operational system presumably has reached the stage where it operates satisfactorily (at least to the extent that it is used by a user group). An unexpected implication of the stage of development on this sample is the extent to which it influences the report of unmet needs for data or software. Respondents for systems which are operational noted few needs. Respondents for systems under development noted many needs, primarily reflecting characteristics under consideration, but not yet operating.
2. Sponsorship: Reflects, in part, the degree of control over system development, and also reflects the geographic coverage and amount of data stored in the system.
3. Method of geodefinition: Reflects the way the data are entered, stored and output from the system and the types of analysis which can be most easily performed on the data. Four of the systems have external indexing, ten have implicit references, thirty-three have explicit reference, and three exhibit a combination of the above.
4. Derived analysis: The transformation of the primary data into forms with more meaning to the user, such as suitability, accessibility, cost, etc. This is an indication of system sophistication, and of the extent spatial data processing capabilities are being used to their potential.

Two maps are provided to graphically demonstrate some of the characteristics of the systems residing in the Pacific Northwest states. Figure 3-1 illustrates the stage of development of the systems in this region. Figure 3-2 illustrates the primary type of location identifier used to reference data in each of the systems.

Tabuluar Overview and Summary of Distinguishing Characteristics

Tables 3-2 and 3-3 summarize the descriptive characteristics for the total survey population, and differentiate the responses for each of the representative groups of system users. Though primarily reported for the purpose of providing an introductory profile of the sample, examination of the table provides some very interesting observations relevant to this study. Some have already been cited in the summary; others are noted below.

1. The land use planning and land management systems are the most versatile and the most likely to integrate data storage and retrieval functions with data analysis and graphic display functions. The resource planning and management systems are nearly equally split in number between integrated and single use systems. The mapping systems are all single purpose.

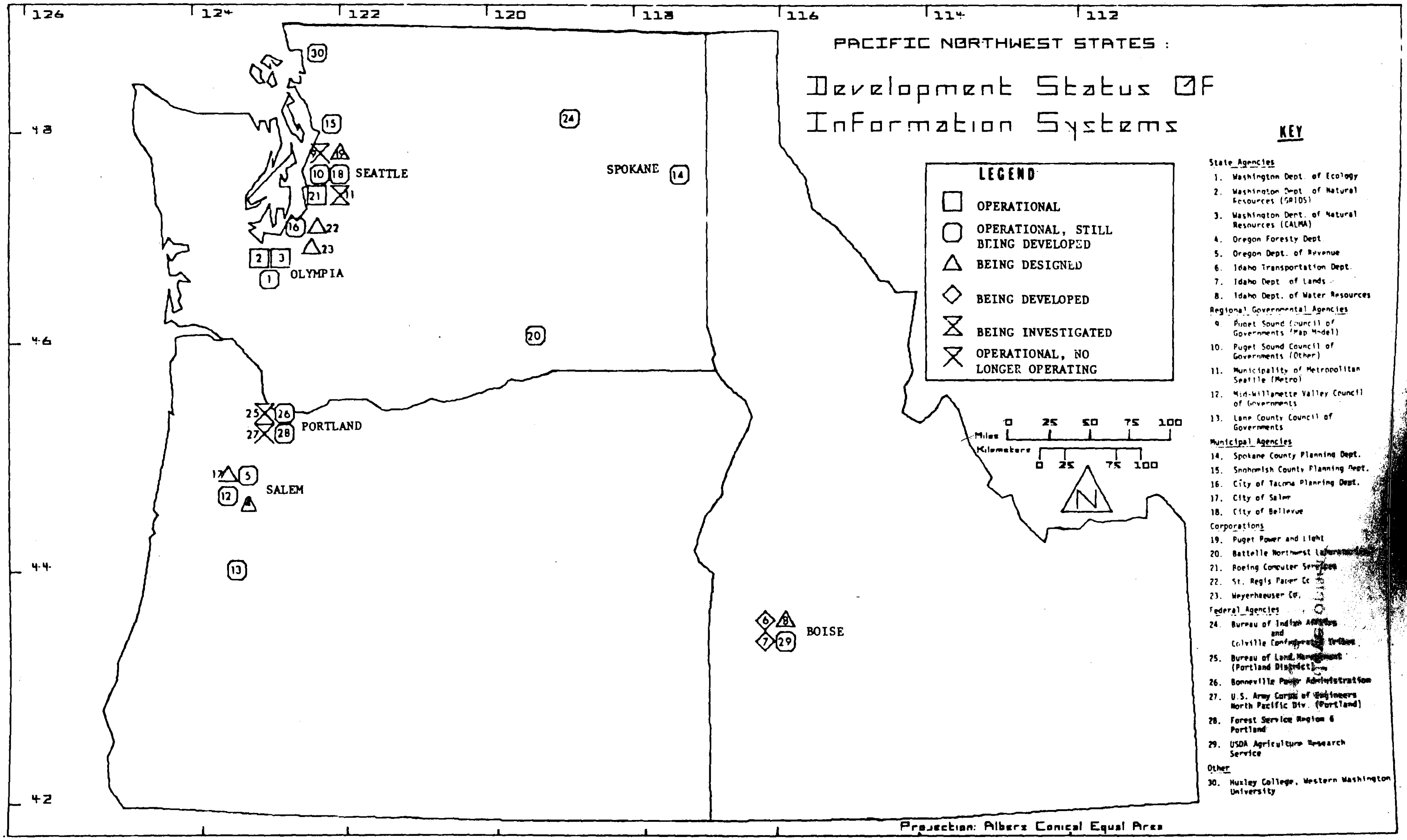

Figure 3-1: Development status of information systems.

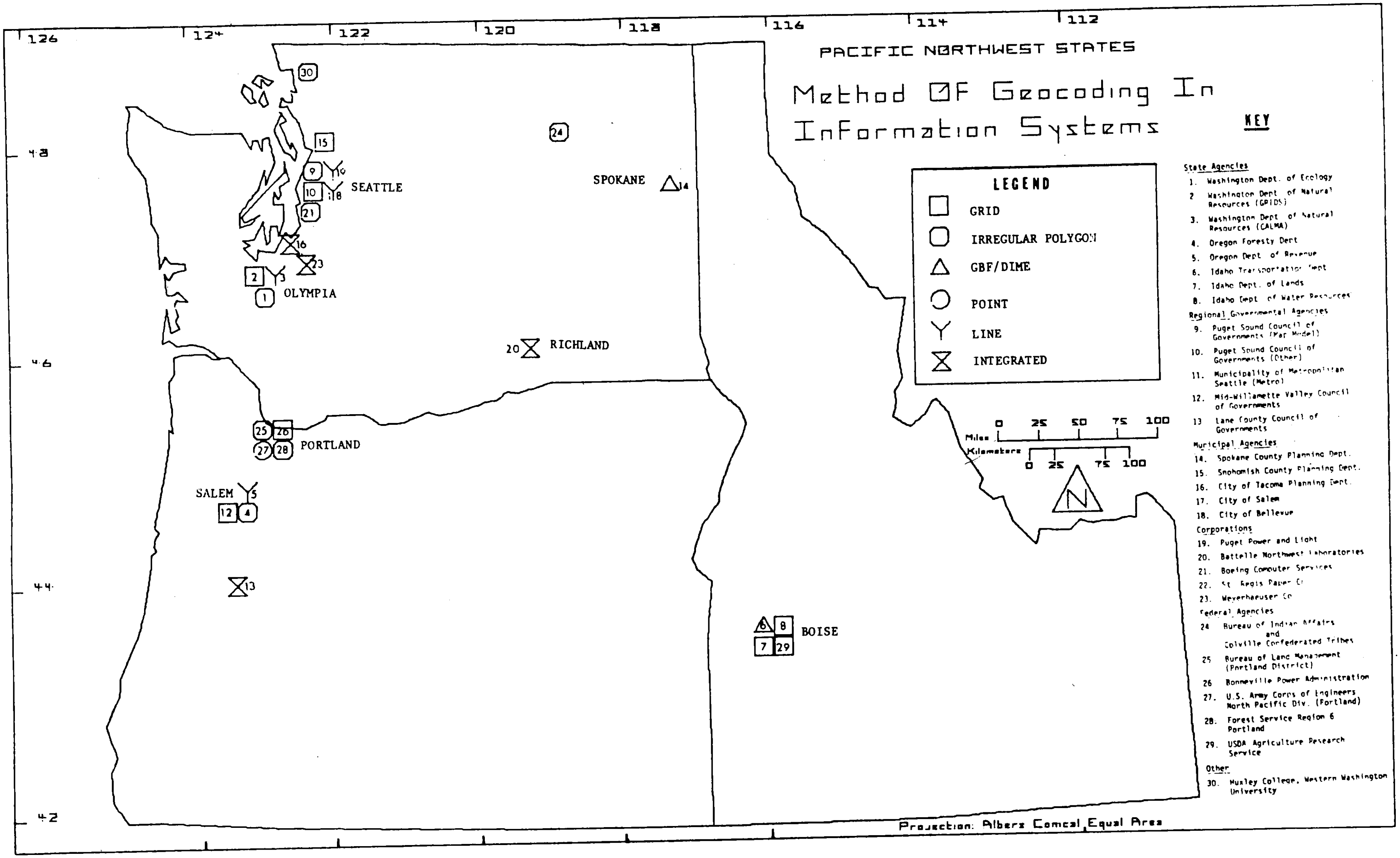

Figure 3-2. Method of geocoding in information systems.

Table 3-2

General Characteristics of the Sample Systems

INTERPRETATION

Numbers in the cells are the actual number of responses classed into each group. Total sample size is in parentheses.

BASIC RESPONSIBILITY OF RESPONDENT:		STAGE OF DEVELOPMENT:						SPONSORSHIP							INTEGRATED DATA BASE	DERIVED ANALYSIS	GEODEFINITION			
		Operational	Operational and still being developed	Being designed	Being developed	Being investigated	Operational but no longer operating	Federal	State	Regional	County	City	Corporate	Other			External	Implicit	Explicit	Combination
Metropolitan Land Use Planning	(4)		3		1					1	1	2			3	1			2	2
Regional Land Use Planning	(5)		4				1	1		3	1				5	4	1	3	2	
Land Management	(5)	1	3		1			3	2						5			2	2	
Mapping	(6)	2	4					4	2						5	1			6	
Environmental Protection	(3)	1	2					2	1						3	2			3	
Resource Planning and Management	(14)	4	5	3			2	10	2				2		14	4	3	2	8	1
Special Area Planning	(2)		1		1			1	1						2	1		1	1	
Other	(11)	5	6					8					2	1	9	5		2	9	
Total	(50)	13	28	3	3		3	29	8	4	2	2	4	1	46	18	4	10	33	3

Table 3-3

Operating Characteristics of the Sample Systems

INTERPRETATION

Numbers in the cells are the actual number of responses classed into each group. Total sample size is in parentheses.

BASIC RESPONSIBILITY OF RESPONDENT:	VENDOR SUPPLIED			USER FRIENDLY		TRANSFERABLE SOFTWARE				COMPUTER MAPPING CAPABILITY	GRAPHIC LINE REPRODUCTION CAPABILITY			INTEGRATION OF NON-ENVIRONMENTAL DATA		
	Predominant	Not Vendor Supplied	Partial	Yes	No	Predominant	Partial	No	Unknown or Unreported		Yes	No	Unknown or Unreported	Yes	No	Unknown or Unreported
Metropolitan Land Use Planning (4)	1	2	1	4		1	1	2		3	3	1		3		1
Regional Land Use Planning (5)		4	1		5	2	1	2		5	2	3		3	1	1
Land Management (5)		4	1	4	1			2	3	3	2	3		3	1	1
Mapping (6)	6			3	3	4		1	1	6	6			5	1	
Environmental Protection (3)		3		3			2	1		2	1	2		1	2	
Resource Planning and Management (14)	3	10	1	7	7	2	1	8	3	8	4	9	1	3	9	2
Special Area Planning (2)	1		1		2			1	1	1	1		1	2		
Other (11)	5	5	1	7	4	1	1	3	6	10	8	2	1	4	6	1
Total (50)	16	28	6	28	22	10	6	20	14	38	27	20	3	24	20	6

2. The majority of the systems, even if operational, are still developing. New applications are being found for existing systems and new hardware and software is being acquired to broaden the utility of the systems. The planning agencies are most likely to be anticipating further system development. The systems built around a particular data storage and retrieval function are most likely to be operational and not reporting further system development.
3. The majority of the systems surveyed are federally sponsored. The next largest group are the state systems; followed by regional, then county and city. It appears that a combination of factors such as diversity of responsibility, geographic area of coverage, volume of data, and the amount of money to spend for research and development have influenced the tendency for the lesser levels of government to have less sophisticated data handling operations and fewer computer-assisted applications.
4. There are few respondents who report that their systems are used for derived mapping or analysis, even in cases where the software would allow more sophisticated data interpretation to be performed.
5. The scale at which agencies work influences the type of geodefinition. Metropolitan planning agencies with parcel level responsibility have a greater proportion of systems with explicitly defined data than regional planning agencies which are concerned more with regional trends. All mapping is explicit by its nature. Resource management systems are divided between explicit definition for recording observations and for resource conservation, and external indexing for regional statistical reporting.
6. The main vendor supplied system component is the graphics element. All of the mapping systems are vendor supplied, as are the output mapping subsystems of some of the federal systems. Many of the special application federal systems were developed by and/or supplied by contractors. Few of the planning, land management, and other resource management systems in the Northwest are vendor supplied.
7. Most municipal planning systems are user friendly, interactive, and conversationally directed, probably because of the need to access data quickly for reviewing permits and answering public inquiry. The regional planning systems are all batch processed systems requiring specialist users and exhibiting much longer response time. The environmental protection and resource management systems are mostly conversationally directed to allow specialists easy access to data needed for analysis. The resource management systems which are not user friendly are primarily used for statistical reporting and record keeping.

8. The availability of transferable software is poor. Most agencies do not report their software to be documented or available for use by others. Of the transferable software, most was obtained from vendors and documented by the vendor.
9. The production of computer graphics is found to be useful by every type of user. All of the planning agencies, and most of the resource management agencies can produce computer maps. Two-thirds of the computer mapping is plotted graphics. All metropolitan planning agencies have digital line reproduction capability. The regional planning agencies all map using a printer, and none have digital line reproduction capability. Large area resource planning agencies use printer graphics. The systems which do not have computer graphics capability are primarily those which store point defined data or have external reference.
10. The environmental protection agencies have the least interest in integrating environmental with other types of data, probably because the systems surveyed were primarily used to monitor environmental conditions. Resource planning and management agencies also report few systems which integrate data. The planning agencies and land management agencies all report the integration of environmental with nonenvironmental data.

PROFILE OF PREVALENT AND PREFERRED CHARACTERISTICS

The data handling activities and preferences, and the characteristics of the data used by different sectors of the survey population are reported in the remainder of this section. A representative profile is developed for each of the groups of system users, and for each of the classified types of systems. The profile is reported in order to answer the following research questions:

1. What systems are now in use in the region? What types of agencies have them? What are their principal characteristics? What are they used for?
2. What categorical types, hardware/software configurations, and data handling capabilities of systems are characteristic of different groups of users? What are the characteristics of different types of systems?
3. What are the perceived data and geographical referencing needs and system use objectives of different types of users?
4. What types of editing, spatial analysis, and display functions are most prevalent and preferred by different types of users, and performed by different types of systems?
5. What are the principal sources of spatial data for information systems?

The basic responsibility of the respondent is used as the basis for the user profile. The inferences are based upon the desired characteristics reported by the respondents. *The desired (preferred) characteristics are reported because it is a closer approximation of user need.* Present application is limited by existing equipment, mandate, budget, etc., and thus is not truly representative of the characteristics which are perceived to be important. The characteristics chosen for description are, in addition to those already reported in the introductory profile: system application, data analysis, data handling software (data processing capability), data type, data source, data characteristics, and mapping and geographic referencing characteristics.

The *actual* operating characteristics reported by the respondents is used to profile system characteristics. *The actual characteristics of each type of system are used for evaluation because they better represent technical potential and limitations.* The desired characteristics may not be feasibly produced by a particular type of system, but any agency could develop or acquire a new system to meet its needs. The characteristics chosen for description are: system application, data analysis, and data handling software.

Interpretation Technique

Summary tables are provided to portray graphically the patterns of response by each group for each characteristic. These tables are numbered 3-4 through 3-10 and are integrated into the text. Comparison is possible because the graphic symbols represent scaled responses rather than actual numerical tabulations. The numerical record of response from which these summary tables are derived is located in Appendix 5.

The scaling of responses is accomplished by reporting *'percentage of total sample'* summaries. For each, the total sample size of each classification was divided by the number of actual responses within each 'cell,' and a symbol representing the interval within which this value fell was recorded. *For determining the 'percentage of the total sample,' the number of respondents not answering the questions (represented by the 'not reported' category) was subtracted from the total sample size for each classification.* Thus the actual sample size used for calculation of the 'percentage of the total sample' changed from question to question. To illustrate:

> *Category 'A' has a total sample size of eleven. Five variables are to be evaluated, each representing an option for a question: V1, V2, V3, V4 and V5. The number of observations within each 'cell' are:*
>
> *V1 = 3; V2 = 4; V3 = 5; V4 = 1; V5 = 8; Unreported = 1.*

The percentage of response, rather than being based upon eleven, is based upon ten because one respondent failed to answer the question. The percentages and interval classifications which result (and which would be found on the summary tables) are:

Variable	*Percent*	*Interval*	*Tabular Symbol*
V1	*30*	*25% - 49%*	▲
V2	*40*	*25% - 49%*	▲
V3	*50*	*50% - 74%*	■
V4	*10*	*Less than 25%*	•
V5	*80*	*75% or greater*	●
Not Reported			*1 (actual number of observations)*

Interpretation and Use of the Summary Tables

The tables illustrate similarities and differences in responses between groups, and the extent of application of or interest in particular characteristics. Evaluation by row demonstrates the characteristic responses of each group, and thus reflects preference or application. Differences between row responses contrast the responses of the different user groups and the different system groups. Evaluation by column demonstrates which individual characteristics are noted for any group of interest. The column totals represent the extent to which any characteristic is reported by the total survey population. Each of the tables should be examined individually.

Profile of Desired Characteristics of System Users

Tables 3-4 through 3-8 report the relative frequency for which each type of user reported *desire* for each characteristic. The descriptions are based upon an examination of the tables. It is not the purpose of this report to try to analyze fully the significance of these tables. The readers are urged to draw their own conclusions. Though not sufficiently analytical to be used as a substitute for a separate user needs assessment, many interesting patterns of response are reported which can be

Table 3-4

Comparison of the Representative Applications and Types of Analyses Desired by Each Type of System User

KEY

___ None Reported

• Less than 25%

▲ 25% to 49%

■ 50% to 74%

● 75% or Greater

(Note: Sample size in parentheses)

BASIC RESPONSIBILITY OF RESPONDENT:	TYPES OF APPLICATIONS																							TYPES OF ANALYSIS											
	Base Mapping	Resource Inventory	Land Classification	Modeling	Environmental Impact Assessment	Land Suitability Analysis	Critical Area Planning	Thematic Mapping	Trend Projection	Environmental Data Bank	Urban Data Bank	Cadastral Mapping	Route Selection	Site Selection	Land Use Allocation	Air Quality Management	Water Quality Management	Wildlife Management	Timber Management	Agricultural Production	Hazard Identification	Other	Not Reported	Proximity	Capacity	Optimum Location	Quality	Availability	Change	Development Constraints	Accessibility	Statistics	Cost	Other	Not Reported
Metropolitan Land Use Planning (4)	●	●	●	●	▲	●	■	▲	●	▲	●	■	▲	●	■						▲	●	0	■		■		■	■	■		■			2
Regional Land Use Planning (5)	●	▲	■	●	▲	■	▲	▲	▲	●	■		▲	▲	●	•	■	▲	▲	▲	▲		0		■	▲			▲	●		▲			1
Land Management (5)	▲	●	■	■	▲		▲	●	▲	■				▲	●			▲	■	▲		▲	1												1
Mapping (6)	●	•	•					•				•			•								1												2
Environmental Protection (3)		▲		●	●	▲	▲		■	▲			▲	■	▲	▲	▲	▲	▲		▲	▲	0	▲		▲	■	■	▲	■	▲	▲			0
Resource Planning and Management (14)	▲	●	▲	■	•	•	▲	•	•	▲				▲	•		•		▲	•	•	•	2	•	•	•	▲	•		•	•	•		•	3
Special Area Planning (2)	■	●		●	■		■		■		■		●		■								0			■		■		■	■				0
Other (11)	■	■	▲	▲	▲	▲	▲	•	•	•	•		▲	▲	▲			•	▲	•	•	▲	2	▲		•		•	•	▲	•	•	•	•	1
Total (50)	■	■	▲	■	▲	▲	▲	•	▲	▲	•	•	•	▲	▲	•	•	•	▲	•	•	▲	6	•	•	•	•	•	•	▲	•	•	•	•	10

Table 3-5

Comparison of the Data Handling Software Desired by Each Type of System User

KEY

— None Reported

• Less than 25%

▲ 25% to 49%

■ 50% to 74%

● 75% or Greater

(Note: Sample size in parentheses)

	Editing				Spatial Rectification						Measurement				Sorting/Merging						Comparison						Graphic Output					Other		
BASIC RESPONSIBILITY OF RESPONDENT:	SOFTWARE Identify and Correct Closure	Identify and Correct Slivers	Data File Update	Labeling	Removing Map Distortion	Line Generalization	Modify Alignment	Scale Change	Projection Change or Coordinate Conversion	Location Identifier Coversion	Linear Measurement	Area Measurement	Direction Determination	Centroid Determination	Selective Retrieval - Geographic	Selective Retrieval - Descriptor	Edge Matching	Create New Files	Integrate from Remote Files	Contouring	Overlay - Union	Overlay - Intersection	Value Weighting	Modeling	Statistical Analysis	Extreme Value Search	Zooming	Diagram and Chart Display	Lettering	Shading	3D	Digital Relief Analysis	Landsat Data Analysis	Not Reported
Metropolitan Land Use Planning (4)	▲	▲	●	■	●	■	■	■	●	●	●	●	■	●	●	●	●	●	▲	●	●	●	■	■	●	▲	■	●	●	●	▲	●	▲	0
Regional Land Use Planning (5)	▲	•	■	▲	▲	•	•	■	■	■	■	●		▲	●	●	●	●		▲	●	●	■	▲	■	•	■	▲	●	▲		■		0
Land Management (5)	■	▲	●	■	▲	■	▲	■	■	●	■	●		▲	●	●	■	▲		●	■	■			▲			▲	■			▲		1
Mapping (6)	●	▲	●	■	●	■	■	●	●	▲	■	■	▲		●	■	●	●		●	●	■		•	■	▲	■	■	■	▲		▲		0
Environmental Protection (3)	●	▲	▲	■			▲	■	■		▲	▲		▲	●	●				▲	▲	▲			▲		■	▲	■	▲	▲			0
Resource Planning and Management (14)	•	▲	▲	▲	▲	▲	•	■	■	▲	▲	■	▲	▲	●	●	▲	■	▲	■	■	▲	▲	▲	■	▲	▲	■	▲	▲	▲	■	•	2
Special Area Planning (2)	●	●	●	●		●	●	●	●	●	●	●	■	●	●	●	●	●	●	■	●	●	●	●	●	■	●	■	●	■	●	●	■	0
Other (11)	▲	▲	■	■	▲	•	▲	■	■	▲	▲	■	•	▲	●	●	▲	●	▲	▲	■	▲	•	•	■	▲	▲	•	■	▲	•	•	•	0
Total (50)	▲	▲	■	▲	▲	▲	▲	■	■	▲	▲	■	•	▲	●	●	■	■	•	■	■	■	•	▲	■	▲	▲	▲	■	▲	•	▲	•	3

Table 3-6

Comparison of the Data Types Desired by Each Type of System User

KEY

— None Reported

● Less than 25%

▲ 25% to 49%

■ 50% to 74%

⬤ 75% or Greater

(Note: Sample size in parentheses)

BASIC RESPONSIBILITY OF RESPONDENT:		DATA TYPES - GENERAL Census	Health	Assessment	Transportation	Land Use	Land Cover	Zoning	Housing	Codes and Ordinances	Legal Property Descriptions	Utilities	Topography	Land Resources	Other Environmental Data	Variable	Other	Not Reported
Metropolitan Land Use Planning	(4)	⬤		■	▲	⬤	▲	⬤	⬤		⬤	▲	▲	■	▲	⬤	▲	0
Regional Land Use Planning	(5)	■		●	●	⬤	■	▲	●				▲	⬤	●	⬤		0
Land Management	(5)				●	⬤	⬤				■		■	⬤	■	⬤		0
Mapping	(6)			●	▲	■	●	●		●	▲	●	▲	▲		⬤	▲	0
Environmental Protection	(3)					▲	▲							▲	⬤	▲	▲	0
Resource Planning and Management	(14)				●	▲	▲				●	●	●	■	⬤	■	■	2
Special Area Planning	(2)				■	⬤	■	■					■	■	■	⬤		0
Other	(11)	▲	●	●	●	▲	●	●	●	●	●	●	▲	●	■	■	⬤	1
Total	(50)	▲	●	●	●	■	▲	●	●	●	●	●	▲	▲	■	■	▲	3

BASIC RESPONSIBILITY OF RESPONDENT:		ENVIRONMENTAL DATA TYPES Geology	Topography	Vegetation	Wildlife	Surface Hydrology	Groundwater Hydrology	Soil Type	Soil Interpretation	Air	Climate and Weather	Timber Resources	Mineral Resources	Water Resources	Unique and Sensitive Areas	Land Cover	Variable	Other	Not Reported
Metropolitan Land Use Planning	(4)	▲	■	▲	▲	▲	▲	▲	▲	▲			▲	▲			▲	▲	1
Regional Land Use Planning	(5)	▲	■	●	●	▲	▲	⬤	■	●	▲	●			●	■	⬤		0
Land Management	(5)	▲	■	⬤	●	■	●	⬤	⬤		■	⬤	▲	●	■	⬤	⬤		0
Mapping	(6)		▲	●		▲		▲						●		●	■		1
Environmental Protection	(3)	▲		▲	▲	■			▲	▲			▲		▲	▲	▲	▲	0
Resource Planning and Management	(14)	▲	●	▲		■	▲	▲	▲		▲	▲	▲	▲	●	▲	⬤	●	0
Special Area Planning	(2)	⬤		⬤	⬤	⬤			⬤						⬤		⬤	⬤	1
Other	(11)	■	▲	●	●	▲	●	●	●	●	●	●	▲	●	●	▲	⬤	■	0
Total	(50)	▲	▲	▲	●	▲	●	▲	▲	●	●	▲	●	●	●	▲	⬤	▲	3

Table 3-7

Comparison of the Data Characteristics Desired by Each Type of System User

KEY

- — None Reported
- ● Less than 25%
- ▲ 25% to 49%
- ■ 50% to 74%
- ⬤ 75% or greater

(Note: Sample size in parentheses)

BASIC RESPONSIBILITY OF RESPONDENT:	PLACE OF COVERAGE					SIZE OF COVERAGE (estimated when possible)								SOURCE OF DATA											PRECISION (a)					RESOLUTION (a)						
	Idaho	Oregon	Washington	Combination of Two Above	All	Greater than 100,000 sq. mi.	10,000 to 100,000 sq. mi.	1,000 to 10,000 sq. mi.	100 to 1,000 sq. mi.	10 to 100 sq. mi.	Less than 10 sq. mi.	Variable	Not Reported	Field Survey	Field Monitor	Published Surveys and Maps	Pre-encoded Data	Conventional Air Photography	Landsat	Other Remote Sensed Data	Interpretation of Other Data	Multiple	Other	Not Reported	High	Moderately High	Intermediate	Poor	Not Reported	Very Fine	Fine	Intermediate	Coarse	Very Coarse	Variable	Not Reported
Metropolitan Land Use Planning (4)		■	■					▲	■	▲				⬤	▲	⬤	■	■	▲	▲	▲	⬤			▲				3	⬤						1
Regional Land Use Planning (5)		●	■		●		●	■				●		■		⬤	▲		▲	▲		⬤		1	⬤				4		▲	⬤				2
Land Management (5)	●		▲	●	●	■	●	●						■	●	▲		▲			●	■			⬤				4	▲		■				2
Mapping (6)		●	●		■	●		●				■	1	■		⬤		⬤				■	●	1		⬤			5		■	▲				3
Environmental Protection (3)			▲		■	■	▲							■	▲	■		▲				■			⬤				2			⬤				2
Resource Planning and Management (14)	●	●	●	●	■	■	●	●	●	●				⬤	●	▲	▲	▲	●	●	●	■				■			13			▲	■	▲		10
Special Area Planning (2)	■			■				■	■							⬤	■	■			■	■							2				⬤			1
Other (11)			●		■	⬤	●						2	▲	▲	■	▲	●	●	●		■	●			⬤			10		▲	●	■		●	6
Total (50)	●	●	●	●	▲	▲	●	●	●	●		●	3	■	■	■	▲	▲	●	●	●	■	●	2	■	▲			43	●	●	▲	▲	●	●	27

(a) Note: Explanation of the actual intervals represented by these nominal generalizations may be found in appendix 4.

Table 3-8

Comparison of the Mapping and Geographic Location Referencing Characteristics Desired by Each Type of System User

KEY

— None Reported

● Less than 25%

▲ 25% to 49%

■ 50% to 74%

⬤ 75% or Greater

(Note: Sample size in parentheses)

BASIC RESPONSIBILITY OF RESPONDENT:	FORM OF THE LOCATION IDENTIFIER								SCALE (a)								MAP PROJECTION											COORDINATE REFERENCE							
	Grid	Polygon	GBF/DIME	Point	Line	External Index	Integrated	Unknown or Unreported	Very Large	Large	Medium	Medium-Small	Small	Very Small	Variable	Not Reported	Orthographic	Gnomonic	Lambert Azimuthal	Lambert Conformal	Albers	Polyconic	Mercator	Transverse Mercator	Multiple	Other	Not Reported	Latitude/Longitude	State Plane Coordinate	UTM Coordinate	Public Rectangular Survey	Arbitrary x,y	Multiple	Other	Not Reported
Metropolitan Land Use Planning (4)			▲		▲		■	0	⬤	⬤					■	0				⬤							2	▲	⬤		▲	▲	■		0
Regional Land Use Planning (5)	■	●					●	0		⬤		●			▲	0						⬤					2	■	▲	▲	▲	■	▲		1
Land Management (5)	▲	▲		●				0		⬤	▲	▲			▲	1				▲		■					2	▲	■		■	▲	■		1
Mapping (6)	▲				■			3	●	⬤	■	●	●		⬤	1				⬤				■	■		2	●	⬤	▲	●		■		1
Environmental Protection (3)		▲		▲			▲	0		⬤						2						⬤					2	■		■			▲		0
Resource Planning and Management (14)	▲	●		●		●	●	0		▲	▲	▲	▲	●	■	3				▲		●		▲	▲		7	■	●	▲	●	●	●		1
Special Area Planning (2)	■		■					0				⬤			⬤	1						⬤					1	■	■						0
Other (11)	▲	●		▲	●		●	0	▲	▲	●	●	●		■	6				●					⬤		6	■	▲	●	●	●	▲	●	0
Total (50)	▲	●	●	●	●	●	●	3	●	■	▲	●	●	●	■	14				▲		▲		●	▲		24	■	▲	●	●	●	▲	●	4

(a) Note: Explanation of the actual intervals represented by these nominal generalizations may be found in appendix 4.

helpful in understanding the characteristic needs of each group, and thus perhaps focus upon particular issues and options.

Metropolitan Planning: The systems used by metropolitan planning agencies are the most sophisticated, yet meet user needs to the least extent. This is believed to be a result of the wide variety of different types of applications perceived by the respondents in this group. Most of the systems are operational, but still are developing new capabilities. All are conversationally directed and most have graphic line reproduction capability. All integrate environmental and nonenvironmental data.

The applications desired are quite diverse. The only types of applications for which significant desire is not indicated are the various types of applied environmental and resource management applications. Interest is predominantly indicated for systems to perform land use planning related concerns: modeling and monitoring growth trends, land suitability analyses, maintaining urban data banks, and site selection. Mapping at cadastral accuracy is desired, indicating a very fine scale of data collection. Analytical capability is recognized to be important. The types of analysis desired are representative of siting and change monitoring functions. The need to perform statistical analyses is also recognized.

The desire for the ability to have a system perform diverse functions is supported by the recognition of and desire for the greatest variety and most sophisticated data handling capabilities. The greatest desire is reported for measurement, sorting and merging, comparison, and graphic output capabilities. The metropolitan planning agencies are the only group which perceive illustrative graphic output, such as diagram display, shading, and perspective drawing, to be important system capabilities. The ability to integrate data from many sources and to perform logical analytical operations upon the data is perceived to be very important, yet there is little interest demonstrated in the ability to access data from external files. This may be due to the heavy reliance upon data which are collected and placed into usable form by the agency. The analysis of terrain data is important, but there is not very much interest in Landsat data analysis capability.

Topical data needs of metropolitan planning agencies are reflective of metropolitan concerns. Management of the natural environment is not a high priority, therefore there is a lesser desire noted for natural resource data than for most groups. Census, land use, zoning, housing and legal property descriptions are the type of data most desired. A versatile data handling structure is implied due to the variety of formats in which these data are usually maintained. Only one metropolitan planning agency reports additional desire for any type of environmental data, excluding relief information. The heavier desire for nonenvironmental data is expected due to the small and culturally impacted nature of the areas.

The areas of coverage are small, and as expected this influences the scale and precision of the data collected. High precision and resolution requirements are noted. Scale requirements are reported to be larger than 1:24,000. Variable scale data integration is also desired.

Many different data sources are reported. Published surveys and maps and field survey are the primary sources from which data are extracted.

Half of the respondents report the need to integrate different location identifiers. Only Lambert Conformal map projection is reported, indicating the reliance on the standard U.S.G.S. quadrangle map as a base. The most common coordinate reference is state plane coordinates. Referencing is also accomplished using latitude and longitude, public rectangular survey, and arbitrary 'x, y.' Multiple coordinate referencing is reported by half of the municipal planning respondents.

Regional Planning. The systems belonging to regional planning agencies are very different in form from the metropolitan planning agency systems, and the applications, though generally similar, reflect differences in the size of coverage and the administrative mandate. Complex and simple systems are included in this group. None of the systems are conversationally directed, and most rely on batch processing of data, thereby slowing response time considerably. All have computer-assisted mapping capability, but only two handle data in line mode.

The types of applications and analyses preferred by the regional planning agencies are similar to those of the metropolitan planning agencies, with few exceptions. These exceptions are, for example, the greater desire for applied environmental and natural resource management applications, and less preference for the mapping and analytical capabilities. The data handling capabilities, in every category, are desired less frequently than for the metropolitan planning agencies. Sorting and merging capabilities are found to be the most highly desired, followed by comparison, measurement, and spatial data rectification. Digital terrain evaluation is desired, but no respondents indicated desire for Landsat data handling software.

Natural resource data are preferred by a higher percentage of regional planning respondents than by metropolitan planning respondents. Land use data are very important, as are land cover, topography, and zoning. Environmental data needs are diverse. Soil type is the most highly desired. Renewable and nonrenewable natural resources are not highly desired. Data represented as area coverages are more important than point or line formatted data.

The size of the coverage ranges between 1,000 square miles and 100,000 square miles. Data sources are varied. The predominant data source is published surveys and maps. Field surveys, preencoded data, Landsat, and other remote sensing data are also indicated. Most respondents report multiple data sources. Precision requirements are high, but the preferred resolution is in the intermediate range. The predominant form of location identifier is the grid. The predominant scale is large, and two of the five respondents report variable scale data requirements. The only map projection reported is Polyconic. Coordinate reference is varied. Latitude and longitude and arbitrary 'x, y' predominate, and state plan, UTM, and public rectangular survey are also reported. Only one agency reports multiple coordinate reference capability.

Land Management. Resource inventory applications are most prominent for the land management agencies. The systems are, as a rule, less sophisticated than those of other users. The occurrence of unmet needs is also lower because of the simpler data handling requirements. Most of the land management systems are still undergoing development. All are associated with a particular data base, and most are user friendly. Computer mapping capability is desired, but not universal. Thematic mapping and land use allocation are also highly desired, reflecting the need to allocate the use of land between many competing uses. There is, surprisingly, little interest in base mapping and land suitability analysis. No interest in derived analyses are reported.

Data comparison and measurement are the data handling capabilities most desired, and the least interest is reported for graphic output, modeling, value weighting, and statistical analysis. Editing, spatial rectification, and measurement concerns are noted higher than the norm. Digital relief analysis is not considered to be a priority of the sample, and Landsat data classification and analysis is not reported to be a concern of any of the respondents.

Land management agencies show greatest preferences for area coverages and for natural resource data. The most highly reported general data types are land cover, land use, land resources, legal property descriptions, topography, and other environmental data. The interlocking ownerships of state, private, and federal wild lands necessitates the aggregation of data into ownership categories, thus demonstrating the interest for these types of data and the interest in variable boundary and polygon-type systems. The most frequently desired environmental data are soil type and interpretation, timber resources, vegetation (most notably timber) and land cover, all area coverages. Also highly preferred are topography, surface hydrology, climate and weather, and unique and sensitive areas. This group represents area coverage, line, and point data. Coverages range from 1,000 square miles to over 100,000 square miles. The most predominant method of data collection is from field survey, followed by published surveys and maps and conventional aerial photography, in order of preference. Other sources are also reported, but none report the incorporation of Landsat or other remote sensed data into the systems' data bases. A majority of the reporting agencies indicated multiple data sources. Precision requirements are high, and resolution needs are reported in the intermediate and very fine range. Location identifiers are varied. Two grid, two polygon, and one point system are reported. Scale ranges from medium small to large, with large scale predominating. Both Polyconic and Lambert projections are reported and the coordinate references vary greatly. Public rectangular survey and state plane coordinates predominate. Multiple referencing is also desired.

Mapping. Mapping is a special type of use. Few agencies' responsibilities are solely dedicated to map production. However, special programs within agencies often require the specialized services of cartographers and cartographic production systems. All of the systems described are supplied by vendors, but only half are reported to be conversationally directed. All of the systems reproduce line images by use of computer hardware and software. Two thirds of the respondents indicate that the systems are still undergoing modification. Five of the six systems are dedicated to a particular data base or set of data bases, and only one is used for special ad hoc projects for which a data base is not maintained. The mapping agencies do not express desire to serve other than mapping purposes, though the data, hardware, and software are often capable of other applications.

The mapping agencies report a surprisingly high desire for diverse types of software. Editing, spatial rectification, and sorting/merging, are most desired and there is the least desire for analytical capabilities, such as value weighting, modeling and statistical analysis. Though greater than the norm, there is a surprisingly low desire for the more sophisticated graphic output capabilities and no interest in advanced analytical capability.

The mapping agency's data requirements are related to the types of maps which are drawn, and are thus better expressed individually rather than collectively. A few observations can be made, however. The data types reported are principally graphically portrayed as networks or as line boundaries. Land use is the most frequently reported data type, but many other types of data are reported.

Four of the mapping agencies produce maps for national coverage, and one each produce maps for coverages in Washington and Idaho. The sizes of the areas mapped vary widely. The predominant data sources are published surveys and maps, conventional aerial photography, and field survey. Most agencies report multiple data sources. Surprisingly, only one of six reports precision figures, and that one reports requirements to be moderately high. Resolution requirements are reported to be intermediate to fine. Three of the respondents did not report the form of the location identifier, but they are inferred to be encoded as lines. Two report line, and a single respondent reports grid encoding. Scale varies widely from very large to small. 1:24,000 scale predominates. Most report variable scale capability. Lambert Conformal is the predominant projection. State plane and UTM coordinates are most dominant. Very surprisingly, no respondents indicated arbitrary 'x, y' coordinate referencing, which is the common type in most stand-alone graphics systems. It is most probable that the coordinate referencing of the output maps rather than the data in internal storage is described.

Environmental Protection. Spatial data handling systems used by environmental protection agencies are primarily designed to monitor and analyze environmental conditions. The type of system is highly influenced by the types of data which are maintained and the analytical requirements of the users. The small sample makes characterization difficult. All are associated with a particular data base, require explicit data referencing, were developed in-house, and are user friendly. Only one of the three in the sample stores nonenvironmental with environmental data in the data base and only two report computer mapping capability.

The two predominant applications performed by the environmental protection agencies are modeling and environmental impact assessment. Trend projection and site selection are also noted by more than half of the respondents. Environmental protection agencies, along with metropolitan planning agencies, report a significant desire for advanced analytical capability. Optimum location, quality, availability, and development restraints are the most frequently reported.

The small population of environmental protection agencies reports few and not very diverse software requirements in comparison to the total population. Selective data retrieval, and the ability to identify and correct closure are the only capabilities desired by all three respondents. Only editing capabilities are reported more frequently than the norm. Digital relief analysis and Landsat data analysis are not desired by any of the agencies in this group.

The small sample is not indicative of data needs. Each application is unique but area coverages, line networks, and points are noted. Data sources vary. Field survey and published surveys and maps are predominant. Precision requirements are high (due probably to the requirement to locate accurately sampling stations) and resolution requirements are at intermediate levels. Polygon, point, and integrated locational identification are reported. Polyconic projection is the only projection mentioned and latitude and longitude and UTM coordinates are the only coordinate references reported. With a larger sample, more point referenced systems and data from field monitors would be expected.

Resource Planning and Management. The systems surveyed in this group are nearly equally divided between simple data base management systems and more sophisticated resource management information systems. They are primarily designed for handling a single data type or related sets of data.

The predominant applications of the resource planning and management agencies are resource inventory and modeling with lesser frequency applications for base mapping, land classification, critical area planning, maintenance of an environmental data bank, site selection, and timber management. The selection is believed to be highly influenced by the specific functions of the sponsoring agencies. It is surprising that both the land management and resource planning and management agencies show little concern for using their systems for trend projection, base mapping, land suitability analysis, and the more sophisticated types of data analyses. This perhaps can be explained by the high proportion of systems performing inventory functions.

Due to the diversity of this group, a desire for every type of data handling capability is noted, but the consistency of desire for any type in particular is relatively low. The pattern of response generally follows that of the total population. Selective data retrieval is the most desired capability. Spatial data rectification and comparison also rate high. Editing is the only group of capabilities which rates below the norm, possibly due to the fixed format of most of the data. Special types of capabilities such as 3D mapping, diagram, and chart display, value weighting, and integration from remote files each are more highly desired by agencies in this group than the norm. Digital relief analysis is favored by half of the agencies reporting in this group, but Landsat data analysis is only desired by two agencies.

Resource Planning and Management agencies report desire for many types and forms of data. The diversity of the system applications of the sample accounts for this pattern. The same data types which are reported for land management agencies are herein reported, but there is far less desire for property descriptions and greater desire for other environmental data types. Land resources, land cover, and land use are the most frequently reported general data types. Surface hydrology is the only environmental type which is preferred by the majority of respondents. The specific purpose for which the system is designed is the predominant factor in the choice of data. Integration of data from various sources in varying spatial formats is implied. The majority of coverages are larger than 100,000 square miles. The smallest is between ten and 100 square miles. The predominant source of data is field survey. Published surveys and maps, pre-encoded data and conventional aerial photography are also frequently reported. Most respondents prefer multiple data sources. No comment can be made about precision due to the limited response. The predominant resolution is coarse. There is no consistent encoding format reported. The scales of data vary widely from large to very small, and the majority of respondents report variable data scales. The utility of multiple map projection is recognized. The predominant coordinate reference is latitude and longitude, with lesser numbers reported for UTM, state plane coordinate, public rectangular survey, and arbitrary 'x, y' in order of preference.

Special Area Planning. Special area planning agencies perform planning-related functions for specific types of activities such as transportation and health, rather than land use, but still adhere to principles and techniques of planning. The operational needs are therefore very similar. The two responses are indicative individually of needs of the functions of that type of agency, but the sample is too small to be representative of the group at large. Because one of the systems is being developed, it somewhat biases the results.

Neither of the systems is user friendly, but both were at least partially developed by vendors. Integration of environmental data and nonenvironmental data, and the integral data bases are reported. Explicit data referencing is not perceived to be essential.

The special area planning agencies most frequently indicate resource inventory, modeling, and route selection applications. Modeling and resource inventory are believed to be significant. The other predominant choices are believed to be more representative of the special types of functions performed by the agencies which responded, than representing unifying characteristics of this type of data user. Sophisticated data analysis is perceived to be important. Each major category of system software is desired. Proportionally, the frequency of response is equal to or greater than the norm for every category of software.

Special area planning agencies have more focused data requirements due to the singular nature of applications. Land use, again, is the most frequently reported data type. Zoning, transportation, and utilities data again surface as relevant for planning. The single response to the environmental data question is only representative of the responding agency.

Published surveys and maps are the predominant data source. Pre-encoded, interpretation from other data in the system, and conventional aerial photography are also reported. No precision choice is reported and the resolution of the grid system is coarse. Scale is medium-small, but variable. Polyconic map projection, latitude and longitude, and state plane coordinate reference are reported.

Other. The respondents grouped into the 'other' category are diverse, but this diversity is representative of very specialized types of applications and also unique system configurations. The profile for this group has the most meaning if compared to the other groups on the basis of the comparison between general purpose systems and systems designed to meet unique user requirements. A high percentage are fully operational and not developing new capabilities. Also, a high percentage are vendor supplied. Most are user friendly and most are capable of graphic line reproduction. Nearly all have computer mapping capability but few require the integration of environmental with nonenvironmental data. Many types of applications and analysis are reported, but none with any significant frequency. Little consistency and a variety of different preferences for software are also reported. As might be expected, this group as a whole diverges from the norm in many areas. The greatest number of special applications are noted in this group, many of which are not common to the general population. Line generalization, creation of new files, integration from remote files, and labeling are all desired in greater proportion in this group. Surprisingly, diagram and chart display and modeling are not highly rated and digital relief analysis, overlay, and contouring are desired in less proportion than the norm.

There is at least singular desire for all of the data types queried, but again, choice is highly determined by the responsibilities of each reporting agency. There is only one data type preferred by the majority of the respondents and, as might be expected, the 'other' choice is noted frequently. The most common environmental data type reported is geology, most probably due to the large number of systems reported from the U.S. Geological Survey. The other most frequently selected data types are topography, mineral resources, and land cover. The agencies reported in this category predominantly report needs for a variable selection of data. The system configurations are normally centered around a particular type of analysis.

A data-characteristic by data-characteristic description would not provide a representative description. Some highlights are noted. All of the systems have large area coverages. The sources of the data are quite varied and there is a higher reliance upon pre-encoded and remote sensed data than that of other groups of respondents. Resolution requirements are quite varied, but appropriate for the types of application and sizes of coverage. The forms of the location identifiers also are varied. The coordinate referencing is as expected for the type of agencies reporting, and is also quite consistent with the other resource planning and management type data bases exhibiting similar ranges of size and application.

Profile of System Characteristics

Tables 3-9 and 3-10 provide a profile of the *actual* operating characteristics of the classified system types. Representative applications, types of analysis, and data handling software are tabulated for each group. Though not definitive, this evaluation illustrates the types of applications and data handling operations most commonly performed by different types of systems. The limitations and potentials of these systems are inferred. *The tables report the frequency of responses in each descriptive group as a percentage of the total reported for each group.* The numerical frequencies of the actual and desired characteristics are tabulated in Appendix 5.

Since the desired applications and data handling capabilities may not be feasibly produced on the systems, only the actual characteristics are tabulated in the graphic summary, and reported herein. Two issues are significant in this discussion. The first is: what are the applications, types of analyses, and data processing capabilities able to be performed by different types of systems? The second is: which types of systems can perform different types of data processing, analysis, and application which others cannot or do not perform. The text in this section is formatted

Table 3-9

Comparison of the Representative Applications and Types of Analyses Reported for Each Type of System

KEY

— None Reported

● Less than 25%

▲ 25% to 49%

■ 50% to 74%

⬤ 75% or Greater

(Note: Sample size in parentheses)

SYSTEM TYPE:		TYPES OF APPLICATIONS																							TYPES OF ANALYSIS											
		Base Mapping	Resource Inventory	Land Classification	Modeling	Environmental Impact Assessment	Land Suitability Analysis	Critical Area Planning	Thematic Mapping	Trend Projection	Environmental Data Bank	Urban Data Bank	Cadastral Mapping	Route Selection	Site Selection	Land Use Allocation	Air Quality Management	Water Quality Management	Wildlife Management	Timber Management	Agricultural Production	Hazard Identification	Other	Not Reported	Proximity	Capacity	Optimum Location	Quality	Availability	Change	Development Constraints	Accessibility	Statistics	Cost	Other	Not Reported
Data Base Maintenance	(5)		⬤	●		●	●	▲								●			●	▲	●		●	0												1
Output Mapping - Image Production	(6)	■	▲			●		●	●		●											●	●	1	▲		▲	▲	▲		▲	▲				2
Information Retrieval System - Point	(6)		▲		■	▲				▲					●		●	▲		●			●	0				▲	▲	▲	▲		▲			3
Information Retrieval System - Fixed Grid	(7)	●	⬤	▲	⬤	●	●	●	■	●	■	●		●	▲	▲		▲		●	●	●		1		▲	▲		●	●	■	●	●			1
Information Retrieval System - Variable Boundary	(2)	⬤																						1												1
Information Retrieval System - GBF/DIME	(2)																						■	0												0
Information Retrieval System - Combined	(8)	■	■	▲	▲	●	▲	●	●	▲	●		●		■	●				●		●	▲	2	●				●		▲	●			●	1
Integrated - Map Overlay	(6)	⬤	■	■	■	●	■	■	▲	▲	●	●		●	■	■		●	●	■	●	▲	●	0	●	●	■	▲	■	●	■	▲	▲	●		0
Integrated - General Purpose	(2)		⬤	⬤	⬤			⬤			⬤					⬤				⬤				1	⬤		⬤	⬤					⬤			1
Digital Terrain Model	(1)																							0												0
Other	(5)	▲	▲	▲	▲	●	●		▲		▲				●	●				●	●		▲	0	■					■	▲	▲	■		▲	1
Total	(50)	▲	■	▲	▲	●	●	●	●	●	●	●	●	●	▲	●	●	●	●	●	●	●	●	6	●	●	●	●	●	●	▲	●	●	●	●	10

differently to provide a better direct comparison between the system types. Rather than profiling the aggregated characteristics of each system type, each issue is addressed separately. It is again noted that the tables and text are exemplary.

Applications and Analyses. Data base management systems are most highly used for resource inventory applications. Data users also access data from these systems for conventional nonautomated analysis, display, and reporting. No derived analyses, siting, trending, mapping, modeling, or similar applications are performed with these systems.

Output mapping (Image Production) systems are most highly used for base mapping and resource inventory, but may also be used to produce maps suitable for use and interpretation by others. The additional applications reported are the result of a single response, and therefore may not be representative of the group as a whole.

The composite of types of information retrieval systems demonstrate a much more versatile and sophisticated range of applications and analysis than the previous two types of systems. Applications such as modeling, trend projection, thematic mapping, and various management applications are noted. The types of analyses which are reported are also more sophisticated and diverse. Fixed grid and combined systems appear to be more versatile than the GBF/DIME, variable boundary, and point systems, but the greater number of operating systems in this group may be biasing the results. The point systems are most highly used for modeling, trend projection, resource inventory, water quality management, and environmental impact assessment. The type of data recorded as points (i.e., sampling sites) would tend to limit the applications as well. The grid systems are reported to be used most for resource inventory, modeling, thematic mapping, and the maintenance of an environmental data bank, but nearly all applications are reported. The types of analysis are also quite diverse, and development constraints, optimum location, and capacity have the highest frequency of response. Many more analysis applications are reported for this type of information retrieval system than any other. Only one variable boundary and GBF/DIME system are reported, thus providing a poor example for analysis and comparison. The combined information retrieval systems add the line mode to the other data formats and thus report base mapping in addition to the other types of applications previously indicated. Resource inventory and site selection are also favored applications. Modeling, thematic mapping, maintenance of mutii-resource data banks, and resource management applications are less pronounced than for the grid systems. Surprisingly, few derived analysis applications are reported for these types of systems.

The integrated map overlay type system is reported to perform the greatest range of applications and the greatest range and frequency of derived analyses. Image production and other output mapping subsystems enable the integrated map overlay systems to be used for base mapping. The overlay capability facilitates land suitability analysis, site selection, land use allocation, and strategic resource planning and management without losing the capability for modeling and thematic mapping common in the information retrieval systems. Every form of analysis is reported. Optimum location, availability, and derivation of development constraints are the types of analysis most frequently reported for these types of systems.

Only one integrated general purpose system is described. It performs many and varying applications and types of analysis, none of which are unique to this type of system.

Base mapping may be performed by any system with graphic line reproduction capability. This is true of the image production systems, the variable boundary, and combined map overlay systems. Resource inventory applications are performed by each system except GBF/DIME and information retrieval-variable boundary, where the storage of contiguous area data is difficult and requires much generalization. Modeling and trend projection requires analytical capability and the ability to maintain fixed geographic encoding units. The point, grid, map overlay, and combined systems are most appropriate and most frequently reported for modeling. Land suitability analysis, critical area planning, site selection, and land use allocation are most frequently performed by integrated systems. Land suitability analysis is performed by integrated and combined systems, site and route selection is performed by grid and combined information retrieval systems and integrated-map overlay systems. Air quality and water quality management are favored in point and grid information retrieval systems. Timber, wildlife, and agricultural management are reported to be equally well served by data base maintenance and the more sophisticated integrated systems.

The other types of applications are either not well enough documented, or are too frequently performed by various types of systems to be herein highlighted.

Proximity, statistics, optimum location, quality, and availability are the most often reported analyses performed with integrated systems. Information retrieval systems, specifically the combined systems and grid systems, are most often cited as performing capacity, change, development constraints, and accessibility analysis. This author believes these findings are more the result of the functions performed by the agencies than the limitations of the systems. Most integrated and information retrieval systems should be capable of performing derived analysis.

The more sophisticated the system, the wider is the range of potential applications and the greater is the frequency of derived analysis. Systems built rigidly around one application or type of application are the least flexible to perform other functions. The map overlay capability is seen as the tool which allows the greatest range of applications and types of analysis. Image production systems may produce graphic output which may assist in data analysis and facilitate the users' applications, but is not as important as the ability to perform logical operations on the data. This observation is also true of the data base maintenance systems.

Data Processing Capability. Table 3-10 reports the proportion of the different types of systems actually performing the recorded data handling operations. The digital terrain model and GBF/DIME type systems have the least associated software for performing data manipulations. The map overlay, combined information retrieval systems, and image production-output mapping systems have the greatest distribution and frequency of associated software. Map overlay, image production, and 'other' systems report the greatest amount of editing software. Image production, variable boundary, map overlay, and 'other' systems report the greatest amount of spatial data rectification software. Measurement is found to be used most extensively in the map overlay systems, and with less though still significant frequency in image production, variable boundary, combined, general purpose, and 'other' systems. Sorting and merging software is important in data base maintenance systems, though selective retrieval is by far the most highly used capability. Selective retrieval is also important in image

Table 3-10

Comparison of the Data Handling Software Reported for Each Type of System

KEY

— None Reported

• Less than 25%

▲ 25% to 49%

■ 50% to 74%

● 75% or Greater

(Note: Sample size in parentheses)

SOFTWARE	Editing				Spatial Rectification						Measurement				Sorting/Merging						Comparison						Graphic Output					Other		
SYSTEM TYPE:	Identify and Correct Closure	Identify and Correct Slivers	Data File Update	Labeling	Removing Map Distortion	Line Generalization	Modify Alignment	Scale Change	Projection Change or Coordinate Conversion	Location Identifier Conversion	Linear Measurement	Area Measurement	Direction Determination	Centroid Determination	Selective Retrieval - Geographic	Selective Retrieval - Descriptor	Edge Matching	Create New Files	Integrate from Remote Files	Contouring	Overlay - Union	Overlay - Intersection	Value Weighting	Modeling	Statistical Analysis	Extreme Value Search	Zooming	Diagram and Chart Display	Lettering	Shading	3D	Digital Relief Analysis	Landsat Data Analysis	Not Reported
Data Base Maintenance (5)			▲					▲	■	▲		▲		▲	●	●		▲			▲				▲	▲								1
Output Mapping - Image Production (6)	■	▲	■	■	●	■	■	■	■	•	■	■	▲	•	■	■	■	■		●	■	■		•	•	•	■	■	●	▲		•		0
Information Retrieval System - Point (6)			•	▲				•	•	•					●	●		■							▲		▲	•	▲	•	▲			1
Information Retrieval System - Fixed Grid (7)			•	•			•	•	▲	▲	▲	▲		•	■	■	▲	▲	•		▲	▲	▲	▲	•	•	•		▲			■		0
Information Retrieval System - Variable Boundary (2)	■		■	■		■	■	■	■	■	■	■			■	■	■	■			■				■				■	■				0
Information Retrieval System - GBF/DIME (2)											■				■	■					■													0
Information Retrieval System - Combined (8)	▲	▲	●	▲	•	▲	•	■	▲	■	▲	■	▲	▲	●	●	▲	■	▲	■	■	▲	•	•	■	▲	■	▲	●	•	•	▲		0
Integrated - Map Overlay (6)	■	●	●	●	●	■	■	●	●	•	●	●		▲	●	●	●	●		●	●	●	•	▲	■	▲	■	■	●	▲		•		0
Integrated - General Purpose (2)	●				●			●	●		●	●			●	●	●	●	●	●	●	●			●		●	●			●	●	●	1
Digital Terrain Model (1)		●			●			●	●																●	●						●		0
Other (5)	●	•	▲	●	■	▲	▲	●	■	●	▲	■	•	▲	●	●	▲	■	•	■	●	■	•	•	•	▲	▲	▲	●	■	•	▲	▲	0
Total (50)	▲	▲	■	▲	▲	▲	▲	■	▲	▲	▲	▲	•	•	●	●	▲	■	•	▲	■	■	•	•	▲	•	▲	▲	■	▲	•	▲	•	3

production, point, grid, variable boundary, and combined information retrieval systems, and in map overlay, general purpose, and 'other' type systems. Comparison software is most noted in combined, map overlay, general purpose, and 'other' type systems. Graphic output is found to be an important element of the image production, combined, map overlay, and 'other' type systems. Digital relief analysis can be performed with fixed grid, combined, map overlay, general purpose, and digital terrain models. Landsat data analysis is performed on special systems in the 'other' category, and on one general purpose integrated system.

As expected, the data base maintenance system's highest reported capability is the selective retrieval of data. The other capabilities which are reported are not expected, which leads this author to believe that one system was misclassified, or that other operations are performed manually upon the data once they are retrieved from the system.

The image production-output mapping systems perform the requisite editing, spatial rectification, and graphic output operations necessary to produce line maps, but in addition include measurement and logical overlay capability. This implies very versatile performance capabilities for this type of system. It is noted, however, that these systems are limited in their ability to perform more sophisticated comparisons such as statistical analysis and modeling, and are also restricted because the data are encoded in line mode and location identifier conversion, while possible, is not operational on most systems.

Point encoded information retrieval systems are limited to the portrayal of data as points. Selective retrieval is easily performed, but overlay and other coverage-related analysis techniques are absent. Editing is limited to the descriptor records. Statistical analysis is possible and graphic display may also be performed. Spatial data rectification and measurement are not perceived to be important due to the nature of point records. Neither digital relief nor Landsat analysis are performed.

Fixed grid information retrieval systems have data representative of area coverages. The nature of the grid allows overlay, modeling, statistical analysis, and value weighting to be easily performed. Editing is also limited to descriptor data, as the grid is fixed and does not require coordinate digitizing. The types of spatial data rectification are also influenced by the fixed nature of the area encoding unit. Alignment modification and scale change are not required by most systems, but coordinate conversion and location identifier conversion are used often. Sorting and merging are operational on some systems, probably being influenced by the nature of the source data. Versatile graphic output is not prevalent, probably due to the reliance for graphic display on line printers. Digital relief analysis is reported frequently, but is limited to the storage of previously calculated elevation or slope values. Landsat data analysis is not performed.

The interpretation of the significance of the information for the variable boundary system is biased by the limited population and the fact that one of the systems is still in the development stages. Capabilities are found in each of the major software categories, but they are not consistently reported. Spatial data rectification, measurement, and sorting and merging software are the most consistently reported, and comparison is the least consistently reported probably due to the emphasis of these systems upon data aggregation rather than sophisticated analysis. Graphic output is not reported to be an integral part of these systems. Digital relief and Landsat data analysis is not performed.

GBF/DIME systems are not reported to have very sophisticated or diverse software. No editing, spatial rectification, or graphic output capabilities are reported. The only type of measurement reported is linear, and the only type of comparison reported is union type overlay. Selective retrieval of geographic and descriptor data is reported. GBF/DIME type systems could have many other capabilities, but the limited sample does not demonstrate this. In both cases, the applications performed by the systems reported in this category are specialized, thus mitigating the wider use of the systems' potential capabilities.

The combined information retrieval systems incorporate the attributes of the encoding formats which are combined. Most often, the combination results from the incorporation of line with point, grid, or variable boundary type analysis, thus enhancing graphic line reproductions and true boundary display. Capabilities are found in each software group, and the frequency of use is relatively high in most groups. Sorting and merging software are most prevalent. The concentration of software is nearly evenly distributed among the other groups. Editing, measurement, comparison, and graphic output software are more prevalent in this type of system than the norm.

Integrated map overlay systems contain the greatest variety and highest concentrations of software. Each class is above the norm. These systems are the most versatile and sophisticated systems surveyed. Their versatility also makes editing, spatial rectification, and sorting and merging capabilities more important. The overlay capability is implicit, but the complexity of the spatial data structures also makes modeling and statistical analysis more difficult and therefore less frequently reported. Each type of graphic output software is reported more frequently than the norm, indicating that versatile output is perceived to be important to convey the results of data analysis and manipulation. Polygon systems predominate, thus the requirement for correction of closure and slivers and the low response to location identifier conversion. Digital relief analysis is performed much less frequently in these systems than in grid systems, though the capability exists. There is no Landsat data analysis reported.

Only one integrated-general purpose system is reported. Software is contained from each group, but there are many capabilities not reported. Sorting and merging and comparison are the most frequently reported classes of software. Digital relief and Landsat data analysis also are performed by these systems.

The digital terrain model represents a unique application and therefore the software which is reported is also unique. Identification and correction of slivers, removing map distortion, scale change, modeling, statistical analysis, extreme value search, shading, and digital relief analysis are the operations which are reported. Others might be expected, but the singular response biases a more definitive observation.

The systems in the 'other' category encompass all of the data handling capabilities which are reported. As expected, different systems incorporate different types of software to meet their unique purposes. Due to the diverse nature of this group of systems, no definitive observations are reported.

The types of systems exhibiting the greatest diversity of applications consistently report the greatest diversity of software. Data storage and retrieval is the most basic function of all systems. Other types of data handling operations are performed to support the collective and individual functions of the reporting agencies. The sophistication of the operating systems are determined by the range of operations implied by the software.

Comparison of the Federal and Nonfederal Systems

The segregation of federal and nonfederal systems compares some of the operating characteristics of the systems, the data processing software, and selected data and geographical referencing characteristics. These characterize differences between data suppliers (the federal systems), and data users (the nonfederal systems). Prospects of spatial data integration also are explored.

The federal systems are normally designed around large data bases of primary data. Some include application programs to assist the data users while others are designed simply for data storage and retrieval. The federal system users are also a more satisfied group than the nonfederal system users, reporting far fewer desired characteristics. Nonfederal systems are usually designed around broader purpose data use objectives of the users, and are therefore more versatile in their data use and data manipulation capabilities. Data from many sources are usually integrated into the system's data base, and data manipulation, analysis, and variable output is common. These differences are illustrated in Table 3-11. Note the lower percentage of federal respondents reporting desire for capabilities not presently operating, and the lesser frequencies of response for spatial data rectification and image data manipulation.

Significant differences are also observed in the characteristics of the data maintained in the data bases of the federal system and those used by other data users. Digital mapping and digital storage of spatial data are now common occurrences in most federal resource management systems. The agencies which do not have computer-assisted spatial data handling capability are in the process of developing it. The cartographic and other georeferenced data bases associated with these attempts to more effectively handle data are useful to planners and resource managers. Hydrology, topography, natural resource occurrence and description, air quality, geology, soils, and land use are used routinely at the federal, state, corporate and municipal levels. In order to avoid costly duplication, these data should be compatible between systems. A comparison between

Table 3-11

Comparison of Spatial Data Handling Software

Between Federal and Nonfederal Systems

	Federal		Nonfederal	
	Operating	Desired	Operating	Desired
EDITING				
Identify Closure	31	04	38	08
Identify Slivers	08	04	33	13
SPATIAL RECTIFICATION				
Rubber Sheeting	23	04	42	08
Scale Change	50	08	50	17
Projection Change	30	15	39	08
Coordinate Conversion	35	19	63	17
Polygon to Grid Conversion	19	04	25	25
MEASUREMENT				
Linear	23	08	50	17
Area	30	08	63	25
Direction	04	04	25	29
IMAGE DATA MANIPULATION				
Edge Matching	19	15	54	25
Overlay (Union)	38	15	63	21
Overlay (Intersection)	19	15	54	25
Statistical Analysis	31	12	33	25
GRAPHIC OUTPUT				
Diagram Display	15	04	46	13
Lettering	46	04	54	13
Shading	23	04	17	25
3-D Display	15	04	04	13

Tabulation is percent of those responding.

federal digital data bases and the data used by nonfederal computerized data users shows some interesting results. These are illustrated in Table 3-12. For example, eighty-three percent (83%) of the sample of nonfederal respondents collect data from published surveys and maps, compared to only thirty-five percent (35%) of the federal. Conversely, twenty-three percent (23%) of the federal systems collect data from field monitoring stations compared to only eight percent (8%) of the nonfederal systems. Conventional aerial photography is a data source for forty-one percent (41%) of the nonfederal systems, but for only nineteen percent (19%) of the federal systems. These differences also affect other data characteristics.

The scale of the data is obviously influenced by the size of coverage. Fifty-four percent (54%) of the nonfederal systems encode data at scales of 1:24,000 or larger. Only nineteen percent (19%) of the federal data bases are encoded at these scales, and the majority encode data within the 1:100,000 to 1:500,000 range. Similar differences are noted in the form of the location identifier, the map projection, the coordinate reference, and the form of output.

It is not implied by this evaluation that all federal data bases should be reformatted, but this does highlight the need for close inspection of the characteristics of the data before use by other data users, the need for more versatile data products, and the utility of spatial data rectification software.

Table 3-12

Comparison Between Selected Characteristics of Federal and Nonfederal Spatial Data Bases

Evaluation Variable	Predominant Characteristic	Other Significant Observations
Data Source		
Federal	Field monitor	Field surveys, published surveys and maps
Nonfederal	Published surveys and maps	Conventional aerial photography, pre-encoded data
Scale		
Federal	1:62,000-1:1,000,000	
Nonfederal	1:24,000 or larger	
Location Identifier		
Federal	Coordinate Point	Grid, External Index
Nonfederal	Irregular Polygon	Coordinate Point, grid
Map Projection		
Federal	Transverse Mercator	Lambert Conformal Conic
Nonfederal	Polyconic	Lambert Conformal Conic
Coordinate Reference		
Federal	Latitude/Longitude	UTM, State Plane Coordinate
Nonfederal	State Plane Coordinate	Latitude/Longitude, UTM
Type of Output		
Federal	Computer tape	Tabular, printed maps
Nonfederal	Printed maps	Computer tape, tabular, chart, interactive display

Chapter IV. OTHER RESEARCH FINDINGS

Not all the research questions could be answered by profiling the system and user characteristics. Other questions required additional interpretation of the data from the survey. These miscellaneous questions are addressed individually in this chapter. In order, these are: interrelationships of data characteristics, digital data coverage, differences between operating and desired characteristics, documentation of system design and data, transferable software, and factors limiting further development and use of geoprocessing systems.

INTERRELATIONSHIPS OF DATA CHARACTERISTICS

The choice of certain data decision variables will influence other data characteristics. Many interrelationships are obvious, others may be deductively reasoned or observed from the previous profile. A test was made on the sample to determine the validity of some of these assumptions about data interdependencies.

The CROSSTABS option may record any 'n' dimensional joint frequency distribution of the sample. Many of the data characteristics are cross-tabulated in this way. The result, for the total sample, is the frequency for which any two variables of any selected data characteristic are mutually recorded. For example, how many times is a particular scale or area of coverage, or how many times are grid or polygon location identifiers found in common with different data types? Though not statistically validated, it is believed that this type of empirical analysis of the responses for operating information systems may illustrate interrelationships.

Only particular relationships of greatest interest are tested in this manner. Each is selected to be illustrative of interrelationships believed most likely to occur. The results of the evaluation are noted below. Each relationship sought is identified, and for each the results are reported. The primary result is the observation of whether significant interrelationships appear to exist. The specific interrelationships which are observed are reported, and in some cases comments are noted.[1]

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[1] The numerical results of the cross-tabulations are recorded on a series of computer printouts and summary tables in the possession of this author.

CROSSTAB	VERIFICATION	COMMENTS
1. Data Type and Location Identifier	No	Every type of data is stored in point, grid and polygon form in at least one system. While some similarities between the format of the source data and the encoding format exist, the in-nature data format is not considered to be a limiting factor in system design.
2. Data Type and Data Source	Yes	Some data types are acquired for encoding from only one or two sources, and each has a dominant data source. There is, of course, a distinction between the storage format of primary and secondary data. All types of data may be obtained from published surveys and maps if recorded on this medium.
3. Precision and Data Source	Partial	Remote sensed data definitely exhibit less precision than data from other data sources. Any other observations are masked by the small sample.
4. Resolution and Data Source	No	The expected resolution of the data sources is not reflected in the reported resolution of the data stored in the system.
5. Resolution and Size of Coverage	Yes	Though a direct linear relationship is not exhibited, the larger coverages have coarser resolutions, and the smaller coverages have finer resolutions.
6. Data Source and Size of Coverage	No	Each data source is reported for coverages in each of the reported size ranges. While the remote sensed data predominate for larger coverages, they are not seen to replace field methods for larger areas, nor are field monitors excluded from small coverages.
7. Location Identifier and Size of Coverage	Yes	Coordinate point, grid and external index predominate for larger areas. Irregular polygon is more predominant for smaller coverages. Many irregularities do exist, especially in the use of grids for small coverages.
8. Coordinate Reference and Size of Coverage	Partial	Latitude and longitude definitely predominate for large area coverages. UTM coordinates alos predominate for large coverages. State plane coordinates are common to all coverages. Public rectangular survey, which would not be expected for larger coverages, is reported.

CROSSTAB	VERIFICATION	COMMENTS
9. Precision and Size of Coverage	No	The small sample may mislead the analysis, but precision increases with size of coverage, which contradicts logical expectation.
10. Map Projection and Size of Coverage	Partial	The three projections chosen are representative of regional and smaller coverages, but are also tied to commonly used base maps and coordinate references. Though the choice among the three is not related to size of coverage, the choice of these three, from the total, is appropriate and expected.
11. Scale and Resolution	Yes	The finer resolutions definitely correlate with the larger scales and the coarser resolutions with smaller scales.
12. Scale and Size of Coverage	Yes	Though there is some discrepancy and overlap in the middle ranges, the larger scales are definitely correlated with smaller areas, and the larger areas correlated with smaller scales.
13. Scale and Precision	Yes	Larger scales are correlated with higher precision, but the lack of reported responses for the larger scales precludes assessment of the correlation at various scale ranges.
14. Location Identifier and Precision	Partial	Coordinate point, as expected, exhibits the highest precision, but grid and polygon identifiers also are reported with high precision. Again, the limited sample size precludes any further evaluation.
15. Location Identifier and Resolutions	No	The selection of location identifier does not appear to be influenced by resolution or vice versa. Coordinate point location identifiers span the resolution range from very fine to coarse as do grid and polygon.
16. Map Projection and State of Residence	Partial	Lambert projections are most common in Washington and Oregon, and variable projection systems are most common nationally, but no patterns seem to exist for the transverse mercator and polyconic projections.
17. Coordinate Reference and State of Residence	Yes	Latitude and longitude is most highly noted for national and bi-state coverages. State plane coordinates are noted for coverages in Oregon and Washington. Some variations exist, but the patterns are as expected.

DIGITAL DATA COVERAGE

A section of the questionnaire is devoted to a description of digital data coverage. Each respondent was asked to document the location of coverage, the types of data recorded and various descriptive attributes of the data such as location identifier, scale, coordinate reference, and precision. These individual pages of the questionnaire together provide a preliminary directory of computerized geocoded data coverage for the region.[2]

Though many systems which store or supply data are surveyed, the actual extent of digital data coverage is sparse and is further limited because the systems each have different types, formats, and scales of data, and many systems maintain data only to satisfy their own program needs. A regional description of digital data coverage suitable for making data transfer decisions would therefore necessitate the creation of a directory with at least the detail of the original questionnaire; a task not to be undertaken in this report.

The characteristics and coverages of the data which are stored, processed and utilized in the surveyed systems are as diverse as the systems themselves. This section therefore provides a very general description of the types, characteristics and coverages of the data from representative systems, focuses upon a few programs of more than local significance, and provides some general observations about the status of digital data coverage in the region.

Table 4-1 summarizes the data coverages of the systems which maintain geographically specific data bases and which also contain some form of environmental data.[3] Some of the more illustrative data descriptors are

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[2] The data directory page from the questionnaires and a descriptive summary of the characteristics of each of the systems which are surveyed were provided to NASA and are available from the Technology Applications Branch of the NASA-Ames Research Center, Moffett Field, California. Copies are also in the possession of the author.

[3] The table is not meant to replace a thorough directory. It is exemplary only. The necessary data base descriptors are not reported. There is therefore no inference which can be made of compatibility or transferability between individual systems. All of the systems which are surveyed are not described, and the descriptions are not verified by the respondents.

Table 4-1

Summary of Digital Environmental Data Coverage in the Pacific Northwest States

AGENCY	COVERAGE	DATA TYPES	LOCATION IDENTIFIERS	OUTPUT SCALE	COORDINATE REFERENCE
Washington					
Washington Department of Ecology	Coastal area[1]	Geology, mineral resources, land cover, vegetation, wildlife, land use, slope stability, flooding potential	Polygon	1:24,000	UTM Coordinates
Washington Department of Natural Resources	Agency managed lands	Geology, topography, soil type, land cover, timber resources, land use, ownership	Point representing 10 acre grid	1:48,000	State Plane Coordinates and U.S. Rectangular Survey
	Federal, state and private forest lands[1]	Soils, ownership	Line	1:12,000- 1:24,000	State Plane Coordinates
	Total state	Land survey network	Point and line	Variable	State Plane Coordinates
Puget Sound Council of Governments	Five county region	Transportation, land use, land cover, soils, topography	5.74 acre grid	Variable	Arbitrary 'x,y'
	Portion of five county region[2]	Soils	Polygon	Variable	State Plane Coordinates
Snohomish County Planning Department	Snohomish County	Land use, land cover, zoning, surficial geology, slope, pollution sources, hydrologic character, watershed boundaries, flooding, soils	2½-40 acre grid	Variable	Arbitrary 'x,y'
City of Tacoma Planning Department	City of Tacoma	Wide variety of urban and environmental data, including: census, transportation, land use, land cover, zoning, topography, utilities, landscape features, vegetation, watershed boundaries, water resources, landmarks, air quality	Point, grid, polygon, streets and addresses, census tracts	Variable	State Plane Coordinates
Weyerhaeuser Corporation	Company owned lands	Soil, land cover, timber resources, ownership	Polygon	Variable	State Plane Coordinates
Bureau of Indian Affairs and Colville Confederated Tribes	Colville Indian Reservation[1]	Geology, soil, land cover, timber resources, land use, surface hydrology, groundwater hydrology, ownership	Polygon	Variable	Not Reported
Oregon					
Oregon Forestry Department	Department managed lands[2]	Timber resources, land use, land ownership, soils management	Polygon	1:24,000- 1:60,000	State Plane Coordinate
Oregon Department of Revenue	Individual counties[1]	Land use, zoning, legal property boundaries, transportation, major facilities, ownership, surface hydrology	Line	Variable	State Plane Coordinates and U.S. Rectangular Survey
Mid-Willamette Valley Council of Governments	Three county region	Topopgraphy, soils, land cover	10 and 40 acre grid	1:24,000	Arbitrary 'x,y'
Lane County Council of Governments	Metropolitan areas of Lane County	Soil, utilities, administrative boundaries, land use, transportation	Line, point	Variable	State Plane Coordinate
Federal Bureau of Land Management	Siuslaw Forest Unit[2] (Lane County)	Topography, vegetation, surface hydrology, soil, timber resources, land cover	Polygon	Variable	UTM Coordinates
Idaho					
Idaho Department of Water Resources	Southerr Idaho[1]	Land cover	5 kilometer grid	Variable	UTM Coordinates

Table 4-1--continued

AGENCY	COVERAGE	DATA TYPES	LOCATION IDENTIFIERS	OUTPUT SCALE	COORDINATE REFERENCE
Idaho -- continued					
USDA Agricultural Research Service	Small watershed in Southern Idaho	Geology, contour, vegetation, surface hydrology, soil, rainfall, land cover	Grid	Not Reported	Latitude and longitude, U.S. Rectangular Survey
Regional					
Battelle Northwest Laboratories	All three states[1]	Land use, land cover, topography, geology, surficial hydrology, groundwater hydrology, water resources	Point, Polygon	Variable	Latitude and longitude
Bonneville Power Administration	8,000 sq. miles in Southwestern Washington and Northern Idaho	Land use, land cover, zoning, topography, land resources, landscape features, vegetation, habitat, surface hydrology, soil, unique and sensitive areas, agricultural resources	Grid, 1 min. latitude by 1 min. longitude	Variable	Latitude and longitude
U.S. Army Corps of Engineers	All three states	Hydrological conditions, water quality, rainfall, wind, temperature, solar radiation	Point	Variable	Latitude and longitude
USDA Forest Service Region 6	National Forests in Oregon and Washington	Soil, land cover, vegetation, wildlife, timber resources, land use, ownership[3]	Polygon	1:15,840	Arbitrary 'x,y'
USGS Topographic Division	State of Idaho	Boundaries, land survey network, surface hydrology, ownership, transportation	Line	1:500,000	Latitude and longitude
	Northern Washington, Western Oregon, Central Idaho	Topography	Line	1:80,000	State Plane Coordinates, UTM Coordinates
	West Central Idaho and Southern Oregon	Topography	Line	1:24,000	UTM Coordinates

FEDERAL DATA BASES AND MAPPING PROGRAMS

AGENCY	DIVISION/SYSTEM	DATA TYPE	COVERAGE	LOCATION IDENTIFIER
Mapping Programs				
U.S. Geological Survey	Topographic Division (Digital Mapping Program)	Digitization of quad maps	Scattered throughout the nation, may contract for selected coverage	Line
U.S. Geological Survey	EROS Data Center (Landsat Program)	Spectral imagery which may be selectively classified to record many types of land cover and resource information	International	57 meter by 79 meter grid
U.S. Geological Survey	Geography Program (Geographic Information Retrieval and Analysis System)	Land use/land cover, federal land ownership, river basins and sub-basins, political subdivisions, census tracts	Scattered throughout the nation, may contract for selected coverage	Line, Polygon
U.S. Department of Agriculture	Soil Conservation Service (Advanced Mapping System)	Soil type and topography	Scattered throughout the nation, program is very new	Line, Polygon
U.S. Geological Survey	Mineral Resources (Computerized Resource Information Bank)	Mineral resources location and production	National at site of occurrence	Point
U.S. Geological Survey	Geologic Division (Rock Analysis Storage System)	Results of analysis of geologic samples	National at site of occurrence	Point

Table 4-1--continued

AGENCY	DIVISION/SYSTEM	DATA TYPE	COVERAGE	LOCATION IDENTIFIER
Mapping Programs -- Continued				
U.S. Geological Survey	Geologic Division (Petroleum Data System, well history control system)	Oil and gas well locations and descriptions	National at site of occurrence	Point
U.S. Geological Survey	Geologic Division (WATSTORE)	Surface and groundwater hydrology - quality and quantity at sampling locations	National	Point
U.S. Environmental Protection Agency	(STORET)	Over 200 water quality parameters at sampling sites	National	Point
U.S. Environmental Protection Agency	(SAROAD)	Air quality parameters at sampling sites	National	Point

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[1] Not complete

[2] Not maintained

[3] Not in digital form, but supported by digitizing equipment

noted for each data base described. It can be readily seen from the table that, while there is considerable digital data handling activity in the region, the coverages are separated, the data scales and formats are dissimilar, and the large area coverages are generally of data types or at scales which are inappropriate for most applications. Nevertheless, the variety of the data is itself a significant observation because it demonstrates that agencies have many data encoding options. Soils information is the most predominant type of land resource data recorded. Land use and land cover are also very common coverages. There are more systems which record slope or elevation as individual records, than record elevation contours as lines. There are eleven separate systems which store multiple environmental data coverages (i.e., multiresource data systems) and four which store many integrated types of urban data.

A program which also promises to provide considerable additional data to users is the Landsat program.[4] Satellite-acquired remote sensing data may be classified to accomplish many types of resource analysis applications and to produce many useful data products. Modes of application have been identified by Westerlund as follows (IV. Westerlund, 1977):

1. Synoptic Overview -- obtaining an orientation to and familiarization with the spatial and environmental context of the study area.
2. Reconnaissance -- narrowing the geographic area of inspection based upon selective elimination of improbable alternatives, i.e., for the purpose of narrowing the scale of inspection.
3. Base Map Preparation and Improvement -- small scale base mapping, map verification and frequent updating.
4. Discrete Feature and Thematic Data Extraction -- classification, interpretation, or processing of imagery which results in recorded information about particular land use/land cover features or related phenomena, i.e., areas of vegetation disease, high water table, snow fields, or clear cuts.
5. Area-Continuous Classification -- classifying an entire area of coverage into systematic meaningful, and area-exclusive units (e.g., land use, soil type, vegetation type).

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[4] An excellent overview of the applications in the Pacific Northwest is contained in the article, "Landsat - Pacific Northwest Using Satellite Data for Planning and Resource Management," *Practicing Planner*, December 1976. Further inquiry can be directed to the Technology Applications Branch of the NASA-Ames Research Center, Moffett Field, California.

6. Change Detection -- frequent and systematic monitoring of change in the desired phenomena of coverage.
7. Public Communication -- use of various small scale, graphic output products to demonstrate features, trends, or spatial relationships for public presentation.

Worldwide coverage is repeated every nine days, so there is a constant source of unclassified imagery available for interpretation and analysis. The actual classification requires sophisticated data processing software and hardware, but the techniques can be performed by nontechnical users. Since 1974, there has been a program to demonstrate the application of Landsat data to data users in the region. Many different types of analysis have been performed, and some agencies are actively seeking new and longer-term applications. The Pacific Northwest Regional Commission, the principal sponsor of the demonstrations, with technical assistance from NASA, is seeking operational Landsat data interpretation capability for the region. Steps have been taken to transfer the technology to each state, and users are being solicited.

The imagery in unclassified digital form is available for the whole region for any day which the satellite passed over (barring cloud cover). Thus there is potential data coverage for any local area for any phenomenon which is desired, and limited only by the technical abilities of the person doing the classification and the resolution and precision requirements of the users. Opportunity and costs may presently restrict greater applications, but the potential is not thereby diminished. A potentially more useful and readily available digital data source is the classified data which at its finest resolution is a 57 by 79 meter grid termed a 'pixel.' Figure 4-1 identifies the areas for which Landsat data have been classified in the various demonstration projects previously mentioned. It provides an exemplary summary of the coverage, but should not be considered to imply availability or transferability.

UNSATISFIED DATA AND DATA HANDLING NEEDS

Three sections of the questionnaire provided the respondents the opportunity to note desired characteristics along with presently operating characteristics. The three sections are data handling software, data needs and system applications. Appendix 5 contains the numerical summary of the questionnaire responses. Many of the entries on these tables contain dual

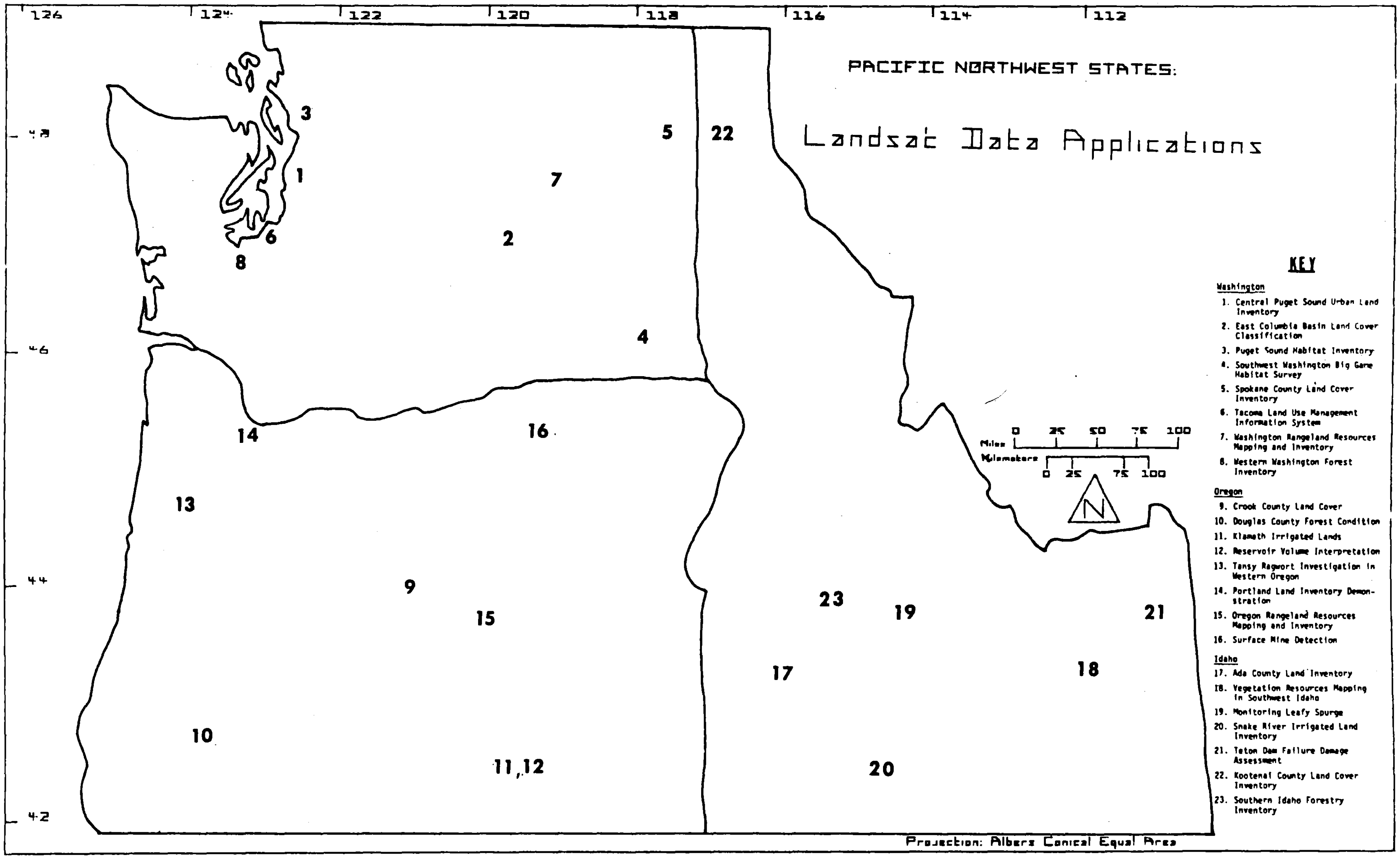

Figure 4-1. Landsat Data Applications. Source: "Land Resource Inventory Demonstration Project," An Informational Brochure published by the U.S. Government Printing Office, 1979.

numbers corresponding to: 1) the number of individual respondents which identified present characteristics, and 2) the total number of responses of which need is implied. The difference in the numbers is the number of respondents in each category with unsatisfied need for the specific characteristic. Both the relative percentage of unsatisfied need as a function of the total need identified, and the total number of agencies indicating unsatisfied need, are relevant to this discussion. The numerical summary of the comparisons based upon the basic responsibilities of the respondents imply unmet needs, but also imply to a lesser degree limitations in the capabilities of the systems. It is noted, however, that these figures should not be interpreted to be definitive statements of unsatisfied demand and system limitations, since the questions on the questionnaire from which these figures originate were not designed to specifically address these issues. For this reason, only the most general trends are herein noted, and the writer is cautious to avoid overstatement of the implications of these numbers. Nevertheless, the reader is directed to the tables for independent analysis of the frequencies for which unmet needs are identified for the different types of systems, and by the basic responsibilities of the respondents.

An overall evaluation of the response indicates that there is not a great discrepancy between actual and desired characteristics. The majority of the survey population report few unmet needs. There are very few applications, data handling capabilities, or data types for which there are double the number of respondents reporting desirability than the number reporting actual use. Similarly, there are very few applications, data handling capabilities, or data types for which all respondents indicating preference have already included the characteristics into their systems' operation. There are no cases where a respondent indicated that a characteristic which is present is not desired.

The unsatisfied system applications, data handling software needs and data needs of the survey population are highlighted below.

Types of Applications

The types of applications for which there is the greatest discrepancy between preference and operation are: maintenance of an urban data bank, land use allocation, route selection, and wildlife management. Wildlife management and the maintenance of an urban data bank are probably limited by data availability. Route selection and land use allocation are most probably limited by appropriate analytical procedures and software. The least discrepancy between desired and operating characteristics are noted for the resource management applications and for thematic mapping. The planning agencies appear to have the most number of unmet needs.

The respondents with metropolitan planning responsibility report the greatest number of unmet needs in the analytical categories such as modeling, trend projection, land suitability analysis, site selection, and land use allocation, and also report unmet needs for both urban and resource data inventory. The respondents with regional planning responsibility report fewer needs in the data analysis areas, but more need in the areas of resource management. It is difficult to determine whether these restrictions are due to the lack of available data, lack of mandate, lack of technical expertise or limitations in data processing and analysis capability.

The respondents with land management and resource management responsibility report virtually no unmet needs. This may be due to the data and application-specific nature of these systems, but the variation between these and the planning responses is striking. The respondents in the other categories each report selective unmet needs unique to their areas of concern, but none with any noticeable regularity or pattern of response.

The types of systems for which the greatest frequency of unmet needs are reported are the information retrieval - combined, the information retrieval - fixed grid, and the output mapping - image production. The responses from the integrated - map overlay, the data base maintenance, and the integrated - general purpose systems do not report any desired applications which are not being performed by at least one respondent. The general pattern of response confirms the versatility of the integrated systems and the lack of flexibility of the GBF/DIME and the fixed grid systems.

Data Handling Software

There are no groups of software or individual data handling capabilities for which major discrepancy exists between desired and operating characteristics, and there are none for which every respondent indicating preference has the capability operating for the system. There are four capabilities which are operational for less than half of the population indicating desire. These are: Landsat analysis, three-dimensional display, value weighting, and direction determination. The capabilities for which there are the greatest absolute numbers of respondents indicating unmet software needs are shading, overlay, projection change, centroid determination, edge matching, and statistical analysis. None of the above are restricted to particular types of systems, and only Landsat analysis requires special hardware. It can thus be assumed that appropriate programming could overcome these limitations. The types of software for which there are fewest occurrences of unmet need are the system-specific types and include identifying closure, modification of alignment, diagram and chart display, lettering, and the general application software such as selective retrieval of geographic and descriptor data.

The special area planning, resource planning and management, mapping, and environmental protection respondents report the greatest discrepancy between desire and operation. The land management and the planning respondents report the least discrepancy. The more specific interpretations for each group can be gained from examining the tables.

Table A-6 records the desired and operating software reported by each respondent for each type of geoprocessing system. Again, the actual frequency of operating capabilities provides a better indication of a particular type of system capability to perform the operations than the numerical difference between the number of desired and operating capabilities which is the topic of this section. Nevertheless some interesting observations may be made from these data.

There is, as expected, correlation between the types of systems with unmet desires for carrying out different types of applications, and the software needed to support these applications. The data base maintenance, output mapping, information retrieval - point, and integrated types of geoprocessing systems most closely meet the data handling needs of the respondents. The information retrieval - fixed grid, information retrieval - variable boundary, and information retrieval - GBF/DIME type systems are reported to have the greatest discrepancy between desires for software and actual operation of the software. The data base maintenance type systems, though lacking in versatility, perform each of the data handling requirements reportedly desired by the respondents. The output mapping - image production, integrated - map overlay, and information retrieval - point systems are only lacking in a few cases, and no software type is lacking by more than two respondents.

The information retrieval - fixed grid, information retrieval - variable boundary, and information retrieval - GBF/DIME type systems are reported to be lacking many types of desired software. Not all of these can be interpreted to be limited by the inherent characteristics of the system groups. Many are simply limited by the applications for which the systems are dedicated.

Data Type

The primary determinants for the types of data included in a system are need and availability. Table A-7 provides a very descriptive indication of need versus availability if one assumes that the data are encoded if they are in the proper format. A quick overview of the table suggests that, while there are a few data types which are desired by the total population but unavailable, sectors of the population are without the types of data which they desire. It is not known whether the limitation is the area of coverage, the scale, the location identifier, or the classification, but serious deficiencies are noted. The availability of data is especially found to be a factor for the metropolitan planning respondents, the resource planning and management respondents, and the respondents in the 'other' group. The land management and mapping groups are less restricted by the lack of desired data.

Overall, few data types are not available in some form for most areas. The data types for which there is the most desire and least use are zoning, vegetation, groundwater hydrology, geology, the miscellaneous resources, and unique and sensitive areas. The most fulfilled demand is for census, assessment, transportation, topography, surface hydrology, soil type and interpretation, and timber resource data.

The reader may consult Table A-7 for the specific types of unmet data needs expressed by the various groups of respondents. Briefly summarized, the metropolitan planning respondents report unsatisfied need for nearly every form of environmental data, and also desire the incorporation of assessment, land use, zoning, housing and legal property boundary data. It is assumed that lack of coverage is the primary deterrent to the incorporation of environmental data. The regional planning respondents note far fewer unmet needs. The land management agencies seem to have the data which are required, perhaps due to the data-dependent focus of the systems and agency-internal data acquisition responsibility. The responses relating to the mapping systems indicate nearly universal availability of desired data. The environmental protection agencies only lack data in a few environmental categories for which data are generally available, and since only one respondent is affected, these are not believed to be representative of unsatisfiable needs.

The resource planning and management agencies also are well supplied with needed data, with the exception of data on unique and sensitive areas. The special area planning agencies do not report any unsatisfied data needs. The 'other' group of agencies reports every general data need to be satisfied.

DOCUMENTATION AND TRANSFERABILITY

Documentation

Documentation is a key factor for successful system design, continued system utility, and data and technology transferability. The issues are different for system documentation and data documentation, but the underlying principles are similar. Documentation forces greater attention to detail, it establishes historical records, it is insurance against the loss of a key person or product, it allows others access to knowledge of the inner workings of the system, and it legitimizes the process and product. Documentation of the source data and the data manipulations performed by or with the system, in addition to its obvious bearing on system design and data transferability, is significant as a factor in the legitimacy of decisions which the system supports.

Each respondent is asked whether there is documentation available for their system. Six important elements of system design are noted, and the respondents are asked to check the elements for which documentation is available. The elements are: hardware, software, data encoding procedure, data structure, data type, and data assessment procedure. The question is asked primarily to provide reviewers of the individual questionnaires with knowledge of the types of documentation which might be available should the reviewer desire further description of the system. The responses are tabulated in Table 4-2 to provide an overview of the extent to which systems are documented and of the types of documentation which are most common.

Table 4-2

System Documentation Reported by Respondents

Types of Documentation	Frequency	Percent
NONFEDERAL AGENCIES	(21 total)	
Hardware	5	23
Software	8	38
Data Encoding Procedure	8	38
Data Structure	8	38
Data Type	8	38
Data Assessment Procedures	2	9
All of Above	2	9
Unreported	3	14
Documentation Available (no type specified)	2	9
No Documentation	3	14
TOTAL SAMPLE	(50 total)	
Hardware	16	32
Software	23	46
Data Encoding Procedure	26	52
Data Structure	27	54
Data Type	26	52
Data Assessment Procedures	5	10
All of Above	4	8
Unreported	3	6
Documentation Available (no type specified)	3	6
No Documentation	7	14

Proportionally, there do not appear to be major differences between the responses from the nonfederal systems and the total sample. It is noted that the elements which are necessary to determine technical data transferability and to document system operation are known for a majority of the systems, but the same elements are not known for all.

It is somewhat alarming to note the lack of data documentation. The reasons for this are not clear. The response to previous questions on data source, scale, format, etc. are fairly well reported, though questions on precision and resolution are less well known. It must be concluded that there is knowledge of data handling procedures, but it is not in material form. Access and analysis of the data are thus limited by the lack of general knowledge of where the data came from, how recent is their vintage, who collected them and how, to what degree they are generalized, and how they are interpreted.

It is reassuring to discover that few agencies do not maintain any documentation for their system. It is less reassuring to see that few agencies completely document their system.

Transferability

An underlying purpose of this investigation is the evaluation of data and software compatibility. The issues are whether data exist in forms relevant to potential users and in formats which might accommodate data transfer, and whether software which has been written to accomplish the data handling requests of one user can be applied or in some way transferred to other users.

Data compatibility is first a function of common need. The technical considerations which affect data handling are record format, volume and data format. The unique problems of changing record formats or transferring data between similar formats are too specialized to be herein reported, often requiring considerable technical expertise and equipment (I. Tomlinson and Calkins, 1977, p. 100). The data use criteria are less specialized, often being able to be resolved simply by asking the question, 'can these data be used for the purposes intended?' The technical considerations are coverage, scale, vintage, spatial and temporal precision, and classification detail. Access to data is another consideration, and includes ownership, administrative obstacles, confidentiality, and cost (I. Tomlinson and Calkins, 1977, pp. 84-96).

The issues of software transfer are similar to those of data transfer. The basic consideration is knowledge that desired software exists. The programming issues are technical, the details of which change with each occurrence. Some of the factors to be dealt with are programming language, data structure, storage restraints, record format and hardware. The access to software is influenced similarly by the factors influencing data transfer. The simplest type of software transfer is the exchange of information about the software (algorithms) from which other programmers can write similar programs to meet the restraints imposed by the operating system. To establish the extent of this type of availability, each respondent is asked to identify whether their software is transferable to other systems. The only criteria are that it be 1) available, and 2) documented. Thus technical programming considerations are not considered to be limiting. The results of this inquiry are noted below as Table 4-3.

Table 4-3

Occurrence of Transferable Software

		Frequency	Percent
	NONFEDERAL	(21 total)	
Predominant		4	19
Spatial Rectification Only		2	10
Graphics Only		2	10
None		10	47
Unknown/Unreported		3	14
	TOTAL SAMPLE	(50 total)	
Predominant		9	18
Spatial Rectification Only		3	6
Graphics Only		2	4
None		19	38
Unknown/Unreported		17	34

It is readily seen that few (approximately 20%) of the respondents reported that their software was both documented and available. These numbers include some vendor-supplied software for which documentation and transferability is implied. In some cases, either the graphics or the spatial rectification (scale change, projection change, etc.) types of software are documented. These normally are the result of the use of vendor-supplied substystems for these operations. It is interesting to note the relatively high percentage of nonfederal systems for which software is nontransferable, most probably due to the in-house programming of these systems. The predominance of unknown or unreported responses from the federal agencies may reflect that many of these systems were developed by contractors, and the present operators do not know the extent of documentation. Another explanation may be the specialized nature of these systems. It is noted, however, that the extent of transferable software reported in this section is less than that expected from the response to the previous questions on documentation. Regardless of which figures are used, the potential for software transfer does not appear to be high except for the specific types of programs which might have been written for a documented system. The extent to which nondocumented software could be shared is conjecture.

FACTORS LIMITING SYSTEM DEVELOPMENT

The respondents are asked on the questionnaire to identify the reasons which they perceive limit the wider application of their geoprocessing systems. The results of that inquiry are reported in Table 4-4.

Limited mandate, budget, and time are the most often reported limitations. Agencies which indicated limited mandate almost exclusively ranked this as the most limiting factor. It can thus be assumed that the systems are built around very specific needs, are versatile enough to accommodate diverse applications, or the potential use of the system is not perceived. Whichever the reason, the greatest proportion of respondents believe their system now meets the needs for which it was designed.

Budget and time are noted limitations of the majority of respondents. They are 'umbrella' concerns which affect the ability to remedy each of the other perceived limitations. It is thus not known whether increased budget and time would be used to hire more staff, get more equipment, increase analytical capabilities, collect more data or improve data accuracy.

The other recorded limitations may provide a clue to answer this question, but it is again noted that each individual agency will perceive priorities differently. In order of decreasing priority, the following

Table 4-4

Factors Reported to Limit System Development[a]

	Ranking			
Limiting Factor	Most Limiting	2nd Most Limiting	3rd Most Limiting	Total
NONFEDERAL AGENCIES (21 total)				
Availability of Source Data	3	1		4
Data at Appropriate Scale		1		1
Hardware Availability				0
Software Availability	1	2		3
Technical Staff Expertise	2	1	2	5
Limited Mandate	8		1	9
Time	4	4	9	17
Budget	6	8	2	16
Base Map Precision	1			1
Data Accuracy	2	1		3
Not Reported				3
TOTAL SAMPLE (50 total)				
Availability of Source Data	5	2	1	8
Data at Appropriate Scale	4	3	1	8
Hardware Availability	2	4		6
Software Availability	5	2	3	10
Technical Staff Expertise	5	3	6	14
Limited Mandate	13	1	1	15
Time	10	8	13	31
Budget	12	15	3	30
Base Map Precision	1	1	1	3
Data Accuracy	5	2	1	8
Not Reported				3

[a] Note: Numbers represent the frequency each factor was selected and ranked by the aggregated survey population. Each respondent was asked to rank first, second, and third choices. Where no ranking was indicated, each response was considered to be most limiting.

limitations are noted most frequently: technical staff expertise, availability of source data, availability of software, data accuracy, data at appropriate scale, hardware availability, and base map precision. The nonfederal agencies' pattern of response is quite similar, but less need for hardware and software is reported.

The implications of the above list of priorities at this level of analysis is only conjecture. Nevertheless, a few observations are noted. Limitations of the data are not perceived to be as important as technical system design limitations. Neither is perceived to be as important as the administrative type of limitations. The lack of concern for data accuracy and base map precision is consistent with the responses to other questions on the questionnaire for which few respondents were even aware of the data accuracies or precision of their systems. If access to data is a problem, it surely does not show up in this survey.

Needs for additional software are reported more often than needs for hardware. This would indicate that more agencies would do more with their systems if software which was transferable to their machines were available. Limited staff expertise is rated quite high, indicating the need for more trained personnel in the field. One anomaly which stands out quite strikingly is the time factor. Respondents believe time to be the most limiting factor for increased system use, yet one of the purported purposes of information systems is time savings.

To close on an optimistic note, it appears that none of the limitations are intrinsically limiting. One can believe that over time systems will evolve to be more efficient, versatile, and better able to meet user needs.

Chapter V. SUMMARY AND EVALUATION

The purpose of this study has been to investigate the issues of environmental data use and data handling practice in computer-assisted spatial data handling systems, and to apply this knowledge to an examination and empirical description of applications in the Pacific Northwest states, and the underlying objective of this research to provide insights which would be useful to environmental data users and information system designers. Research questions were devised which, using a regionally focused and somewhat restricted population, would provide added insight for system design and data specification based upon actual users' responses, and the status of geoprocessing in the region.

SUMMARY OF PRODUCTS AND RESULTS

A number of products and some very illuminating observations resulted from the study. The products include: 1) the identification of systems and geocoded data sources; 2) the questionnaire which is a tool for system and data inventory and for assessment of user need; 3) the descriptive information which the survey provided about each respondent--a preliminary directory of systems and data; 4) a profile of the prevalent and preferred data handling characteristics of types of systems and groups of system users; 5) an examination of the interrelationships between various system attributes and data characteristics; 6) observations about the limitations and potentials of geoprocessing systems, about the contemporary status of geoprocessing in this country, and about the prospects of geoprocessing in the region; and 7) an evaluation of the research technique. The first five of these are briefly described below, the remaining two in ensuring sections of the chapter.

(1) IDENTIFICATION OF SYSTEMS AND DATA SOURCES. The survey identified twenty-five agencies or firms residing in the Pacific Northwest which have or are developing geoprocessing systems for environmental data handling. Most use their systems routinely to support data storage, analysis, and graphic data display requirements. Forty-six systems were identified which contain geocoded environmental data files for areas within the Pacific Northwest.[1] The applications of the systems are diverse, and range from resource inventory and mapping to modeling and assistance for permit

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[1] This is not an all-inclusive list but it is believed to be representative. The numbers are from the selected sample of fifty.

processing. The types of data contained are also diverse and include every type of land resource, land use, census, and facility data. The characteristics of the most prominent of these systems are recorded as Table 4-1. The complete list of systems making up the survey population is noted on Table 2-2.

(2) THE RESEARCH QUESTIONNAIRE. The questionnaire serves two principal purposes. The individual questions can be used alone or in combination to describe and make inferences about the systems and the agency use of the systems. If an individual questionnaire is used it is descriptive of the particular system characteristics and diagnostic of user needs of a particular respondent. Used in combination, inferences about the data handling practices and needs of groups of users, about system applications, or about any geographical area of coverage can be made. A copy of the questionnaire is attached as Appendix 2.

(3) PRELIMINARY DIRECTORY OF SYSTEMS, DATA COVERAGE AND USER NEED. The completed questionnaires form a preliminary directory of the systems which were surveyed, the data within the systems, and the preferred applications and data characteristics of the respondents. The completed questionnaires and a summary sheet describing each response are on file at the NASA-Ames Research Center. These are available for inspection and evaluation. The completeness of response is not uniform, however. A descriptive tabular index to the questionnaires was prepared to assist the reader in selecting the questionnaires which may be of interest. This is attached as Appendix 3 to this report.

(4) PROFILE OF PREVALENT AND PREFERRED SYSTEM AND DATA CHARACTERISTICS. For each of eleven types of geoprocessing systems,[2] the types of applications and data analyses performed, and the types of data handling software operating and desired are described to infer the potentials and limitations of each system type. The profile of eight groups of system users includes characteristics of data handling capability and also includes the data types, data characteristics, and mapping and geographical referencing characteristics which are reported and desired. It is thus possible to compare the data handling characteristics of different system users and of different system types, and to determine which characteristics are desired, but not presently operating or available. Results of this investigation are reported in Chapter IV. Summary tables report the numerical tabulation of response. These are contained in Appendix 5.

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[2] The classification is explained in Chapter II.

(5) INTERRELATIONSHIPS BETWEEN SYSTEM AND DATA CHARACTERISTICS. It is recognized that applications and system design characteristics do not solely influence the characteristics of the data acquired for and used by the agencies. The responses are thus used to examine the interrelationships between such factors as scale, precision and resolution, area of coverage, data type, and data source. It is found, for example, that the area of coverage is a significant determinant of resolution, scale, map projection and coordinate reference. Scale also is a significant determinant, but data type and data source do not highly influence the other characteristics of the data. The results of this investigation are reported in Chapter V.

SUMMARY OF RESEARCH OBSERVATIONS

Many empirical, analytical, and deductive observations were made in the course of this study. They reflect some of the problems and potentials of the use of computer-assisted spatial data handling systems, and provide comment upon the status of spatial data handling in this country. The observations reported below are separated into two groups. The first group is representative of geoprocessing issues in general, and by inference has relevance for the Pacific Northwest region. These are derived from an analysis of the questionnaire responses from the total survey population. The second group of findings focuses upon the Pacific Northwest as a region, and upon the availability and utility of geocoded data and spatial data handling systems.

Findings of General Interest

STAGE OF DEVELOPMENT: The systems surveyed are in various stages of development. Most agencies are still experimenting with their systems, and new applications are being developed. Most respondents seem to be open to new ideas, and are very interested to know what other system users are doing. The systems built around a particular data storage and retrieval function are least likely to be considering new applications.

DIVERSITY OF SYSTEMS: There is a diversity of types, forms, and sophistication of systems but each seems to satisfy the basic requirements of the users. Many of the same applications are performed by systems with very different characteristics. The geoprocessing elements of the systems are quite diverse, and include computer-assisted graphics systems, mathematical models with spatial data components, georeferenced data bases, assemblages of data analysis software and dedicated hardware/software configurations.

IN-HOUSE PROGRAMMING: A very high percentage of the respondents reported that the data handling capabilities were developed in-house. This approach typically results in lack of documentation, and lack of concern for data or software transferability. Vendor supplied software is available for nearly every data handling task, but few agencies recognize or take advantage of this resource. The only system component which is nearly universally supplied by vendors is the graphics component. Federal systems are most likely to be vendor supplied.

LIMITED APPLICATION: Most systems are dedicated to the performance of very specific applications and are constructed around the performance of these tasks. Though many systems seem to have the software to perform more sophisticated data analysis and display, there are few reports of systems being used to their potential.

DATA ACCURACY AND DATA DOCUMENTATION: There is a noticeable lack of concern for data accuracy and data documentation. Less than 15% of respondents are aware of the precision of their data, and most do not maintain descriptions of the basic characteristics of the data necessary to assess its utility. Access to and analysis of the data are thus limited by the lack of general knowledge of where the data came from, when and how they were collected, and by whom, and to what degree they are generalized and interpreted.

DATA INTEGRATION: Systems are able to store many different types and formats of data, each uniquely referenced by geographical location. Only half of the systems surveyed actually do store data in more than one format. Most report that they can and do commonly store environmental data with nonenvironmental data such as land use, census, facilities, political boundaries, etc. The extent of integration of different data files for comparison or analysis using the system hardware and software is not known, but it is not believed to be very great.

DIVERSITY OF DESIGN OPTIONS: The characteristics of the systems and the way in which data are handled in the systems are very different, even among respondents with similar administrative responsibilities and data needs. There are, therefore, many different system design options which may satisfy similar user needs.

RELATIONSHIP OF SYSTEM SOPHISTICATION TO USER NEED: Respondents, groups of respondents, and types of systems for which the greatest diversity of applications are reported also report the greatest diversity of software. There is, however, a discrepancy between the groups of respondents indicating the greatest number of operating characteristics and satisfied need. The agencies and systems reporting the greatest need for new features also have the greatest amount and diversity of existing features.

ABILITY TO PERFORM DERIVED ANALYSIS: The number of respondents who report the use of their systems for derived mapping and analysis is very small. This is an indication that the special features of geographic information systems which allow spatial comparison and reformatting of data files are not integral to most systems. Even if these capabilities exist, there are few cases where systems are being used for these purposes.

DATA SUPPLIERS AND DATA USERS: Two significant types of systems are recognized, each having different data handling implications. The first are the dedicated data systems which are established to process a particular type or very closely related types of data. These are the potential data suppliers. The data are usually documented and there is some quality control exercised (i.e., screening and editing). The nondedicated systems often obtain data from many sources, and the data coverage though uniform in area is not often uniform in quality. Though potentially a source of data for external use, there are many negating factors. These are the predominant group of data users.

DEMONSTRATED TECHNICAL ABILITY: There are no system applications or data handling capabilities which were queried for which there was not at least one respondent indicating active operation. Therefore technical feasibility is demonstrated and potential operation in or for any system is inferred.

SATISFACTION OF USER NEED: There is not a great discrepancy between desired and presently operating characteristics. Though many systems are limited with respect to other systems, the proportion of respondents, types of systems, or functional responsibilities for which there are significant reports of unmet needs are low.

COMPUTER MAPPING: Computer mapping capability is predominant, but not universal.

MOST DESIRED SOFTWARE: The greatest proportion and frequency of unmet spatial data handling needs are reported for: Landsat data use and analysis, value weighting, direction determination, shading, overlay, projection change, centroid determination, edge matching, and statistical analysis.[3]

FACTORS LIMITING EXPANDED SYSTEM USE: Limited mandate, budget, and time are reported to be the predominant factors restricting the greater application of systems. Data availability, accuracy and reliability are not perceived to be very limiting. There is greater desire indicated for more hardware and software to process data than to improve the quality of data. The lack of trained personnel is also a significant deterrent.

Regional Implications

CHARACTERISTIC RESPONSES: The respondents located in the region respond similarly in some cases, but quite differently in others, to those with data coverage for the region though situated elsewhere. Similarity of response is noted for questions on transferability, documentation, data types, and limiting factors. Disparity of response is noted in the types of systems, types of applications, types of data handling capability used and desired, data sources, and data characteristics.

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[3] Definitions provided in Appendix 1.

SYSTEM DIVERSITY: Different types and configurations of systems are noted within the region in both the public and private sectors. Many different types of applications are also represented. The different configurations and applications make generalization very difficult. Each system must therefore be evaluated individually with respect to the purposes for which it is designed.

DIGITAL DATA COVERAGE: The present digital data coverage for the region is a combination of data specially collected for a particular program of the sponsoring agency and for which the system is dedicated, and data collected from conventional sources (maps, aerial photographs, land surveys, etc.) and encoded to provide an operational data base for many programs or activities. There is little integration of the data between the two types of systems. The types, classifications, scales, encoding formats, location identifiers, and geographic coverages of data are very different. Though there is often geographic overlap of data types, the other characteristics are rarely similar. This is demonstrated in Table 4-1.

DATA AND SYSTEM DOCUMENTATION: Poor data and system documentation is predominant among the systems in the region, though there are some notable exceptions. It would be difficult, in most cases, to transfer files or copy applications from one agency to another due to the lack of knowledge of important information.

MOST COMMON DATA CHARACTERISTICS: The most common sources of data encoded in regionally based systems are published surveys and maps. The U.S.G.S. 1:24,000 quadrangle maps are the predominant base, and State Plane Coordinates are the predominant coordinate reference. Soils data are the most commonly reported environmental data types, and their use as a descriptor of characteristics of the landscape is common in many types of applications, and by a variety of different users.

OPPORTUNITIES FOR DATA EXCHANGE AND COMMON DATA USE IN THE REGION: It is unlikely that exchange of digital data between agencies will take place in the near future; the existing data are too dissimilar and there are too few agencies in the areas covered which are capable of or interested in utilizing the data in the digital form in which they exist. It is much more likely that the existing data systems will integrate the digital mapping bases which will become available, or larger systems will be created at the state or regional level that will be versatile enough to handle data in various formats from diverse sources. Nevertheless, even today the opportunity exists for data transfer and common data usage among agencies because many data needs are similar, programs have been initiated to supply the most commonly used data, and software exists to mitigate problems of dissimilar data. Cooperative data collection and encoding, and the search for and evaluation of already digitized data are viable options that appear to be worthy of consideration.

The digital mapping applications have the most promise for providing useful data to many users. The state of Washington, through the Department of Natural Resources, is far ahead of the other states in this area, providing necessary survey control for nearly the whole state, and is beginning to plot contours, soil type, and land ownership for its own base mapping and other special programs. The Oregon State Department of Revenue has an innovative program to maintain county cadastral maps in digital form for each of storage and update, and to provide municipalities with this base if they wish to build an information system. There is a current demonstration of this application being carried out by the city of Salem. The U.S. Geological Survey mapping programs also hold much promise. Digital terrain and topographic mapping systems are operational and are producing digital maps of U.S.G.S. quads and special map series for many geographic areas in the region. A similar need to produce maps more efficiently has spawned a computer-assisted mapping system in the Soil Conservation Service which is now producing computer geocoded soils maps. The U.S. Forest Service, Bureau of Land Management, and Fish and Wildlife Service are developing geographic information systems to store data for large areas of the federal land domain.

Any accurately georeferenced data file can be located with respect to any other geographically referenced data file. There are, however, few cases within the region where georeferenced data files of the various federal agencies are logically or cartographically merged with other locally generated data files. The states of Oregon and Washington are actively evaluating the feasibility of tying into these data sources. Individual research institutions and state agencies already have gained access to some of the federal agency data systems. Caution is advised, however, due to the differences in scale, classification, format, and positional accuracy of the data contained in the federal files and that desired by the state and local data users.

LANDSAT DATA USE: There are few agencies surveyed which have integrated Landsat derived data into their information systems. Few indicate desire for Landsat data classification software. This, however, is not a true indication of potential because the technology is not yet readily available. The diversity of data products available from Landsat data interpretation correlates well with the needs of many users. This should signal a significant interest in and application for classified Landsat data in the region. An immediate application which is envisioned is to fill the gaps between the other scattered digital coverages. More information is needed, however, to document adequately the potential for Landsat and conventional data integration. This is the direction being pursued by the Technology Transfer Task Force through the Landsat Applications Program. The technology is becoming less costly and more accessible to the "agency" data users, and the accuracy of classification is improving.

EVALUATION

The report on which the present publication is based provides an illustrative, though certainly not comprehensive view of the status and characteristics of geoprocessing in the region, and by association many observations which are equally relevant to the field as a whole. There are many individual systems, and some types of geoprocessing systems which are excluded from this population, but it is believed, nevertheless, that the findings which are recorded are appropriate and representative at the level of detail at which they are reported.

Digital spatial data processing is gaining wider application in many disciplines. A representative sample of applications and characteristics of geoprocessing systems is sufficient for the illustration of the use potentials, present operational status, and user needs. The statement of problems and prospects is not diminished by the size of the sample.

The questionnaire was designed to elicit a wide spectrum of information from a diverse set of respondents. Prior to this study, there was little known regionally about the specific characteristics of geoprocessing systems, about their use within agencies which have them, about the characteristics of the data which are maintained, about the availability and application of data handling software. The questionnaire was designed both to seek information from agencies and to determine how much agencies actually know (or wish to share) about the characteristics of their data or about the use of their system.

Each respondent had the option of responding to the questions which were deemed appropriate, and in the degree of detail which they desired. A uniformly detailed response, though desired, was not expected. Each system which was queried had unique purposes, program, and data handling characteristics which made some questions more appropriate than others. There were a number of other factors which influenced the accuracy and completeness of response, including the stage of development of the system, the technical knowledge of the respondent, the administrative responsibility of the respondent, the interest of the respondent, the respondent's perception and understanding of the questions, and the appropriateness of the predefined answer choices.

Despite these limitations, the response record was relatively good for a mailed survey, and the information obtained very useful as an introductory overview. Most of the objectives for which this study was designed were fully or partially served as a result of interpretation of the questionnaires.

A numerical breakdown of the response to the questionnaire follows:

Number of questionnaires sent	91
Number received	65
Number fitting criteria	52
Number used for analysis	50
Number adequately completed	23
Number partially completed	27

Many users of geoprocessing systems, and considerable information about the characteristics of the system and the data needs of the users are identified. The completed questionnaires represent a preliminary directory of systems and data, but are not suitable for widespread distribution in their present form. The original questionnaires are certainly useful to determine in a general fashion 'who has what' data and 'what is being done by whom,' but the questionnaires are an unscreened and unverified primary data source, and are not organized for selective data retrieval. The summary forms and computer tapes of the information extracted from the questionnaire, and used for the summaries and cross-tabulations also are not organized for selective retrieval. A map-based directory of data would be very useful, but the diversity of types, formats, classifications, and coverages of data complicates the establishment of mutually exclusive data groupings necessary for meaningful map recording. The incomplete and inconsistent response to many questions on the questionnaire reduces the accuracy of any published directory stemming directly from the questionnaires. If adequately completed, however, the questionnaires can with little modification serve this purpose. This is evident from the responses from the agencies which did fill out the questionnaire completely. Thus it may be assumed that a more supervised and verified response would serve these purposes. For use by agencies interested in internal documentation or data needs assessment, the questionnaire would need to be modified to meet special objectives, but the content and format appear to be sound. In order for the descriptions from the questionnaires to be of optimal use by the user community, as individual agency summaries, the most pertinent descriptors should be identified, the data extracted from the questionnaires, the summaries completed and verified by the respondents, the information published or stored in indexed and retrievable form, and arrangements made to update, maintain and distribute the information.

The completed questionnaires and the analysis of the data received from them is intended to be a tool for persons and agencies interested in geographical information system design. There are unquestionably many things about computer assisted spatial data handling which are not known. A foundation for understanding many of the issues of systems design and development is provided in this report. The present status of computer-assisted spatial data handling, and the characteristics and needs of users are described to the extent allowed by the completed responses.

The use of the summarized questionnaire to provide an overview of data handling practice and the need of sectors of the survey population, to assess the status of geoprocessing in the region, and as a basis for the examination of implications for system design and technical assistance has been described. The analysis, however, is no more accurate than the original data, and the techniques which are used to extract the data for analysis. The evaluation of the questionnaire is limited by the following:

1. the appropriateness of the descriptive variables and options chosen as a basis for description, comparison, and evaluation;
2. the selection of the groups of responses for which the profiles are reported;
3. the adequacy and appropriate use of the summary tables.

RECOMMENDATIONS

Many very important considerations had to be overlooked or simplified to make the survey form manageable and still be able to assess the wide range of concerns which this report covered. The questionnaire was unable to serve any particular purpose completely. Data needs should be assessed separately from the present data handling activity, and a directory of systems should be separated from a directory of data. The persons to whom the questionnaire is sent, the survey questions, and the method of response should be tailored to each separate objective. The survey should either be used for descriptive overview or for individual agency assessment.

It is further recommended that consideration be given to the evaluation and further study of some of the issues briefly raised: 1) the establishment of a system directory; 2) the establishment of a digital spatial data directory; 3) a clearinghouse for technical assistance; 4) user needs assessments for different types of data users; 5) coordinated or shared data acquisition and use, software development and software transfer; 6) standardization of data classification; 7) studies of data precision; and 8) implications of the choice of the decision variables upon one another and upon other issues of system design. There are undoubtedly many more which could be considered in the light of the changing technology, greater data user awareness, greater potential for local application, and lack of integrated or synoptic research. Any attempt to design a system should follow a rational design plan, and be based on extensive evaluation of user needs, available resources, and administrative barriers.

The use of computer-assisted methods for the storage, retrieval, analysis, and graphic display of spatial data is a technology with proven application, and though still in its developmental stages promises greater data handling efficiency, more sophisticated data analysis capability, and more illustrative graphic display possibilities. Thus study, though providing much new information, has only scratched the surface. Much more attention would seem warranted in order to be prepared for the inevitable wider application of this technology which is close on the horizon.

Appendix 1

INTRODUCTORY CONCEPTS OF SPATIAL DATA HANDLING

SPATIAL DATA

All data have three characteristic features: the thematic or descriptive feature tells what it is and its value; the spatial feature tells where it is and its spatial format (point, line, area); and the temporal feature tells when it was measured (I. Tomlinson, ed., 1972, p. 36). Spatial data are a special type of data for which the spatial and thematic feature are linked for reference, or simply data for which the location is a part of the data record. A map is one medium for recording spatial data. On it may be a place name, a feature, or an interpretive rating. Spatial data have three components which together form the record of any observation. These components are a data attribute, a spatial locator, and some physical medium upon which the data reside (I. Kennedy and Meyers, 1977, p. 30). The data attribute, sometimes termed the data content or descriptor, is a characteristic observation or evaluation. It may be expressed in nominal, ordinal, interval, or ratio form. Examples are slope, pollution levels, suitability ratings, locations of facilities, well logs, etc. The spatial locator, sometimes called the spatial entity, are points, lines, or surfaces with which spatial data attributes are associated (Computer Sciences Corporation, 1979, p. 1-1). These include names of locations, geographic coordinates (which may form lines or areas), special districts, political boundaries, mile indexes, etc. The physical medium holds the data attributes and spatial locators in storage. Common media include maps and charts, film (aerial photography), computer tapes, and card files.

COMPUTERIZATION OF SPATIAL DATA

Computerization of spatial data necessitates some way in which the descriptive and the spatial component can be placed in computer readable form, stored and manipulated. Placing data in machine readable form is called encoding. There are many ways in which this is done, each varying in complexity and very much dependent upon the degree to which the computer is to simulate and maintain relationship between spatial patterns. The descriptive component can be stored similarly to any other type of data. Alphanumeric symbols are keypunched onto cards, tape, or disc. The spatial component, which on a map is referenced within a coordinate framework of latitude and longitude, must be nonvisually referenced in a computer. A code is therefore assigned to represent this spatial component. This code is called the location identifier, and can take many forms. Four basic types which are recognized are: 1) external index; 2) coordinate reference; 3) arbitrary grid; and 4) explicit boundary.[1]

External index referencing assigns a nominal code representation to a particular geographic area or location. The index is external because the true location or spatial configuration of the area is not known unless another source, such as a map, is consulted.

Coordinate reference makes use of a single 'x, y' coordinate point to represent location. The coordinate value may represent a single point of data specific to location, such as a monitoring station, or the centroid of a spatially defined area. The relative position of the data is thus known, but the actual boundaries are not known without external reference. Computer assisted spatial analysis and thematic representation of the data at that location is possible.

Arbitrary grid, sometimes called implicit boundary, and explicit boundary location identifiers add a two-dimensional representation to the data by recording boundaries made up of patterns of indexed coordinates.

An arbitrary grid location identifier is characterized by an arbitrary scale, regular grid structure, laid over the data in matrix form. Each cell of the matrix is defined by parallel and perpendicular line segments of equal proportion. It is thus assumed, for ease of processing, that the data value is constant over the whole area, even though the spatial configuration of the data element may not correspond to the boundary.

The explicit boundary location identifier is the most sophisticated and simulates true spatial form to the highest degree. The actual (or as near to actual as is desired) boundary of the spatial data element is formed by the nodal coordinate points selected to form the area boundary. The more points which make up the boundary lines, the greater is the potential similarity to the actual spatial configuration.

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[1] The explanation is the result of the review of many sources, the most prominent being: I. Calkins and Tomlinson, 1977, pp. 9-12; II. Dangermond, 1972, pp. 184-198; I. Redekop, 1974, pp. 14-33.

The location identifier, being a part of the data record, is capable of being edited, summarized, compared, measured, or displayed similarly to the descriptor record.

The encoding options and procedures are different for spatial data with different configurations (i.e., point vs. area). Data originating as points (i.e., sampling sites) are well represented by coordinate points. Area coverages, however, may be represented in many ways. A coordinate point may, for example, be used to identify a centroid, or a grid may be overlain on top of the coverage and the boundary aggregated into the cell. Each may be done manually, or machine aided. Explicit reference of areas requires a different set of procedures, especially if the relation of any spatial entity to its neighbors is to be maintained, for example recreating a map. Encoding of the data from their original form to machine-readable form is the major data transfer function needed to set up a computer-aided spatial data handling capability. Encoding of points for explicit reference is called digitizing.[2] Digitizing is the assignment of coordinate location values to the data. It can be done automatically or machine aided using a digitizer, or may be done by manual methods. In each, the relative 'x' and 'y' values for specific points are recorded with respect to an arbitrary origin. The origin is a predefined point representing a corresponding location on the surface of the earth. Combinations of points define lines or areas. The descriptive characteristics of the data are matched to the points, lines or areas by internally referencing computer programs. It is thus possible to produce machine images such as computer drafted maps or CRT displays which correspond to any spatial activities or areas that can be represented in graphic form on a map. Once the data are in computer processable form, both the boundaries and the descriptive data can be edited, or selectively manipulated for measurement, statistical analysis, thematic representation, or re-creation of the original map.

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[2] Excellent discussions of encoding and digitizing may be found in: I. Calkins and Tomlinson, 1977, p. 207; I. Tomlinson, ed., 1972, p. 44.

LOCATION IDENTIFICATION FOR SPATIAL DATA RECORDS

Spatial entities may be represented as points, lines, or areas. When data are introduced into a system, the original data may be altered for ease of data handling. Once data are encoded, they are described by their geocoding format as represented by the location identifier. Format influences data handling and data accuracy. The influence on accuracy is due to changes in the spatial configuration of the data entities as the data pass through the system. There is, for example, a significant loss of accuracy due to point or line defined entities having to be represented as grids, or due to area-continuous coverages having to be defined as points or grids.

Source data format does not itself influence data base design, but it is a significant data descriptor because of its influence upon encoding format, maintenance of the information content of the original observations, and upon precision and resolution.

Spatial data handling is more directly influenced by the form of the location identifier. Table A-1 summarizes the salient features, benefits, and liabilities of each of the principal methods of location identification. Generally, the handling of the location identifier is more complex as the resolution increases and the mapping units become smaller (I. Calkins and Tomlinson, 1977, p. 107).

The choice of location identifiers is most critical for area data, where various coding options may be considered, and no option can perfectly represent the spatial entity as it exists on a map. Discussion of grid vs. polygon representation is extensive (II. Dueker, 1975, pp. 29-35; II. Dangermond, 1973; III. Power, 1975, pp. 31-35; IV. Westerlund, 1977, pp. 34-47). It is now generally accepted that each has its merits and applications, and since software has been developed to merge polygon formatted data into grid formats, one is no longer forced to choose. The polygon argument centers around the trade-off between the ability to closely approximate boundary conditions and the storage volumes necessary to store the numerous points defining each boundary. The numerous points create added editing problems as well, and the overlay of separate coverages often results in 'spurious' polygons, which are small, often unreliable polygons created by the intersection of two or more polygons near the

Table A-1: Evaluation of Location Identifiers for Spatial Data Handling

Location Identifier	Characteristics	Benefit	Liability	Example
I. External Index	Boundary only known by referencing to an index such as a map.	Simple listing and tabular summary; Simple encoding of data; Hierarchical summary.	Data must be transferred to another medium for graphic display and/or measurement; Manual creation of original reference data base; No boundary conditions known.	Census file records; Resource inventory records.
II. Coordinate Point	Assignment of a unique earth surface coordinate to represent each spatial data unit.	Can be used as implicit reference to represent grids or polygons; Ease of data storage; Ease of spatial analysis (e.g., simple display on a line printer); Points represented as points; Relative location known to system; Data summarization by units is easily performed; Compatible with many mapping programs.	Boundary display and analysis not possible; Slow semi-manual creation of original reference base; Unable to record line data.	Location sampling stations; Parcel centroids; Thematic mapping; Digital terrain models.
III. Implicit Boundary-Grid	Boundary known to system by overlay of regular grid over area covered; Area continuous coverage with data coded by cell; Cell contents as numbers, percents, or simple descriptors (e.g., soil type "A").	Ease of data storage; Data summarization by units is easily performed; Simple retrieval and display; Simple display on line printer; Simple overlay; Straightforward computation; Compatibility with many computer graphics programs; Compatibility with many mathematical models; Easy programming.	Forces special collection of data to unnatural units; Detail is lost in generalization to grid structure; Requires laborious manual reworking of data to put in grid form; Line data is poorly represented; Data not positionally accurate over large areas.	Common computer mapping programs; Thematic mapping; Hydrologic and air pollution dispersion models.
IV. Explicit Boundary-Grid	True boundary of grid is digitized and known to system; Data storage same as arbitrary grid;	Allows comparison with irregular polygon data; Less storage needed than irregular polygon; Grid data remains in grid form; Simple overlay of data sets;	Forces special collection of data in unnatural units; Detail is lost in generalization to grid structure; Line data poorly represented.	Point in grid routines; Window overlay; Mathematical models.

Source: Kenneth Gordon, "Environmental Data Handling in Geographic Information Systems: An Evaluation Based Upon a Study of Applications in the Pacific Northwest States." M.S. thesis, Western Washington University, 1979, pp. 70, 71.

Table A-1--continued

Location Identifier	Characteristics	Benefit	Liability	Example
		Compatibility with many graphic programs; Consistent aggregation; Different size grids are possible; Data can remain positionally accurate by referencing grid corners to coordinate references; Can accept boundary data as separate data set.		
V. Explicit Boundary-Irregular Polygon	True boundary expressed by straight line connections between points delineating a data element.	Accurate measurement; Accurate boundary representation of area continuous data; Direct encoding of data possible into digitized polygons; Measurement, analysis, combination are possible internally; True cartographic representation; Can accept boundary data as separate data set; Correspondence with mapped information; Grouping point data to polygon.	Spurious polygons; Large data volume and sophisticated data storage, search and manipulation; More sophisticated hardware needed to avoid time-costs of digitizing.	Land classification; Computer assisted cartography; Area masking; Area calculation; Point in polygon routines.
VI. Explicit Boundary-Lines	True boundary (value) expressed by line segment connections between points delineating a linear data element.	Accurate representation of line data as lines; Accurate measurement; Correspondence with mapped information.	Can only represent lines accurately.	Roads; Contours; Networks.

system resolution limit. Gridded data preserve the spatial integrity of the recording unit and are therefore most suitable for repeat analyses such as for modeling and change detection. Grids can also be printed on a line printer, making display less costly. Encoding into grids requires the squaring of boundary edges to fit the grid, often obscuring small polygons and boundaries that cross the cell but do not predominate in area. Coding of a cell as a combination of percents mitigates this error for statistical recording only.

External references are expected where fidelity is not a concern, such as in statistical reporting and record keeping, and where the size of the area precludes more finite spatial identification. Coordinate point identifiers are expected where the source data originate as points, where relative location is of greater concern than delineation of spatial boundaries, where data records can be related to a geographic base file, or where data storage is a limiting factor. Grid identifiers are expected in cases where spatial fidelity is of lesser concern than ease of data handling, where multiple coverages are to be compared, and where record volume is a limiting factor. Polygon data are expected for smaller areas, for cases where boundary conditions are critical, and for more explicit spatial comparisons.

The choice of location identifier is expected to be influenced by the data volume, system sophistication, cost, applications, ease of data handling, and accuracy. Also, it can be expected to be influenced by the size of the coverage, data type, classification detail, precision and resolution, and scale. The location identifier in turn exerts influence upon data volume, system sophistication, cost, ease of data handling, and accuracy. Also, the location identifier affects classification detail, precision and resolution, and coordinate reference.

SPATIAL DATA PROCESSING CAPABILITIES (SOFTWARE)

Once the data are in machine storage, computer programs direct the computer or its peripheral equipment to carry out selected operations in the desired fashion. The computer programs which encode, edit, analyze, display or otherwise manipulate data are broadly defined as the software. Data handling capabilities can be equated with the software which directs the computer to carry out the selected operations. The range of possible operations on the data is great, and is largely affected by the tasks which are to be performed, and the desired output.

There are two options for the implantation of software into an information system: external acquisition and internal generation. The choice of either of the above itself is a design decision and herein will not be evaluated.

Table A-2 describes some representative data handling capabilities which this author believes are of greatest utility for spatial data handling, and suggests their purpose and utility.[3]

Software is equated with data handling capability and therefore system sophistication. It is best evaluated based upon a thorough analysis of the types of tasks which are desired to be performed, and balanced by the availability of software or programming capability. The principal consideration, however, is the overall benefit to the data user. One may ask, can computerized capability perform tasks better, more quickly, more accurately, or less costly than manual operations, and are the benefits worth the added costs?

The specific types of software which are operationalized by the user also depend upon other data handling decisions: what types of data are to be encoded? which location identifier is to be used? how are the files to be accessed? what form of output is desired? how much versatility is required? etc., and by the restraints of the existing system.

Description of software and software specification should consider the attributes of availability and transferability, and what types of software are operating, planned and desired. The routineness of use and whether the software is internally programmed or vendor supplied provides additional knowledge for specification.

Each type of function performed by software is related to the application for which it is designed, which is a function of each of the other

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[3] The descriptions were gleaned from many sources, some with conflicting terminology and different categorical placement of the capabilities. The reader is referred to the original works (III. IGU, 1976a; I. Tomlinson, ed., 1970, pp. 67-145; I. Tomlinson, ed., 1972, pp. 758-889; I. Calkins and Tomlinson, 1977, pp. 227-256) for more information on technical detail and categorical placement.

Table A-2: Software for Spatial Data Handling

Operation	Explanation	Use
	EDITING	
Identify and Correct Closure Errors	Polygon boundaries must be closed to define a continuous area spatial data set. This program searches digitized records to determine if all polygons are closed. Can identify unclosed polygons with error message and/or automatically close a line.	Create error-free digital polygon records.
Identify and/or Correct Slivers	Slivers are the result of digitizing too small a polygon, or not matching boundaries. Unmatched boundaries may create overlapped polygons or uncovered areas with no direct correlation to the graphic data set. Matching of boundaries within certain tolerances can automatically correct errors.	Create error-free line record.
Data File Update	Programs to alter the content of the descriptive or image data set.	Code new parameters. Update parameters. Correct errors in record.
Labeling	Programs to assign alphanumeric symbols to spatial data sets.	Labeling geographic features. Unique referencing of individual entities for search or edit. More flexibility for data manipulation and comparison.
	IMAGE DATA MANIPULATION	
SPATIAL RECTIFICATION (Spatial Data Massaging)	This set of programs can be used to alter the relative position, coordinate reference, or location identifier to achieve compatibility between data sets or to compensate for graphic inaccuracies.	
Removing Map Distortion (Rubber Sheeting)	Maps can shrink or swell with changes in humidity and temperature. Also, changes in medium, i.e., map to transparency, or slight misorientation on a digitizer can introduce error in linear relationships. This program enables all the coordinates to be altered to match pre-established control points. Sometimes called rubber-sheeting.	Maintaining high standards of geodetic and coordinate accuracy between separate data files, or between distorted graphic and true image form.
Line Generalization (Smoothing)	Use of a mathematical algorithm to reduce the number of points in each line or polygon either by equal spacing or "leveling" jogs in the polygon boundary.	Reduce total number of digitized points. Smooth polygon boundaries.
Modify Alignment (Transformation)	Programs to reposition the spatial display over the 'x,y' field, for example, altering position around an axis (rotation) or above or below an origin (transposition).	Correct positioning on the printed media. Alignment to proper axis.
Scale Change (Scaling)	A special type of transformation whereby there is a change in the linear scale of the data for output, measurement or overlay. All 'x,y' coordinates multiplied by scale factor.	Versatile display. Matching records derived from different scale graphic input. Enable overlay and merge.
Projection Change and Coordinate Conversion	The ability to change coordinates from one projection to another to maintain accurate positioning between data sets referenced to or plotted on different geodetic bases. Usually mathematically derived conversion factors for different areas on the earth's surface.	Allow plotting over different base maps. Maintain high standards of geodetic and coordinate accuracy between separate data files.
Location Identifier Conversion (Format Change)	A group of programs to change the distribution and spatial configuration of data sets, usually to maintain continuity for analysis/display. Examples are line to grid, polygon to grid, and grid to polygon.	Automates what normally would require manual data transfer before encoding. Allows combination of data with different location identifiers. Point in polygon algorithms allow data summary.
MEASUREMENT	These programs calculate the scalar and area qualities inherent in any spatial data entity. Since coordinates represent locations, simple geometrical algorithms sensitive to graphic/image scale differences are used to simulate manual measurement techniques.	
Linear	Measurement of simple, uncorrected straight line distance between the 'x,y' coordinates, or calculation of distance rectified to projection and to scale.	Centroid determination. Nearest neighbor analysis.
Area	Measurement of the area within a boundary.	Quantitative input into models. Statistical summary for inventory.
Direction	Calculation of compass bearing or degree deviation between any two 'x,y' coordinates. Can be relative to known direction or calculated from geodetic coordinates.	Engineering. Cadastral mapping and verification. Routing.

Source: Kenneth Gordon. "Environmental Data Handling in Geographic Information Systems: An Evaluation Based upon a Study of Applications in the Pacific Northwest States." M.S. thesis, Western Washington University, 1979, pp. 89-91.

Table A-2--continued

Operation	Explanation	Use
	IMAGE DATA MANIPULATION - continued	
MEASUREMENT - continued		
Centroid	The mathematical determination of the geometrical center of a group of points representing a boundary.	Provide for easier contouring and thematic representation. Allow spatial entities to be represented by single points thereby reducing storage. Locating and labeling polygons. Determine geometrical center of data clusters.
	DATA MANIPULATION - IMAGE AND DESCRIPTOR	
SORTING/MERGING	These are file maintenance programs. Sorting is the segregation of data based upon desired parameters. Merging is the combination of separate data sets into an integrated whole.	
Selective Retrieval - Geographic	These programs will produce a readout and/or mapped display of selected files based upon a desired geographic area, or set of location identifiers.	Isolating areas for display or analysis. Base mapping. Orientation.
Selective Retrieval - Descriptor	These programs will produce a readout and/or mapped display of selected files based upon any single coded attribute of the data, or set of descriptions.	Isolating data for display or analysis. Extracting data for tabular summary. Locating areas with desired characteristics.
Merge Adjoining Maps (Edge Matching)	Piecing together of two or more parts of one digitized file representing one graphic record with a file representing adjacent graphic records. Requires matching/merging coordinates for each entity whose border crosses the boundary, and rectifying scales, projections, etc.	Compositing graphic records. Allow encoding of data represented on two or more maps.
Create New Files	This program allows new files to be created from merged records and/or updated records.	Compositing data files. Re-classifying areas with multiple data input. Allows nominal and ordinal measurement comparison.
Integrate from Remote Files	These programs allow transfer of data between periferal storage devices and the host computer, and the subsequent merge of this data with the files being acted upon.	Incorporating pre-encoded data such as census and/or LANDSAT. Sharing digital boundary and descriptor data with other agencies.
Contouring	The calculation and/or display of isolines representing classed variations in the variables.	Averaging point data. Creating interval measurement zones from ratio data. Thematic representation of volume.
COMPARISON	The use of data in either the image data set or the descriptor data set to determine some relationship between two or more data files and/or parameters based upon criteria derived from one or both data sets and/or parameters. Requires numerical and/or spatial comparison between data sets, search for appropriate relationships and listing/display.	
Overlay-Union	The additive combination of data sets fitting a desired criteria such that the final product contains the information of both.	Computer assisted cartography. Viewing composit conditions for an area or entity.
Overlay-Intersection	The mutually compatible combination of data sets fitting a desired criteria such that the final data product contains the information common to both.	Route and site selection. Locating areas with desired characteristics. Point in polygon routines.
Value Weighting	The assignment of a relative value to a data set or parameter in ratio comparison to others such that during analysis of the data that factor can be favored.	Environmental analysis. Quantifying interrelated conditions. Route and site selection. Modeling and prediction.
Modeling	Any of various algorithms or other equations to mathematically simulate "real" conditions.	Hydrological models of flow, sedimentation, etc. Land use allocation. Pollution dispersion.
Statistical Analysis	A variety of different types of calculatable numerical relationships between or among summarized values (e.g., mean, standard deviation).	Quantifying spatial distributions. Providing values for modeling and/or prediction.

Table A-2--continued

TABLE 7 -- Continued

Operation	Explanation	Use
	DATA MANIPULATION - IMAGE AND DESCRIPTOR - continued	
COMPARISON - continued		
Extreme Value Search	Comparisons of records to determine which record and spatial entity has the highest or lowest value of the desired parameter.	Site and route selection. Identification of sensitive conditions. Allocating distributions.
	GRAPHIC OUTPUT	
Zooming	The expansion or contraction of the viewed image according to pre-determined increments (normally on a CRT).	Display for edit. Differential scale mapping. Uncluttering display of multi-feature base maps.
Diagram and Chart Display	Charts, graphs, diagrams, or other non-map products to represent the descriptive, analytical content of the spatial data.	Architectural renderings. Display of products of statistical analysis. Engineering.
Lettering	These programs are used to place alphanumeric symbols on graphic displays. The computer allows for differential size and placement of symbols.	Displaying 'finished' graphic products, e.g., computer assisted cartography.
Shading	These programs use dot symbols or overprinting to produce graded gray scale shading in order to represent classes of data for ease of visual interpretation.	Thematic representation of classed data providing a more distinct impression. Identification of different features or classes of features.
3D	Various programs which display surfaces in three dimensions so that the quantitative values of the data can be graphically represented with their spatial location.	Thematic representation of volume data values, projecting a striking graphic image.
	OTHER	
Digital Terrain Analysis	These programs cover a range of special applications in the analysis of surfaces. The special surface is relief, which is simply a form of digitized point data.	Relief mapping. Slope calculation. Perspective drawing. View determination. Routing.
Landsat Data Analysis	Any of the software which allows satellite imagery to be classified, registered to the ground, and statistically or graphically analyzed.	Land cover classification. Change monitoring. Satellite photo composit.

data and system attributes. Software can remedy scale differences, or change projection or coordinate reference, allow the location identifier to be altered and the data to be encoded or compared in different spatial formats.

It is thus assumed that these and similar interrelationships determine the software which is implemented in any system, and that this is uniquely a function of the perceived needs of the system designers.

Appendix 2

QUESTIONNAIRE

Organization ______________________ Respondent ______________________ Date ____________

1. Do you have, are you developing, or have you previously developed an AUTOMATED, GEOCODED DATA COLLECTION, STORAGE OR RETRIEVAL SYSTEM, or an AUTOMATED CARTOGRAPHIC SYSTEM to serve all or part of your agency's information (data) handling requirements?

   ( ) Yes ( ) No

2. Check the stage of development of your system:

   ( ) System is being designed.
   ( ) System is being developed.
   ( ) System was developed, but not presently operating.
   ( ) System is operational.*
   ( ) System is operational, but development still being carried out.

3. Which of the following best describes the function (responsibilities) of your agency, or the department of your agency which uses geocoded environmental information? CHECK MORE THAN ONE IF APPROPRIATE.

   ( ) municipal land use planning
   ( ) regional land use planning
   ( ) land management
   ( ) research
   ( ) cadastral mapping
   ( ) automated cartography
   ( ) environmental protection
   ( ) other resource** planning and management
   ( ) special area planning (transportation, health, etc.)
   ( ) other (please specify) ______________________

4. Which of the following best describe your computer facilities?

   ( ) own or rent and operate own computer
   ( ) use central government computer center
   ( ) use another department's computer
   ( ) use a private sector computer center
   ( ) use a university computer center
   ( ) other (please specify) ______________________

5. a. Are your capabilities for edit, data analysis or graphic display the product of a "packaged" program that was commercially obtained?

   ( ) Yes ( ) No

   b. If yes, please name the major program(s), identify their function (i.e., edit, display, statistical analysis, modelling), and list their source.

Name (Acronym)	Function	Source

   c. Data processing language ____

6. The following questions relate to the type of equipment which you use to process your data. Please check the appropriate box or boxes.

   a. Computer: ( ) mini ( ) main frame Make and model ______________________
   b. Storage: ( ) less than 16K ( ) 17-64K ( ) 65-128K ( ) 129-512K ( ) 513-1000K ( ) more than 1000K
   c. Periferal Devices: ( ) Keypunch ( ) Scanner ( ) CRT ( ) Manual digitizer ( ) Off line disk ( ) On-line terminal ( ) Line Printer ( ) Automatic line follower ( ) Tapes (pre-encoded data) ( ) Hard copy terminal ( ) Drum plotter ( ) Electrostatic plotter ( ) Flat bed plotter ( ) Color plotter ( ) Other ____________
   d. Comments for clarification (i.e., if use mini for digitizing and macro for processing):

7. Check the type of data which you process in your information system. Indicate in the second column the data elements you automate yourself. In the third column, indicate those elements which are given automated coordinate (digitized) geographic reference. In the fourth column, indicate those elements that are analyzed in conjunction with environmental data within the system.

Data Type	Self-Automated	Computer Geocoded Reference	Interact with Environmental Data
( ) Census			
( ) Health			
( ) Economic			
( ) Assessment			
( ) Transportation			
( ) Land Use			
( ) Land Cover			
( ) Zoning			
( ) Housing			
( ) Codes and Ordinances			
( ) Legal Property Descriptions			
( ) Topography			
( ) Land Resources (soils, geology)			
( ) Other Environmental Data (air, water, etc.)			
( ) Other (please specify)			

8. Is the data which is used stored in the form of a data bank for your entire jurisdiction or study area?

   ( ) Yes ( ) No

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*Continuously acquiring information and supplying output regularly, or capable of doing so on a short-term project basis.

**Resource - air, water, timber, mineral, etc.

9. Are the data types which are geocoded uniform for this whole area?

( ) Yes ( ) No

10. Does your information system provide computer mapped output?

( ) Yes ( ) No

11. Is your system user friendly (i.e., are the functions conversationally directed for use by non-programmers)?

( ) Yes ( ) No

12. How frequent is the demand for use of the geoprocessing system within your agency?

( ) seldom ( ) sometimes ( ) often ( ) very often ( ) continuously

13. How frequently is the data which is stored or processed by your information system used by agencies outside your organization?

( ) never ( ) seldom ( ) sometimes ( ) often ( ) very often

14. a. Are records kept which describe the characteristics of the source data?

( ) Yes ( ) No

b. If so, which of the following characteristics are known?

( ) source
( ) scale
( ) location of source data
( ) person who interpreted data
( ) person who encoded data
( ) accuracy of source data
( ) method of data interpretation
( ) map/coordinate precision

15. What are the factors limiting the expanded use of your system for the particular purpose or other purposes of your agency? (Please rank the three most important, giving the factor which is most important a ranking of "1".)

( ) availability of source data
( ) data at appropriate scale
( ) availability of hardware
( ) availability of software
( ) technical staff expertise
( ) limited mandate
( ) time
( ) budget
( ) base map precision
( ) data accuracy

16. a. Do you have any written documentation of your system?

( ) Yes ( ) No

b. If so, which of the following can you provide? Description of:

( ) hardware
( ) software
( ) data encoding format/procedure
( ) data structure
( ) data type (i.e., parameter lists)
( ) data assessment procedures

AFTER RESPONDING TO THE REMAINING QUESTIONS:

17. Are there any significant features of your system or your plans for developing an information system which were not covered in this questionnaire and which you would like to comment upon?

18. Are there any answers to questions which you wish to remain confidential? If so, which?

THE REMAINING SPACE IS LEFT FOR YOUR COMMENTS.

19. GEOGRAPHIC INFORMATION SYSTEM SOFTWARE

This portion of the survey queries automated capabilities for processing geocoded data. Please fill out the appropriate sections pertaining to your information system. Answer whether these capabilities are: 1) now operational in your system; 2) planned; 3) would assist your normal operations if they were available to you. If the capability is part of your system, answer whether it was self-programmed or acquired, whether you believe it to be transferable (documented and available) to other systems, and whether it is routinely used.

OPERATION	Operating	Planned	Desired	Self-Programmed	or	Acquired	Transferable	Routinely Used
SCALING AND COORDINATE CONVERSION								
Removing map distortion								
Scale change								
Projection change								
Coordinate conversion								
EDITING								
Identify closure errors								
Correct closure errors								
Identify slivers								
Correct slivers								
Thinning								
Label change								
Polygon delete								
Modify alignment								
Donut hole (island) recognition								
Automatic donut hole correction								
Data file update								
DATA MANIPULATION								
Selective retrieval (geographic)								
Selective retrieval (data parameter)								
File report								
Linear measurement								
Area calculation								
Perimeter calculation								
Merge adjoining maps								
Create new files from merged data								
Overlay (union) of separate data sets								
Overlay (intersection) of separate data sets								
Window overlay								
Line to grid conversion								
Polygon to grid conversion								
Grid to polygon conversion								
Direction determination								
Distance of polygon or point from designated point								
Centroid allocation								
Extreme value search								
Contouring								
Statistical analysis								
Integrated input from remote files								
Interpolation								
Extrapolation								
Modelling								
Value weighting								

Respondent ______________________________

Organization ______________________________

System ______________________________

Date ______________________________

OPERATION	Operating	Planned	Desired	Self-Programmed	or	Acquired	Transferable	Routinely Used
TOPOGRAPHY								
Elevation report								
Slope calculation								
Aspect calculation								
Intervisibility								
Drainage pattern								
Cross section								
GRAPHIC OUTPUT								
Diagram display								
Data display at any scale								
Zooming								
Graphic overlay of selective layers								
Plotting selected polygons (grids)								
Title and/or legend								
Shading								
View perspective								
Contoured map								
Selected contour interval								
Shaded perspectives								
REMOTE-SENSING RELATED (LANDSAT, etc.)								
Geometric correction								
Map registration								
Spectral classification (interactive)								
Spectral classification (bulk)								
Masking for data summary								

OTHER (please fill in)

20. DIRECTORY OF GEOCODED DATA

TYPE/COVERAGE/CHARACTERISTICS

I. Background

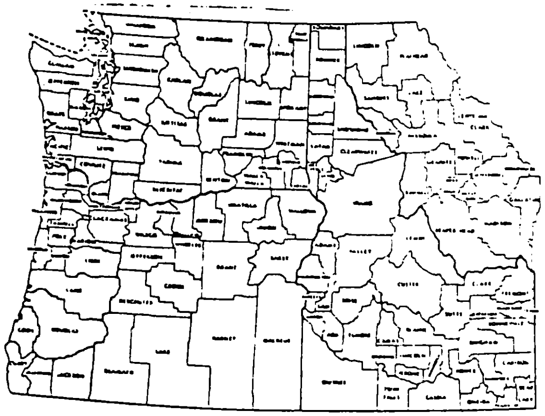
A. Respondent ____________________

B. Your Organization ____________________

C. System ____________________

D. Date ____________________

II. A. Please indicate on the map below the approximate boundaries of the area for which an automated geobased data file exists. Please use one questionnaire per study, or per system administered by your agency.



B. How would you best describe the type of geographic area for which the geocoded data is collected?

( ) national
( ) state
( ) region
( ) county
( ) other political jurisdiction
( ) resource management district
( ) special project area
( ) watershed or river basin
( ) other (please specify) ____________________

III. Please provide the following information about the geocoded data designated on the map.

A. Name of area (geographic name) ____________________

B. Size of area ____________________

C. When was original source data collected? ____________________

D. When was data encoded? ____________________

E. How often is data updated? ____________________

F. Upon which map projection is data referenced? ____________________

G. Upon which system of coordinate reference is the ground location of the data tied?

( ) latitude/longitude
( ) state plane coordinates
( ) UTM
( ) public rectangular survey
( ) arbitrary, X, Y
( ) other ____________________

H. What is the form (location identifier) of the encoded data?

( ) coordinate point
( ) regular grid (cell)
( ) irregular polygon
( ) streets and addresses
( ) census districts
( ) political boundary

I. What is the source of the encoded data?

( ) field survey
( ) field monitor
( ) published surveys and maps
( ) tapes (pre-encoded data)
( ) other (please specify) ____________________
( ) conventional air photography
( ) LANDSAT
( ) other remote sensed data
( ) interpretation of other data within system

J. What is the scale of the encoded data? If variable, indicate range.

____

K. What is the scale of the outputed data? If variable, indicate range.

____

L. What is the accuracy of the encoded data?

1. Estimated precision: ____________________
2. If point data, average sampling density: ____________________
3. If line/arc, minimum line length: ____________________
4. If cell or polygon, minimum size: ____________________

M. What form does the outputed information take?

( ) printed map
( ) interactive display
( ) statistical summary
( ) acetate overlay
( ) computer tape
( ) graph (plot)
( ) other ____________________

N. Indicate data or maps computerized and given georeference.

( ) geology
( ) topography
( ) soil
( ) mineral resources
( ) land cover
( ) socio/economic
( ) vegetation
( ) wildlife
( ) air quality
( ) timber resources
( ) land use
( ) surface hydrology
( ) groundwater hydrology
( ) climate/weather
( ) water resources
( ) ownership

O. Indicate new data or maps created or composited.

( ) proximity
( ) statistics
( ) capacity
( ) habitat
( ) other (please be specific)
( ) optimum location
( ) quality
( ) availability
( ) change
( ) development constraints
( ) land classification
( ) accessibility
( ) cost

P. Please describe briefly the purpose for encoding data for this area (i.e., project or data base purpose).

21. DATA COLLECTION AND PREFERENCE

Respondent ____________________ Organization ____________________ System __________ __________

Please fill out the following table concerning the types and characteristics of the data which form your geocoded data base. Indicate the types of data that your system contains or your agency maintains in digital form, and indicate the characteristics of that data unique to your geocoded data base. In many cases, the data characteristics are uniform for all data elements. If this is the case, you need not repeat this information for each separate data element. If you indicate a desire for data not now in your information system, please specify the preferred characteristics of the data in the cases where you believe it appropriate.

Presently contained	Desired	Data Variable	Source	Age of source data	Scale/ resolution	Spatial Configuration		No. of classifi- cations	Frequency of collection/ update
						Source	Encoded		
		A. GEOLOGY							
		A_1 Physiographic areas							
		A_2 Landscape features							
		A_3 Surficial geology							
		A_4 Bedrock geology							
		B. TOPOGRAPHY							
		B_1 Contour							
		B_2 Slope							
		B_3 Aspect							
		C. VEGETATION							
		C_1 Species							
		C_2 Communities							
		C_3 Ecological zones							
		C_4 Quality							
		C_5 Quantity (density)							
		C_6 Management areas							
		C_7 Succession							
		C_8 Age							
		D. WILDLIFE							
		D_1 Species							
		D_2 Quantity							
		D_3 Quality							
		D_4 Management							
		D_5 Habitat							
		E. SURFACE HYDROLOGY							
		E_1 Pollution sources							
		E_2 Water body type							
		E_3 Volume							
		E_4 Hydrologic character							
		E_5 Watershed boundaries							
		E_6 Quality							
		E_7 Flooding							
		E_8 Stream order							

DATA COLLECTION AND PREFERENCE - Page 2

Presently contained	Desired	Data Variable	Source	Age of source data	Scale/ resolution	Spatial Configuration		No. of classifications	Frequency of collection/ update
						Source	Encoded		
		F. GROUNDWATER HYDROLOGY							
		F_1 Pollution sources							
		F_2 Quality							
		F_3 Quantity							
		F_4 Recharge							
		F_5 Discharge							
		F_6 Well location							
		G. SOIL							
		G_1 Type							
		G_2 Series							
		G_3 Association							
		G_4 Engineering charactistics							
		G_5 Capability class							
		G_6 Productivity							
		H. AIR							
		H_1 Quality zones							
		H_2 Pollution sources							
		H_3 Management zones							
		I. CLIMATE/WEATHER							
		I_1 Rainfall							
		I_2 Wind							
		I_3 Exposure							
		I_4 Temperature							
		I_5 Solar radiation							
		J. RESOURCES							
		J_1 Timber							
		J_2 Mineral							
		J_3 Water							
		J_4 Unique areas							
		J_5 Agriculture							
		K. LAND COVER							
		L. OTHER (please specify)							

22. INFORMATION SYSTEM/DATA USE

Respondent ______________________ Agency ______________________ Date ______________

The following are uses for which your information system or geocoded data base may be used. Please check whether your agency now uses its system for this purpose, whether it is anticipated that it may, or whether it is desirable. Then indicate the characteristics of the data that are most desirable for the use considered. If your agency uses its information system for this purpose, please indicate whether the operations are done by the system (automated) or by manual interpretation/manipulation of the data once it is outputed from the system.

Presently Used	Anticipated	Desired	USE	Scale/ resolution	Precision	Spatial configuration	Automated or Manual		Form of output	Frequency of collection/ update
			Base mapping							
			Resource inventory							
			Land classification							
			Modelling							
			Environmental impact assessment							
			Land suitability analysis							
			Critical area planning and management							
			Thematic mapping (classified data)							
			Trend projection							
			Environmental data bank (atlas)							
			Urban data bank (atlas)							
			Cadastral mapping and verification							
			Route selection							
			Site selection							
			Land use allocation							
			Air quality management							
			Water quality management							
			Wildlife management							
			Timber management							
			Agricultural production							
			Hazard identification							
			Other (please specify)							

Appendix 3

TABULAR INDEX TO QUESTIONNAIRE

AN OPEN LETTER OF EXPLANATION AND TRANSMITTAL FOR QUESTIONNAIRES COMPILED AS A RESULT OF A SURVEY OF DIGITAL GEOGRAPHIC DATA HANDLING ACTIVITIES AND ENVIRONMENTAL DATA COVERAGE IN THE PACIFIC NORTHWEST

The questionnaires which are enclosed are the result of a survey of digital geographic data handling activities and geographically referenced environmental data coverage in the Pacific Northwest states (Idaho, Oregon, Washington). This file, an explanatory report of the research, and a preliminary directory of automated geoprocessing systems and geocoded environmental data coverage are the products of a research project funded under a University Consortium Agreement between collaborators at Western Washington University and NASA-Ames Research Center (Interchange NCA2-OR862-801).

This file constitutes the original record from the survey, which was conducted during the summer and fall of 1978. The questionnaires appear in the condition in which they were received from the respondents. The questionnaire, a copy of which is attached, queries:

a. hardware and software;
b. system use;
c. data content, characteristics, and preferences;
d. data handling capabilities and preferences;
e. extent of data coverage;
f. system documentation.

Sixty-seven responses are documented. They represent questionnaires and literature received from federal, state, municipal, and corporate personnel. The completeness of response is varied.

A descriptive index for the file of questionnaires is provided herewith. The index cites the questionnaires, in the order in which they appear in the file, by agency respondent and the name of the information system (where appropriate). Additional descriptive information is provided on the stage of development of the system, the completeness of response, whether a data directory was filled out as part of the questionnaire, and whether additional literature is enclosed. The stage of development indicates whether the system is operational, whether it is in a lesser stage of development, or whether it is being designed or considered. A response with reference to a fully operational system will provide more information on "what is" while a developing system response will have more information on "what should be." This also has a bearing in the completeness of the response. The continuum which is represented is from complete, to nearly complete, to partially complete, to incomplete. The availability of the data directory refers to the completion within the questionnaire of a page describing the coverage and characteristics of geographically referenced data.

The index is designed to assist the reader select the questionnaires which are of interest. Complete questionnaires have more content than those which are partially completed. The data directory describes data availability. The stage of development describes the mix of system documentation versus desire for system attributes. It thus may act as a selection guide.

For each questionnaire, a summary has also been completed. The summary describes the stage of development, purpose of the system, completeness of response, geographic coverage, principal data types, form of location identifier for the data (coordinate point, line, grid, irregular polygon), and other special characteristics. Among these characteristics are whether there is documentation available, whether needs for data are reported, and whether needs for software are reported. The person to contact regarding the system which is described is also noted on the summary form.

This information is provided with the expectation that it will facilitate the use and exchange of the questionnaires.

Table A-3

List of Completed Questionnaires in Order of their Placement in this File

NO.	AGENCY	SYSTEM	STAGE OF DEVELOPMENT	COMPLETENESS OF RESPONSE	DATA DIRECTORY COMPLETED	LITERATURE ENCLOSED
State Agencies						
1.	State of Washington Department of Ecology	Coastal Zone Atlas and Information System	Operational and still being developed	Complete	Yes	No
2.	State of Washington Department of Natural Resources	CALMA Mapping System	Operational	Complete	Yes	Yes
3.	State of Washington Department of Natural Resources	Gridded Resource Inventory Data System (GRIDS)	Operational	Complete	Yes	No
4.	State of Oregon Forestry Department		System being designed	Incomplete	No	Yes
5.	State of Oregon Department of Revenue	Computer Assisted Mapping System (CAMS)	Operational and still being developed	Partially complete	Yes	Yes
6.	State of Idaho Transportation Department	Unnamed	System being developed	Partially complete	Yes	No
7.	State of Idaho Department of Lands		System being developed	Partially complete	No	No
8.	State of Idaho Department of Water Resources		System being designed	Complete	Yes	No
Regional Governmental Agencies						
9.	Puget Sound Council of Governments	'EMPIRIC' Activity Allocation Model and Associated Data Files, Software and Hardware	Operational and still being developed.	Complete	Yes	No
10.	Puget Sound Council of Governments	Map-Model	Developed, not now operating	Complete	Yes	No
11.	Municipality of Metropolitan Seattle (METRO)		System being investigated	Partially complete	No	No
12.	Mid-Willamette Valley Council of Governments	Oregon Planning System	Operational and still being developed	Complete	Yes	No
13.	Lane County Council of Governments	Unnamed	Operational and still being developed	Nearly complete	Yes	No
Municipal Agencies						
14.	Spokane County Planning Department	GBF/DIME	Operational and still being developed	Partially complete	Yes	No
15.	Snohomish County Planning Department	Unnamed	Operational and still being developed	Complete	Yes	No
16.	City of Tacoma Planning Department	Geographic Base System	Portions operational and still being developed	Complete	Yes	No
17.	City of Salem	Computer Assisted Map Information System (CAMIS)	System being developed	Nearly complete	No	No
Corporations						
18.	Puget Power and Light	Electric Plant Data Base	Portions operational, comprehensive system being designed	Complete	Yes	No
19.	Battelle Northwest Laboratories	Water and Land Resources Computer Facility	Operational and still being developed	Partially complete	Yes	No
20.	Boeing Computer Services	Natural Resources Information System	Operational	Partially complete	Yes	No
21.	St. Regis Paper Company		System being designed	Partially complete	No	No
Federal Agencies Situated in the Northwest						
22.	Bureau of Indian Affairs and Colville Confederated Tribes	Natural Resources Information System	Operational and still being developed	Nearly complete	Yes	No
23.	U.S. Department of the Interior Bureau of Land Management	Map-Model	Was developed, no longer operating	Partially complete	Yes	No

Table A-3--continued

NO.	AGENCY	SYSTEM	STAGE OF DEVELOPMENT	COMPLETENESS OF RESPONSE	DATA DIRECTORY COMPLETED	LITERATURE ENCLOSED
	Federal Agencies Situated in the Northwest -- continued					
24.	Bureau of Transmission Engineering, Bonneville Power Administration	PERMITS	Operational and still being developed	Nearly complete	Yes	No
25.	U.S. Army Corps of Engineers North Pacific Division	CROHMS	Was developed, no longer operating	Nearly complete	Yes	No
26.	U.S.D.A. Forest Service, Region 6	TRI	Operational and still being developed	Complete	Yes	Yes
27.	U.S.D.A. Agricultural Research Service	Hydrological Data Bank	Operational and still being developed	Nearly complete	Yes	No
	Federal Agencies Outside the Northwest					
28.	U.S. Geological Survey Topographic Division Digital Applications Team	UCLGES - DLG-3 CONEDIT DCDI	Operational and still being developed	Complete	Yes	Yes
29.	U.S. Geological Survey Western Mapping Center	Digital Elevation Models (DEM)	Operational and still being developed	Complete	Yes	Yes
30.	U.S. Geological Survey Western Mapping Center	Digital Line Graph (DLG)	Operational and still being developed	Nearly complete	Yes	Yes
31.	U.S. Geological Survey Geologic Division	Geologic Retrieval and Synopsis Program (GRASP)	Operational	Partially complete	No	No
32.	U.S. Geological Survey Mineral Resources Division	Computerized Resources Information Bank (CRIB)	Operational	Partially complete	Yes	Yes
33.	U.S. Geological Survey Branch of Isotope Geology	Radiometric Age Data Bank	Operational	Nearly complete	Yes	No
34.	U.S. Geological Survey Geologic Division	Gravity projects	System is being developed	Complete	Yes	No
35.	U.S. Geological Survey EROS Data Center Digital Applications Laboratory	LANDSAT System and associated data analysis subsystems	Operational and still being developed	Complete	Yes	No
36.	U.S. Geological Survey Geography Program	Geographic Information Retrieval and Analysis System (GIRAS)	Operational and still being developed	Partially complete	No	Yes
37.	U.S. Geological Survey Geologic Division	Digital Image Processing System	Operational and still being developed	Nearly complete	Yes	No
38.	U.S. Geological Survey Geologic Division Seismic Engineering Branch	Earthquake Strong Motion Data System	Partially operational, still being developed	Nearly complete	Yes	No
39.	U.S. Geological Survey Geologic Division	Rock Analysis Storage System (RASS)	Operational	Nearly complete	Yes	No
40.	U.S. Geological Survey Conservation Division	Geophysical Interpretive Aid System (GIAP)	Operational and still being developed	Complete	Yes	No
41.	U.S. Geological Survey Geologic Division	Well History Control System and Petroleum Data System	Operational	Partially complete	Yes	No
42.	U.S. Geological Survey Geologic Division	WATSTORE	Operational and still being developed	Partially complete	Yes	Yes
43.	U.S. Geological Survey Water Resources Division	National Water Data Exchange Hydrologic Unit Map Base	Operational and still being developed	Nearly complete	Yes	Yes
44.	U.S. Environmental Protection Agency	STORET	Operational	Nearly complete	Yes	Yes
45.	U.S. Environmental Protection Agency	Storage and Retrieval of Aerometric Data (SAROAD)	Operational and still being developed	Nearly complete	Yes	No
46.	U.S.D.A. Soil Conservation Service	Conservation Needs Inventory	Operational	Partially complete	Yes	No

Table A-3--continued

NO.	AGENCY	SYSTEM	STAGE OF DEVELOPMENT	COMPLETENESS OF RESPONSE	DATA DIRECTORY COMPLETED	LITERATURE ENCLOSED
Federal Agencies Outside the Northwest -- continued						
47.	U.S.D.A. Soil Conservation Service	Advanced Mapping System	Operational	Partially complete	No	No
48.	U.S.D.A. Soil Conservation Service	Natural Resources Data System	Operational and still being developed	Nearly complete	Yes	No
49.	Brookhaven National Laboratory Atmospheric Sciences Division	Point and Area Source Emissions Inventory	System being developed	Partially complete	Yes	No
50.	U.S.D.A. Forest Service	Timber Management	Operational	Nearly complete	Yes	No
51.	U.S.D.A. Forest Service	Resource Inventory Display System	Operational	Partially complete	No	No
52.	U.S. Water Resources Council	Second National Water Assessment	Operational and still being developed	Nearly complete	Yes	Yes
Miscellaneous, Late, Incomplete, Confidential or Wrongly Sampled Questionnaires						
53.	Huxley College, Western Washington University	Huxley System	Operational and still being developed	Nearly complete	Yes	No
54.	Weyerhaeuser Company	Forest Inventory and Regeneration Data Base	Operational	(Only summary sheet enclosed -- questionnaire to remain confidential)		
55.	U.S. Bureau of the Census	Pollution Abatement Costs and Expenditures	Operational	(Only summary sheet enclosed -- questionnaire to remain confidential)		
56.	National Oceanographic and Atmospheric Administration National Oceanographic Data Center	Generalized Applications System, Parameter Inventory Display System	Operational and still being developed	Nearly complete (Not land based data)	Yes	Yes
57.	U.S. Geological Survey Pacific/Arctic Branch of Marine Geology	Cruise Data System	Operational and still being developed	Complete (Not land based data)	Yes	No
58.	Oregon Department of Water Resources	IDIMS	Operational	Nearly complete (System is not used in-house)	Yes	No
59.	Oregon Department of Fish and Wildlife		No system being considered	Incomplete	No	No
60.	Boise State University Center for Research,Grants/Contracts		No system reported	Partially complete	Yes	No
61.	U.S. Army Corps of Engineers Seattle District		No system reported	Incomplete	No	No
62.	U.S. Army Corps of Engineers Portland District	System of Information Retrieval and Analysis for Planners (SIRAP)	Operational	Incomplete	No	No
63.	U.S. Geological Survey Geologic Division Western Regional Office	Digital Landslide Susceptability Determination	Operational, but not now operating	Complete	Yes (No coverage in region)	No
64.	U.S. Geological Survey Geologic Division Denver Office	Oil Shale Information System	Operational	Complete	Yes (No coverage in region)	No
65.	U.S. Geological Survey EROS Data Center	B6700	Operational and still being developed	Complete	Yes	No
66.	COMARC Design Systems	Unnamed	Operational	Nearly complete	Yes	No
67.	City of Bellevue	Computer Based Mapping System		(No questionnaire returned)		Yes

Appendix 4

KEY TO DESCRIPTIVE CHARACTERISTICS AND OPTIONS CODED FROM THE QUESTIONNAIRES

Table A-4

Key to Descriptive Characteristics

CHARACTERISTIC	VARIABLE NAME	NUMBER OF CHOICES	CARD/ COLUMN	CODING SYMBOL INTERPRETATION
IDENTIFICATION NUMBER	ID	50	1/1,2	
BASIC RESPONSIBILITY OF RESPONDENT	AGRESP	8	1/6	1. Metropolitan Planning 2. Regional Planning 3. Land Management 4. Mapping 5. Environmental Protection 6. Resource Planning and Management 7. Special Area Planning 8. Other
TYPE OF GEOPROCESSING SYSTEM	SYSTYPE	13	1/7,8	01. Data Base Maintenance 02. Output Mapping - Grid 03. Output Mapping - Image Production 04. Information Retrieval - Point 05. Information Retrieval - Line 06. Information Retrieval - Fixed Grid 07. Information Retrieval - Variable Boundary 08. Information Retrieval - GBF/DIME 09. Information Retrieval - Combined 10. Integrated - Map Overlay 11. Integrated - General Purpose 12. Digital Terrain Model 13. Other
STAGE OF DEVELOPMENT	STAGE	6	1/9	1. Operational 2. Operational and Still Being Developed 3. Being Designed 4. Being Developed 5. Being Investigated 6. Operational, But No Longer Operating
GEODEFINITION	GEODEF	5	1/10	1. External 2. Implicit 3. Explicit 4. Combination 5. Unknown or Unreported
USER FRIENDLY	UF	3	1/11	1. Yes 2. No 3. Unknown or Unreported
USE OF VENDOR SUPPLIED OR PACKAGED PROGRAMS	VP	2	1/12	1. Predominant 2. No 3. Partial
TRANSFERABLE SOFTWARE	TRANS	4	1/13	1. Predominant 2. Partial 3. No 4. Unknown or Unreported
DERIVED MAPS AND ANALYSIS	TWOLEV	3	1/14	1. Yes 2. No 3. Unknown or Unreported
INTEGRATION OF CULTURAL DATA WITH ENVIRONMENTAL DATA	NOENV	3	1/15	1. Yes 2. No 3. Unknown or Unreported
GRAPHIC LINE REPRODUCTION CAPABILITY	VIRT	3	1/16	1. Yes 2. No 3. Unknown or Unreported
FORM OF GEOCODING	GEOCOD	8	1/17	1. Grid 2. Polygon 3. GBF/DIME 4. Point 5. Line 6. External Index 7. Integrated 8. Unknown or Unreported
MAINTAIN DATA BASE	DB	3	1/18	1. Yes 2. No 3. Unknown or Unreported

Table A-4--continued

CHARACTERISTICS	VARIABLE NAME	NUMBER OF CHOICES	CARD/ COLUMN	CODING SYMBOL INTERPRETATION
FUNCTIONS OF AGENCY (Multiple Response)	AP	11	1/20-30	
Municipal Land Use Planning	AP 01	2	1/20	
Regional Land Use Planning	AP 02	2	1/21	1 = Yes
Land Management	AP 03	2	1/22	Blank = No
Research	AP 04	2	1/23	
Cadastral Mapping	AP 05	2	1/24	
Automated Cartography	AP 06	2	1/25	
Environmental Protection	AP 07	2	1/26	
Resource Planning and Management	AP 08	2	1/27	
Special Area Planning	AP 09	2	1/28	
Multiple Purpose	AP 10	2	1/29	
Other	AP 11		1/30	
MAP PROJECTION	MP	11	1/32-42	
Orthographic	MP 01	2	1/32	1 = Current
Gnomonic	MP 02	2	1/33	2 = Desired
Lambert Azimuthal	MP 03	2	1/34	
Lambert Conformal	MP 04	2	1/35	
Albers	MP 05	2	1/36	
Polyconic	MP 06	2	1/37	
Mercator	MP 07	2	1/38	
Transverse Mercator	MP 08	2	1/39	
Multiple	MP 09	2	1/40	
Other	MP 10	2	1/41	
Not Reported	MP 11	2	1/42	
COORDINATE REFERENCE	CR	8	1/44-51	
Latitude/Longitude	CR 01	2	1/44	1 = Current
State Plane Coordinates	CR 02	2	1/45	2 = Desired
UTM Coordinates	CR 03	2	1/46	
Public Rectangular Survey	CR 04	2	1/47	
Arbitrary 'x,y'	CR 05	2	1/48	
Multiple	CR 06	2	1/49	
Other	CR 07	2	1/50	
Not Reported	CR 08	2	1/51	
LOCATION IDENTIFIER	LI	10	1/53-62	
Coordinate Point	LI 10	2	1/53	1 = Current
Regular Grid	LI 02	2	1/54	2 = Desired
Irregular Polygon	LI 03	2	1/55	
External Index	LI 04	2	1/56	
Streets and Addresses	LI 05	2	1/57	
Census Districts	LI 06	2	1/58	
Political Boundary	LI 07	2	1/59	
Multiple	LI 08	2	1/60	
Variable	LI 09	2	1/61	
Not Reported	LI 10	2	1/62	
SCALE[1]	SCALE	8	1/64-71	
Very Large	SCALE 01	2	1/64	1 = Current
Large	SCALE 02	2	1/65	2 = Desired
Medium	SCALE 03	2	1/66	
Medium-Small	SCALE 04	2	1/67	
Small	SCALE 05	2	1/68	
Very Small	SCALE 06	2	1/69	
Variable	SCALE 07	2	1/70	
Not Reported	SCALE 08	2	1/71	
PRECISION[2]	PREC	5	1/73-77	
High	PREC 01	2	1/73	1 = Current
Good	PREC 02	2	1/74	2 = Desired
Moderate	PREC 03	2	1/75	
Poor	PREC 04	2	1/76	
Not Reported	PREC 05	2	1/77	
RESOLUTION[3]	RES	7	2/6-12	
Very Fine	RES 01	2	2/6	1 = Current
Fine	RES 02	2	2/7	2 = Desired
Medium	RES 03	2	2/8	
Coarse	RES 04	2	2/9	
Very Coarse	RES 05	2	2/10	
Variable	RES 06	2	2/11	
Not Reported	RES 07	2	2/12	

(Notes at end of table)

Table A-4--continued

CHARACTERISTICS	VARIABLE NAME	NUMBER OF CHOICES	CARD/ COLUMN	CODING SYMBOL INTERPRETATION
UNITS OF DATA COVERAGE	UCOV	11	2/14-24	
National	UCOV 01	2	2/14	1 = Current
State	UCOV 02	2	2/15	2 = Desired
Region	UCOV 03	2	2/16	
County	UCOV 04	2	2/17	
Other Political	UCOV 05	2	2/18	
Resource Management District	UCOV 06	2	2/19	
Special Project Area	UCOV 07	2	2/20	
Watershed or River Basin	UCOV 08	2	2/21	
Multiple	UCOV 09	2	2/22	
Other	UCOV 10	2	2/23	
Not Reported	UCOV 11	2	2/24	
UNITS OF DATA COMPOSITE	UCOM	19	2/26-44	
Counties	UCOM 01	2	2/26	1 = Current
Watersheds	UCOM 02	2	2/27	2 = Desired
Special Project Areas	UCOM 03	2	2/28	
Neighborhood	UCOM 04	2	2/29	
Census Tract/District	UCOM 05	2	2/30	
Local Improvement District	UCOM 06	2	2/31	
Block	UCOM 07	2	2/32	
Management/Administrative Unit	UCOM 08	2	2/33	
Map	UCOM 09	2	2/34	
Section or Township	UCOM 10	2	2/35	
Zoning District	UCOM 11	2	2/36	
School District	UCOM 12	2	2/37	
Hazard Areas	UCOM 13	2	2/38	
Fire/Police District	UCOM 14	2	2/39	
Legisistive District	UCOM 15	2	2/40	
Open	UCOM 16	2	2/41	
Open	UCOM 17	2	2/42	
Variable	UCOM 18	2	2/43	
Not Reported	UCOM 19	2	2/44	
SOURCE	SOURCE	11	2/46-56	
Field Survey	SOURCE 01	2	2/46	1 = Current
Field Monitor	SOURCE 02	2	2/47	2 = Desired
Published Surveys and Maps	SOURCE 03	2	2/48	
Pre-Encoded Data	SOURCE 04	2	2/49	
Conventional Air Photography	SOURCE 05	2	2/50	
LANDSAT	SOURCE 06	2	2/51	
Other Remote Sensed Data	SOURCE 07	2	2/52	
Interpretation of Other Data in the System	SOURCE 08	2	2/53	
Multiple	SOURCE 09	2	2/54	
Other	SOURCE 10	2	2/55	
Not Reported	SOURCE 11	2	2/56	
DATA TYPE (GENERAL)	DG	17	2/58-74	
Census	DG 01	2	2/58	1 = Current
Health	DG 02	2	2/59	2 = Desired
Assessment	DG 03	2	2/60	
Transportation	DG 04	2	2/61	
Land Use	DG 05	2	2/62	
Land Cover	DG 06	2	2/63	
Zoning	DG 07	2	2/64	
Housing	DG 08	2	2/65	
Codes and Ordinances	DG 09	2	2/66	
Legal Property Description	DG 10	2	2/67	
Utilities	DG 11	2	2/68	
Topography	DG 12	2	2/69	
Land Resources	DG 13	2	2/70	
Other Environmental Data	DG 14	2	2/71	
Variable	DG 15	2	2/72	
Other	DG 16	2	2/73	
Not Reported	DG 17	2	2/74	
RESIDENCY	STATE	6	2/76	1. All 2. Idaho 3. Oregon 4. Washington 5. Combination of Two Above 6. Other

Table A-4--continued

CHARACTERISTICS	VARIABLE NAME	NUMBER OF CHOICES	CARD/ COLUMN	CODING SYMBOL INTERPRETATION
DATA HANDLING SOFTWARE	SW	73	3/6-78	
Digitizing	SW 01	2	3/6	1 = Current
Identify Closure Error	SW 02	2	3/7	2 = Desired
Correct Closure	SW 03	2	3/8	
Identify Slivers	SW 04	2	3/9	
Correct Slivers	SW 05	2	3/10	
Island Recognition	SW 06	2	3/11	
Island Correction	SW 07	2	3/12	
Format Change	SW 08	2	3/13	
Thinning	SW 09	2	3/14	
Polygon Delete	SW 10	2	3/15	
Data File Update	SW 11	2	3/16	
Cartographic Edit	SW 12	2	3/17	
Label Change	SW 13	2	3/18	
Modify Alignment	SW 14	2	3/19	
Spatial Rectification	SW 15	2	3/20	
Removing Map Distortion	SW 16	2	3/21	
Scale Change	SW 17	2	3/22	
Projection Change	SW 18	2	3/23	
Coordinate Conversion	SW 19	2	3/24	
Location Identifier Conversion	SW 20	2	3/25	
Line to Grid	SW 21	2	3/26	
Polygon to Grid	SW 22	2	3/27	
Grid to Polygon	SW 23	2	3/28	
Location and Segregation	SW 24	2	3/29	
Centroid	SW 25	2	3/30	
Contouring	SW 26	2	3/31	
Measurement	SW 27	2	3/32	
Linear	SW 28	2	3/33	
Area	SW 29	2	3/34	
Perimeter	SW 30	2	3/35	
Direction	SW 31	2	3/36	
Distance	SW 32	2	3/37	
Sorting/Merging	SW 33	2	3/38	
File Report	SW 34	2	3/39	
Selective Retrieval (Geographic)	SW 35	2	3/40	
Selective Retrieval (Descriptor)	SW 36	2	3/41	
Merge Adjoining Maps	SW 37	2	3/42	
Create New Files	SW 38	2	3/43	
Window Overlay	SW 39	2	3/44	
Integrate from Remote Files	SW 40	2	3/45	
Comparison	SW 41	2	3/46	
Overlay (Union)	SW 42	2	3/47	
Overlay (Intersection)	SW 43	2	3/48	
Value Weighting	SW 44	2	3/49	
Modeling	SW 45	2	3/50	
Extrapolation	SW 46	2	3/51	
Interpolation	SW 47	2	3/52	
Statistical Analysis	SW 48	2	3/53	
Extreme Value Search	SW 49	2	3/54	
Topography (Digital Terrain)	SW 50	2	3/55	
Elevation Report	SW 51	2	3/56	
Slope Calculation	SW 52	2	3/57	
Intervisibility	SW 53	2	3/58	
Aspect	SW 54	2	3/59	
Drainage	SW 55	2	3/60	
Cross-section	SW 56	2	3/61	
View Perspective	SW 57	2	3/62	
Diagram Display	SW 58	2	3/63	
Scaling	SW 59	2	3/64	
Zooming	SW 60	2	3/65	
Selective Layer Plotting	SW 61	2	3/66	
Data Display at any Scale	SW 62	2	3/67	
Cartographic/Thematic	SW 63	2	3/68	
Title/Legend	SW 64	2	3/69	
Shading	SW 65	2	3/70	
Contour	SW 66	2	3/71	
3-D	SW 67	2	3/72	
Remote Sensing	SW 68	2	3/73	
Geometric Corrections	SW 69	2	3/74	
Map Registration	SW 70	2	3/75	
Spectral Classification (Interactive)	SW 71	2	3/76	
Spectral Classification (Bulk)	SW 72	2	3/77	
Masking for Data Summary	SW 73	2	3/78	

Table A-4--continued

CHARACTERISTICS	VARIABLE NAME	NUMBER OF CHOICES	CARD/ COLUMN	CODING SYMBOL INTERPRETATION
DATA TYPE (ENVIRONMENTAL)	DE	2	4/6-23	
Geology	DE 01	2	4/6	1 = Current
Topography	DE 02	2	4/7	2 = Desired
Vegetation	DE 03	2	4/8	
Wildlife	DE 04	2	4/9	
Surface Hydrology	DE 05	2	4/10	
Groundwater Hydrology	DE 06	2	4/11	
Soil Type	DE 07	2	4/12	
Soil Interpretation	DE 08	2	4/13	
Air	DE 09	2	4/14	
Climate/Weather	DE 10	2	4/15	
Timber Resources	DE 11	2	4/16	
Mineral Resources	DE 12	2	4/17	
Water Resources	DE 13	2	4/18	
Unique/Sensitive Areas	DE 14	2	4/19	
Land Cover	DE 15	2	4/20	
Variable	DE 16	2	4/21	
Other	DE 17	2	4/22	
Not Reported	DE 18	2	4/23	
FACTORS LIMITING SYSTEM USE	LF	3	4/25-36	
Availability of Source Data	LF 01	3	4/25	1 = Highest Limitation
Data at Appropriate Scale	LF 02	3	4/26	2 = Next Highest Limitation
Availability of Hardware	LF 03	3	4/27	3 = Next Highest Limitation
Availability of Software	LF 04	3	4/28	
Technical Staff Expertise	LF 05	3	4/29	
Limited Mandate	LF 06	3	4/30	
Time	LF 07	3	4/31	
Budget	LF 08	3	4/32	
Base Map Precision	LF 09	3	4/33	
Data Accuracy	LF 10	3	4/34	
Other	LF 11	3	4/35	
Not Reported	LF 12	3	4/36	
SIZE OF COVERAGE	SIZE	8	4/38	1. Greater than 100,000 mi^2 2. 10,000 mi^2 - 100,000 mi^2 3. 1,000 mi^2 - 10,000 mi^2 4. 100 mi^2 - 1,000 mi^2 5. 10 mi^2 - 100 mi^2 6. Less than 10 mi^2 7. Not Reported 8. Variable
COMPUTER MAPPING CAPACITY	MAP	2	4/40	1 = Yes Blank = No
PACKAGED SOFTWARE	SWPAC	2	4/42	1 = Yes 2 = Not Known
SYSTEM APPLICATIONS	SYSU	23	4/44-66	
Base Mapping	SYSU 01	2	4/44	1 = Current
Resource Inventory	SYSU 02	2	4/45	2 = Desired
Land Classification	SYSU 03	2	4/46	
Modeling	SYSU 04	2	4/47	
Environmental Impact Assessment	SYSU 05	2	4/48	
Land Suitability Analysis	SYSU 06	2	4/49	
Critical Area Planning	SYSU 07	2	4/50	
Thematic Mapping	SYSU 08	2	4/51	
Trend Projection	SYSU 09	2	4/52	
Environmental Data Bank	SYSU 10	2	4/53	
Urban Data Bank	SYSU 11	2	4/54	
Cadastral Mapping	SYSU 12	2	4/55	
Route Selection	SYSU 13	2	4/56	
Site Selection	SYSU 14	2	4/57	
Land Use Allocation	SYSU 15	2	4/58	
Air Quality Management	SYSU 16	2	4/59	
Water Quality Management	SYSU 17	2	4/60	
Wildlife Management	SYSU 18	2	4/61	
Timber Management	SYSU 19	2	4/62	
Agriculture Production	SYSU 20	2	4/63	
Hazard Identification	SYSU 21	2	4/64	
Other	SYSU 22	2	4/65	
None Reported	SYSU 23	2	4/66	

Table A-4--continued

CHARACTERISTICS	VARIABLE NAME	NUMBER OF CHOICES	CARD/ COLUMN	CODING SYMBOL INTERPRETATION
DERIVED MAPS AND ANALYSIS	ANAL	12	4/68-79	
Proximity	ANAL 01	2	4/68	1 = Yes
Statistics	ANAL 02	2	4/69	Blank = No
Capacity	ANAL 03	2	4/70	
Optimum Location	ANAL 04	2	4/71	
Quality	ANAL 05	2	4/72	
Availability	ANAL 06	2	4/73	
Change	ANAL 07	2	4/74	
Development Constraints	ANAL 08	2	4/75	
Accessibility	ANAL 09	2	4/76	
Cost	ANAL 10	2	4/77	
Other	ANAL 11	2	4/78	
Not Reported	ANAL 12	2	4/79	

NOTES

[1]SCALE

Very Large -- less or equal to 1:2,400
Large -- greater than 1:2,400 and less than or equal to 1:24,000
Medium -- greater than 1:24,000 and less than or equal to 1:100,000
Medium-Small -- greater than 1:100,000 and less than or equal to 1:250,000
Small -- greater than 1:250,000 and less than or equal to 1:1,000,000
Very Small -- greater than 1:1,000,000

[2]PRECISION

High -- greater than or equal to 90%
Good -- greater than or equal to 75% and less than 90%
Moderate -- greater than or equal to 50% and less than 75%
Poor -- less than 50%

[3]RESOLUTION	Linear	Area
Very Fine	Less than or equal to 2 ft.	1 acre
Fine	Greater than 2 ft. and less than 40 ft.	1 to 5 acres
Medium	40 ft. to and including 100 ft.	5 to 40 acres
Coarse	Greater than 100 ft. and less than 1,000 ft.	40 to 640 acres
Very Coarse	Greater than 1,000 ft.	Larger than 640 acres

Appendix 5

NUMERICAL TABULATIONS OF THE DATA FROM THE QUESTIONNAIRE RESPONSES GROUPED BY SYSTEM TYPE AND BASIC RESPONSIBILITY OF THE RESPONDENT

Table A-5

Numerical Tabulation of Applications and Analyses Operating and Desired by Each Type of System User

INTERPRETATION

Table cells give the number of recorded responses within each group. For questions with the optional choices of 'operating' and 'desired', the upper number is the number now operating and the lower is the sum of those 'operating' and 'desired'. The difference between the top and the bottom number is the number of desired but not operating characteristics. The total sample size is in parentheses.

BASIC RESPONSIBILITY OF RESPONDENT:	TYPES OF APPLICATIONS																							TYPES OF ANALYSIS											
	Base Mapping	Resource Inventory	Land Classification	Modeling	Environmental Impact Assessment	Land Suitability Analysis	Critical Area Planning	Thematic Mapping	Trend Projection	Environmental Data Bank	Urban Data Bank	Cadastral Mapping	Route Selection	Site Selection	Land Use Allocation	Air Quality Management	Water Quality Management	Wildlife Management	Timber Management	Agricultural Production	Hazard Identification	Other	Not Reported	Proximity	Capacity	Optimum Location	Quality	Availability	Change	Development Constraints	Accessibility	Statistics	Cost	Other	Not Reported
Metropolitan Land Use Planning (4)	2/3	1/3	2/3	1/3	0/1	1/3	1/2	1/1	1/3	0/1	1/3	1/2	0/1	1/3	1/2						0/1	2/3	0	1		1	0	1	1	1		1			2
Regional Land Use Planning (5)	4/5	1/2	1/3	4/4	1/2	2/3	1/2	2/2	0/1	2/4	1/3		0/2	1/2	2/4	0/1	2/3	0/2	0/2	1/2	1/2		0		2	1			1	3		1			1
Land Management (5)	1/1	3/3	2/2	2/2	1/1		1/1	3/3	1/1	2/2				1/1	3/3			1/1	2/2	1/1		1/1	1												1
Mapping (6)	3/5	1/1	0/1					1/1				0/1			0/1								1												2
Environmental Protection (3)		1/1		2/3	3/3	0/1	1/1		2/2	1/1			0/1	1/2	0/1	1/1	1/1	0/1	1/1		1/1	1/1	0	1		1	2	2	1	2	1	1			0
Resource Planning and Management (14)	3/3	10/10	4/4	6/6	1/2	2/2	5/5	1/1	2/2	3/3				3/3	1/1		2/2		4/4	0/1	2/2	2/2	2	1	1	2	3	2		2	2	2	0	1	3
Special Area Planning (2)	0/1	1/2		1/2	0/1		0/1		0/1		0/1		1/2		0/1								0			1		1		1	1	!			0
Other (11)	4/5	6/6	3/4	3/3	2/3	3/4	1/3	1/1	1/1	1/2	0/1		1/3	4/4	3/3			1/2	3/3	2/2	1/2	3/4	2	3		1		2	2	3	2	2	1	1	1
Total (50)	17/23	24/28	12/17	19/23	8/13	8/13	10/15	9/9	7/11	9/13	2/8	1/3	2/9	11/15	10/16	1/2	5/6	2/6	10/12	4/6	5/8	9/11	6	6	3	7	5	8	5	12	6	7	1	2	10

Table A-6

Numerical Tabulation of Data Handling Software Operating and Desired by Each Type of System User

INTERPRETATION

Table cells give the number of recorded responses within each group. For questions with the optional choices of 'operating' and 'desired', the upper number is the number now operating and the lower is the sum of those 'operating' and 'desired'. The difference between the top and the bottom number is the number of desired but not operating characteristics. The total sample size is in parentheses.

	Editing				Spatial Rectification						Measurement				Sorting/Merging						Comparison						Graphic Output					Other		
BASIC RESPONSIBILITY OF RESPONDENT:	SOFTWARE Identify and Correct Closure	Identify and Correct Slivers	Data File Update	Labeling	Removing Map Distortion	Line Generalization	Modify Alignment	Scale Change	Projection Change or Coordinate Conversion	Location Identifier Coversion	Linear Measurement	Area Measurement	Direction Determination	Centroid Determination	Selective Retrieval - Geographic	Selective Retrieval - Descriptor	Edge Matching	Create New Files	Integrate from Remote Files	Contouring	Overlay - Union	Overlay - Intersection	Value Weighting	Modeling	Statistical Analysis	Extreme Value Search	Zooming	Diagram and Chart Display	Lettering	Shading	3D	Digital Relief Analysis	Landsat Data Analysis	Not Reported
Metropolitan Land Use Planning (4)	1/1	1/1	3/3	2/2	3/3	2/2	2/2	2/2	3/3	2/3	3/3	3/4	2/2	2/3	4/4	4/4	2/4	2/3	0/1	3/4	4/4	2/3	2/2	2/2	1/3	1/1	2/2	2/3	2/3	1/4	0/1	1/3	0/1	
Regional Land Use Planning (5)	2/2	1/1	3/3	2/2	1/2	1/1	1/1	2/3	2/3	3/3	3/3	4/4		2/2	5/5	5/5	4/5	4/4		1/2	4/5	3/4	1/3	2/2	2/3	1/1	1/3	2/2	3/4	1/2		2/3		
Land Management (5)	1/2	1/1	1/3	1/2	1/1	2/2	1/1	2/2	1/2	2/3	1/2	2/3		1/1	3/4	3/4	1/2	1/1		2/3	2/2	2/2			0/1			1/1	2/2			1/1		1
Mapping (6)	4/5	2/2	4/5	3/3	6/6	3/3	3/3	4/5	4/6	1/2	3/3	4/4	2/2		3/5	2/4	3/6	4/6		5/5	3/5	2/4		1/1	2/3	2/2	3/3	3/3	4/4	2/2		2/2		
Environmental Protection (3)	3/3	1/1	0/1	2/2			1/1	2/2	2/2		0/1	0/1		1/1	3/3	3/3				1/1	0/1	1/1			1/1		2/2	1/1	2/2	1/1	1/1			
Resource Planning and Management (14)	0/2	2/3	4/5	2/3	2/4	2/5	1/2	5/7	5/7	2/5	2/4	4/6	0/3	1/3	7/9	9/11	3/5	6/8	1/3	4/6	4/7	3/5	0/3	1/4	3/6	2/5	3/5	5/7	4/5	2/4	3/4	3/6	1/2	2
Special Area Planning (2)	0/2	0/2	0/2	1/2		0/2	1/2	1/2	1/2	1/2	1/2	1/2	0/1	0/2	1/2	1/2	1/2	1/2	1/2	0/1	1/2	1/2	1/2	1/2	1/2	0/1	1/2	0/1	1/2	0/1	0/2	1/2	0/1	
Other (11)	5/5	4/4	6/6	7/7	3/3	2/2	3/3	7/8	5/6	5/5	4/5	4/6	1/2	2/3	11/11	11/11	3/3	8/9	3/3	4/4	7/8	4/4	1/1	1/1	6/6	4/4	5/5	1/1	7/7	3/3	1/2	2/2	2/2	
Total (50)	16/21	12/15	21/28	20/23	16/19	12/17	13/15	25/31	23/31	16/23	17/23	22/30	5/10	9/15	37/43	38/44	17/27	26/33	5/9	20/26	25/34	18/25	5/11	8/12	16/25	10/14	17/22	15/19	25/29	10/17	5/10	12/19	3/6	3

Table A-7

Numerical Tabulation of Data Types Used and Desired by Each Type of System User

INTERPRETATION

Table cells give the number of recorded responses within each group. For questions with the optional choices of 'operating' and 'desired', the upper number is the number now operating and the lower is the sum of those 'operating' and 'desired'. The difference between the top and the bottom number is the number of desired but not operating characteristics. The total sample size is in parentheses.

BASIC RESPONSIBILITY OF RESPONDENT:	DATA TYPES - GENERAL																	ENVIRONMENTAL DATA TYPES																	
	Census	Health	Assessment	Transportation	Land Use	Land Cover	Zoning	Housing	Codes and Ordinances	Legal Property Descriptions	Utilities	Topography	Land Resources	Other Environmental Data	Variable	Other	Not Reported	Geology	Topography	Vegetation	Wildlife	Surface Hydrology	Groundwater Hydrology	Soil Type	Soil Interpretation	Air	Climate and Weather	Timber Resources	Mineral Resources	Water Resources	Unique and Sensitive Areas	Land Cover	Variable	Other	Not Reported
Metropolitan Land Use Planning (4)	3/4		1/2	1/1	2/4	1/1	2/4	2/4		1/3	1/1	1/1	2/2	1/1	2/4	1/1		1/1	0/2	1/1	0/1	1/1	0/1	0/1	0/1	1/1			1/1	1/1			1/1	1/1	1
Regional Land Use Planning (5)	3/3		1/1	1/1	3/4	2/3	1/2	1/1				2/2	4/4	1/1	4/4			1/2	3/3	0/1	0/1	1/2	0/2	4/4	3/3	0/1	2/2	0/1			0/1	2/3	4/5		
Land Management (5)				1/1	3/4	4/4				3/3		3/3	4/5	3/3	4/5			2/2	3/3	3/4	1/1	3/3	1/1	4/5	3/4		2/3	4/5	1/2	0/1	2/3	3/4	4/5		
Mapping (6)			1/1	2/2	3/3	1/1	1/1		1/1	2/2	1/1	2/2	2/2		5/5	2/2			2/2	0/1		1/2		2/2						1/1		1/1	2/3		1
Environmental Protection (3)					1/1	1/1							1/1	3/3	1/1	1/1		1/1		0/1	0/1	2/2			0/1	1/1			1/1		0/1	1/1	1/1	1/1	
Resouce Planning and Management (14)				1/1	3/4	4/5				1/2	1/1	1/2	5/6	8/9	5/6	5/6	2	3/4	2/3	5/6		7/8	3/4	5/6	5/6		3/4	4/4	3/4	3/4	0/2	5/6	11/12	2/3	
Special Area Planning (2)				1/1	2/2	1/1	1/1					1/1	1/1	1/1	2/2			1/1		1/1	1/1	1/1			1/1		|				1/1		1/1	1/1	1
Other (11)	3/3	1/1	1/1	1/1	3/3	2/2	2/2	1/1	1/1	1/1	1/1	3/3	2/2	6/6	5/5	8/8	1	5/7	2/3	1/1	1/1	3/3	1/1	2/2	2/2	1/1	0/2	1/2	2/3	0/1	1/1	2/3	7/9	6/7	
Total (50)	9/10	1/1	4/5	8/8	20/25	16/18	7/10	4/6	2/2	8/11	4/4	13/14	21/23	23/24	28/32	17/18	3	14/18	12/16	11/16	3/6	19/22	5/9	17/20	14/18	3/4	7/11	9/12	8/11	5/8	4/9	14/18	31/37	11/13	3

Table A-8

Numerical Tabulation of Data Characteristics Reported and Desired by Each Type of System User

INTERPRETATION

Table cells give the number of recorded responses within each group. For questions with the optional choices of 'operating' and 'desired', the upper number is the number now operating and the lower is the sum of those 'operating' and 'desired'. The difference between the top and the bottom number is the number of desired but not operating characteristics. The total sample size is in parentheses.

BASIC RESPONSIBILITY OF RESPONDENT:		PLACE OF COVERAGE					SIZE OF COVERAGE (estimated when possible)								SOURCE OF DATA											PRECISION (a)					RESOLUTION (a)						
		Idaho	Oregon	Washington	Combination of Two Above	All	Greater than 100,000 sq. mi.	10,000 to 100,000 sq. mi.	1,000 to 10,000 sq. mi.	100 to 1,000 sq. mi.	10 to 100 sq. mi.	Less than 10 sq. mi.	Variable	Not Reported	Field Survey	Field Monitor	Published Surveys and Maps	Pre-encoded Data	Conventional Air Photography	Landsat	Other Remote Sensed Data	Interpretation of Other Data	Multiple	Other	Not Reported	High	Moderately High	Intermediate	Poor	Not Reported	Very Fine	Fine	Intermediate	Coarse	Very Coarse	Variable	Not Reported
Metropolitan Land Use Planning	(4)		2	2					1	2	1				2/3	1/1	3/4	2/2	1/2	1/1	1/1	1/1	3/4			1/1				3	2/3						1
Regional Land Use Planning	(5)		1	3		1		1	3				1		2/2		4/4	1/1		1/1	1/1		3/3		1	1/1				4		1/1	3/3				2
Land Management	(5)	1		2	1	1	3	1	1						3/3	1/1	2/2		2/2			1/1	2/3			1/1				4	1/1		2/2				2
Mapping	(6)		1	1		4	1		1				3	1	3/3		4/4		4/4				3/3	1/1	1		1/1			5		2/2	1/1				3
Environmental Protection	(3)			1		2	2	1							2/2	1/1	2/2		1/1				2/2			1/1				2			1/1				2
Resource Planning and Management	(14)	2	2	1	1	8	9	2	1	1	1				11/11	2/2	5/5	4/4	5/5	1/1	1/1	2/2	9/9				0/1			13			1/1	2/2	1/1		10
Special Area Planning	(2)	1			1				1	1							2/2	1/1	1/1			1/1	1/1							2				1/1			1
Other	(11)			3		8	8	1						2	3/3	3/3	7/7	4/4	1/1	2/2	1/1		8/8	1/1			1/1			10		1/2	1/1	3/3		1/1	6
Total	(50)	4	6	13	3	24	23	6	8	4	2		4	3	26/27	8/8	29/30	12/12	15/16	5/6	4/4	5/6	31/33	2/2	2	4/4	2/3			43	3/4	4/5	9/9	6/6	1/1	1/1	27

(a) Note: Explanation of the actual intervals represented by these nominal generalizations may be found in appendix 4.

Table A-9

Numerical Tabulation of Mapping and Geographical Referencing Characteristics Reported and Desired by Each Type of System User

INTERPRETATION

Table cells give the number of recorded responses within each group. For questions with the optional choices of 'operating' and 'desired', the upper number is the number now operating and the lower is the sum of those 'operating' and 'desired'. The difference between the top and the bottom number is the number of desired but not operating characteristics. The total sample size is in parentheses.

BASIC RESPONSIBILITY OF RESPONDENT	FORM OF THE LOCATION IDENTIFIER Grid	Polygon	GBF/DIME	Point	Line	External Index	Integrated	Unknown or Unreported	SCALE (a) Very Large	Large	Medium	Medium-Small	Small	Very Small	Variable	Not Reported	MAP PROJECTION Orthographic	Gnomonic	Lambert Azimuthal	Lambert Conformal	Albers	Polyconic	Mercator	Transverse Mercator	Multiple	Other	Not Reported	COORDINATE REFERENCE Latitude/Longitude	State Plane Coordinate	UTM Coordinate	Public Rectangular Survey	Arbitrary x,y	Multiple	Other	Not Reported
Metropolitan Land Use Planning (4)			1		1		2		2/3	3/3					2/2					1/2							2	1/1	3/4		0/1	1/1	1/2		
Regional Land Use Planning (5)	3	1					1			3/4		1/1			2/2							3/3					2	2/2	1/1	1/1	1/1	2/2	1/1		1
Land Management (5)	2	2		1						3/3	1/1	1/1			1/1	1				1/1		2/2					2	1/1	1/2		2/2	1/1	2/2		1
Mapping (6)	1				2			3	1/1	5/5	3/3	1/1	1/1		4/4	1				4/4				2/2	2/2		2	1/1	5/5	2/2	1/1		3/3		1
Environmental Protection (3)		1		1			1			1/1						2						1/1					2	2/2		2/2			1/1		
Resource Planning and Management (14)	4	2		3		3	2			4/5	4/5	2/3	3/3	1/1	7/8	3				2/2		1/1		2/3	3/3		7	7/7	3/3	3/4	1/1	1/1	3/3		1
Special Area Planning (2)	1		1									0/1			1/1	1						1/1					1	1/1	1/1						
Other (11)	3	1		4	2		1		2/2	1/2	1/1	1/1	1/1		3/3	6				1/1					4/4		6	8/8	3/3	2/2	1/1	1/1	3/3	1/1	
Total (50)	14	7	2	9	5	3	7	3	5/6	20/23	9/10	6/8	5/5	1/1	20/21	14				9/10		8/8		4/5	9/9		24	23/23	17/19	10/11	6/7	6/6	14/15	1/1	4

(a) Note: Explanation of the actual intervals represented by these nominal generalizations may be found in appendix 4.

Table A-10

Numerical Tabulation of Applications and Analyses Operating and Desired for Each Type of System

INTERPRETATION

Table cells give the number of recorded responses within each group. For questions with the optional choices of 'operating' and 'desired', the upper number is the number now operating and the lower is the sum of those 'operating' and 'desired'. The difference between the top and the bottom number is the number of desired but not operating characteristics. The total sample size is in parentheses.

SYSTEM TYPE:		TYPES OF APPLICATIONS																							TYPES OF ANALYSIS											
		Base Mapping	Resource Inventory	Land Classification	Modeling	Environmental Impact Assessment	Land Suitability Analysis	Critical Area Planning	Thematic Mapping	Trend Projection	Environmental Data Bank	Urban Data Bank	Cadastral Mapping	Route Selection	Site Selection	Land Use Allocation	Air Quality Management	Water Quality Management	Wildlife Management	Timber Management	Agricultural Production	Hazard Identification	Other	Not Reported	Proximity	Capacity	Optimum Location	Quality	Availability	Change	Development Constraints	Accessibility	Statistics	Cost	Other	Not Reported
Data Base Maintenance	(5)		4/4	1/1		1/1	1/1	2/2								1/1			1/1	2/2	1/1		1/1	0												1
Output Mapping - Image Production	(6)	3/4	2/2	0/1	0/1	1/1	0/1	1/1	1/1		1/1		0/1	0/1	0/1	0/2			0/1			1/1	1/1	1	1		1	1	1		1	1				2
Information Retrieval System - Point	(6)		2/2		4/4	2/2				2/2					1/1		1/1	2/2		1/1			1/2	0				1	1	1	1		1			2
Information Retrieval System - Fixed Grid	(7)	1/2	5/5	2/3	6/6	1/2	1/1	1/1	3/3	1/2	3/4	1/2		1/2	2/2	2/3	0/1	2/2	0/1	1/2	1/2	1/1		1		2	2		1	1	3	1	1			1
Information Retrieval System - Variable Boundary	(2)	1/1	0/1	0/1		0/1	0/1	0/1			0/1	0/1		0/1	0/1	0/1		0/1	0/1	0/1	0/1	0/1		1												1
Information Retrieval System - GBF/DIME	(2)	0/1	0/1		0/1	0/1		0/1		0/1		0/1		0/1		0/1							1/1	0												
Information Retrieval System - Combined	(8)	4/5	4/5	2/3	2/3	1/3	2/4	1/4	1/1	2/3	1/2	0/1	1/1	0/1	3/4	1/2				1/1		1/3	2/2	2	1				1		2	1			1	1
Integrated - Map Overlay	(6)	6/6	4/4	4/4	4/4	1/1	3/3	4/4	2/2	2/2	1/1	1/1		1/1	4/4	4/4		1/1	1/1	3/3	1/1	2/2	1/1	0	1	1	3	2	4	1	4	2	2	1		
Integrated - General Purpose	(2)		1/1	1/1	1/1			1/1			1/1					1/1				1/1				1	1		1	1					1			1
Digital Terrain Model	(1)	0/1																						0												
Other	(5)	2/3	2/3	2/3	2/3	1/1	1/2		2/2	0/1	2/3	0/2	0/1	0/2	1/2	1/1			0/1	1/1	1/1		2/3	0	2					2	1	1	2		1	1
Total	(50)	17/23	24/28	12/17	19/23	8/13	8/13	10/15	9/9	7/11	9/13	2/8	1/3	2/9	11/15	10/16	1/2	5/6	2/6	10/12	4/6	5/8	9/11	6	6	3	7	5	8	5	12	6	7	1		10

Table A-11

Numerical Tabulation of Data Handling Software Operating and Desired for Each Type of System

INTERPRETATION

Table cells give the number of recorded responses within each group. For questions with the optional choices of 'operating' and 'desired', the upper number is the number now operating and the lower is the sum of those 'operating' and 'desired'. The difference between the top and the bottom number is the number of desired but not operating characteristics. The total sample size is in parentheses.

	Editing				Spatial Rectification						Measurement				Sorting/Merging						Comparison						Graphic Output					Other		
SYSTEM TYPE: / SOFTWARE	Identify and Correct Closure	Identify and Correct Slivers	Data File Update	Labeling	Removing Map Distortion	Line Generalization	Modify Alignment	Scale Change	Projection Change or Coordinate Conversion	Location Identifier Conversion	Linear Measurement	Area Measurement	Direction Determination	Centroid Determination	Selective Retrieval - Geographic	Selective Retrieval - Descriptor	Edge Matching	Create New Files	Integrate from Remote Files	Contouring	Overlay - Union	Overlay - Intersection	Value Weighting	Modeling	Statistical Analysis	Extreme Value Search	Zooming	Diagram and Chart Display	Lettering	Shading	3D	Digital Relief Analysis	Landsat Data Analysis	Not Reported
Data Base Maintenance (5)			1/1					1/1	2/2	1/1		1/1		1/1	3/3	3/3		1/1			1/1				1/1	1/1								1
Output Mapping - Image Production (6)	4/4	2/2	4/5	4/4	5/5	3/3	4/4	4/5	4/6	1/1	3/4	4/5	2/2	1/1	4/5	3/4	3/5	4/5		6/6	3/5	3/4		1/1	1/2	1/1	4/4	4/4	5/5	2/2		1/1		
Information Retrieval System - Point (6)			1/1	2/2				1/1	1/1	1/1		0/1			4/4	5/5		3/3							2/2		2/2	1/1	2/2	1/1	2/2			1
Information Retrieval System - Fixed Grid (7)	0/2	0/1	1/4	1/3		0/2	1/1	1/2	2/3	3/5	2/3	2/4	0/2	1/2	4/6	5/7	2/5	2/3	1/2	0/2	2/4	2/3	2/3	3/4	1/3	1/1	1/2	0/1	2/2	0/1	0/1	4/5	0/1	
Information Retrieval System - Variable Boundary (2)	1/2		1/1	1/1	0/1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	0/1	0/1	1/2	1/2	1/2	1/2	0/1	0/1	1/2	0/1	0/1	0/1	1/2	0/1	0/1	0/1	1/2	1/2	0/1	0/2		
Information Retrieval System - GBF/DIME (2)	0/1	0/1	0/1	0/1		0/1	0/1	0/1	0/1	0/2	1/2	0/2		0/2	1/2	1/2	0/2	0/2	0/1	0/2	1/2	0/2	0/1	0/1	0/2	0/1	0/1	0/2	0/1	0/2	0/1	0/1	0/1	
Information Retrieval System - Combined (8)	2/2	3/3	6/6	3/3	1/2	2/2	1/1	5/7	3/5	4/4	2/3	4/5	2/3	2/3	8/8	8/8	3/4	4/5	2/2	5/6	5/7	3/4	1/3	1/1	4/7	2/3	4/5	3/3	6/7	1/3	1/1	2/2		
Integrated - Map Overlay (6)	4/4	5/5	5/5	5/5	5/6	4/4	4/4	6/6	5/5	1/1	5/5	6/6		2/2	6/6	6/6	5/5	6/6	0/1	5/5	6/6	6/6	1/1	2/2	3/3	2/2	3/4	4/4	5/6	2/3	0/1	1/3	0/1	
Integrated - General Purpose (2)	1/1	0/1			1/1	0/1		1/1	1/1	0/1	1/1	1/1	0/1	0/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	1/1	0/1	0/1	1/1	0/1	1/1	1/1			1/1	1/1	1/1	1
Digital Terrain Model (1)	0/1	1/1	0/1		1/1			1/1	1/1	0/1					0/1	0/1	0/1	0/1			0/1	0/1			1/1	1/1						1/1		
Other (5)	4/4	1/1	2/3	4/4	3/3	2/2	2/2	4/4	3/4	4/4	2/3	3/3	1/1	2/2	5/5	5/5	2/2	4/4	1/1	3/3	5/5	3/3	1/1	1/1	1/1	2/2	2/2	2/2	4/4	3/3	1/2	2/3	2/2	
Total (50)	16/21	12/15	21/28	20/23	16/19	12/17	13/15	25/31	23/31	16/23	17/23	22/30	5/10	9/15	37/43	38/44	17/27	26/33	5/9	20/26	25/34	18/25	5/11	8/12	16/25	10/14	17/22	15/19	25/29	10/17	5/10	12/19	3/6	3

GLOSSARY

Algorithm: A computer-oriented procedure for resolving a problem.

Alphanumeric: A character set composed of letters, integers, punctuation marks, and special symbols. Used to differentiate digital (number) coding from descriptor coding.

Ancillary Data: Additional, supplemental data.

Application: Those operating activities which share procedures, data requirements, and the like, or among which data flows and is controlled by a series of steps.

Attribute: A descriptive characteristic of a data record, or a descriptive feature used for evaluation or description.

Automation: The entire field of investigation, design, development, application, and methods of rendering processes or machine self-acting or self-moving.

Base Map: Map used as a primary source for compilation or as a framework on which new detail is printed.

Batch Processing: A method whereby items are coded and collected into groups and then processed sequentially.

Conversationally Directed Query (User Friendly): The use of English language instructions to direct the operation of the computer and the manipulation of data.

Coordinate: An ordered set of data values, either absolute or relative, which specifies a location.

Coordinate Reference: The method of geocoding whereby the location identifier is represented as a point defined by the intersection of perpendicular lines in a grid. Location of any point can be determined by a defined direction or distance from a known starting point.

Coverage: A single partitioning of a region into nonoverlapping zones. Areas of like characteristics separated by networks of lines.

Data: One or more characteristics which, of themselves and in their arrangement, represent one recording about a subject.

Data Base: A set of data files or data records (including maps) organized in such a manner that retrieval and updating can be done on a selective basis and in an efficient manner. A collection of discreet data observations located in or on some physical medium and arranged in a way that there is an underlying organization or structure.

Data File: A collection of data records; data set.

Data Format. (also configuration): The spatial representation of the data form, specifically point, line, grid, or irregular polygon.

Data Handling: The collective operations of data acquisition, changing the data to useful formats, storing data in or on some medium, and retrieving and manipulating data to display and analysis.

Data Manipulation: Operations that are performed on data to make them more suitable for further processing; to improve their comparability, facilitate their retrievability, etc.

Data Record: Registered evidence of data observation. The representation of a single datum in a computer.

Data Retrieval: Reading data items off of media with their geographic location identifiers.

Data Series: A sequential and long-standing compilation of data in a predetermined and commonly accepted format usually the result of a data collection program. Examples of data series are: SCS soils maps, USGS water sampling records, etc.

Data Set: A collection of data records; data file.

Data Structure: The method used to link the descriptor and the image portions of the data in computer storage.

Data Transfer: Process of moving data from one medium (document) to another. May take place at any time during data processing.

Data Volume: The number of separate data items or variables recorded.

Datum: One or more characteristics which, of themselves and in their arrangement, represent one recording about a subject.

Decision Variable: An issue of system design that leads to ultimate system specification. Two types are recognized: data decision variables and system decision variables. Data decision variables include issues of scale, precision, data type, and data format. System decision variables include response time, degree of automation, mode of user interaction, etc.

Digital: The representation of a quantity in terms of a number code.

Digitizer: A device which converts graphically represented cartographic data into machine-readable form.

Digitizing: The process whereby an analogue value such as a position in space is converted to digital coordinates.

Derived Analysis: The use of data interpretations rather than the primary data themselves to produce interpreted inferences about the conditions or areas being evaluated. An example is the creation of suitability evaluations.

Descriptor Data: The catalog, thematic part of a digitally stored data record. (Also called an attribute.)

Editing: Editorial treatment and correction of the data obtained in digitizing.

Encoding: The conversion of signals or alphanumeric symbols into a coded digital format suitable for subsequent processing.

Environmental Data: A subset of spatial data which defines naturally occurring characteristics and entities.

Explicit Reference: A geocode whereby the actual spatial configuration of the location identifier is maintained.

Geocoding: The geographic coding of the location of data items. The use of a code to represent the geographic position of a record or event in lieu of its being plotted on a map.

Geographic Base File: A coded network of coordinates representing the spatial interrelationships of the data base in a computer record.

Geographic Information System: Synonymous with spatial data handling system. Also used to describe a special type of computerized geoprocessing system that has the capability to encode data from different sources and formats, the capability of treating each as a separate "layer" for graphic and logical combination, the ability to respond to ad hoc inquiry, and the ability to output data by various mediums.

Geoprocessing (Geographic Data Processing): The series of operations performed on or with spatial data in the translation to its ultimate product. Usually refers to digital spatial data handling operations.

Graphic Line Reproduction: The ability to re-create line images from digital records.

Ground Truth: Positional accuracy measured between the earth's surface and the graphic reduction of the surface.

Hardware: The physical components of a computer and its peripheral equipment.

Image: The visual representation of spatial form on an output device.

Implicit Reference: A geocode whereby the location identifier is represented by a code or symbol which does not maintain the integrity of spatial form.

Information System: An organized and systematic structure or set of procedures, equipment, and personnel supporting the storage, processing, analysis, and output of meaningful data.

In-House Programming: The writing of software by the system designing agency as opposed to acquiring software from a vendor.

Input: Information or data transferred or to be transferred from an external storage medium into the storage medium of the system.

Interactive: A method of operation that allows instantaneous, man-machine communication. May be used for data entry, editing, or to direct the course of a program.

Intersection: Region containing all the points common to two regions.

Landsat: The commonly accepted term for the earth resources investigation satellite, and the technical development program and data application programs associated with it.

Layer: The combined digital and alphanumeric file representing a coverage of a single data type over the subject area.

Location Identifier: A code representing a location or a geographical place which is used to describe that place in an external record. Also called a geocode and a geographic identifier.

Map Projection: Any systematic arrangement of meridians and parallels portraying the curved surface of the sphere or spheroid upon a plane.

Medium: A means or a physical device upon which or within which data are stored and transmitted (i.e., disc, map, tape).

Memory: An organization of data storage units in a computer.

Nominal: As a measurement scale, distinguishes things only on the basis of their intrinsic character.

Ordinal: As a measurement scale, distinguishes things on the basis of rank by some quantitative measure.

Orthophotograph: Copy of a perspective photograph from which distortion due to tilt and relief have been removed.

Output: Information, data, or other results of a computer operation which are recorded on some external storage device.

Overlay: Map of an area to be superimposed on one or more maps of the same area. The purpose is to find data combinations, or more exactly, intersections and unions.

Parameter: Variable that is specified for the duration of some calculation.

Peripheral Device: A device connected to a computer to provide communication or auxiliary functions (e.g., terminal, printer, plotter, digitizer).

Plotter: An 'x, y' mechanism controlled by a computer generally for the recording of location information, e.g., symbols, names, etc. Line drawing may also be carried out but units capable of high accuracy line drawings usually are referred to as drafting units. Lines are drawn as a series of vectors.

Polygon: Plane figure consisting of three or more vertices (points) connected by line segments or sides. The plane region bounded by the sides of the polygon is the interior of the polygon.

Primary Data: Data collected directly from a source platform or by a source method without undergoing generalization or transformation.

Ratio: As a measurement scale, distinguishes things on the basis of magnitudes that are intrinsically meaningful by use of a nonarbitrary zero point.

Remote Sensing: Obtaining information about an object or phenomenon without direct contact.

Secondary Data: Data recorded or interpreted from a primary source ~~and~~ placed on or in a different medium.

Spatial Data: Data which carry an explicit or implicit location identifier and can be referenced geographically by the location identifier.

Spatial Data Content: The descriptive portion of the spatial data record; the descriptor.

Spatial Data Entities: The spatial locator portion of the spatial data record.

Spatial Data Integration: The process of combining multiple spatial data sets and providing for their storage, retrieval, analysis and display.

Software: Programs used to control the operation of computers.

Thematic: Of or related to a theme or special classification.

Transferable: The ability to convey from one source or storage medium to another. May be transmitted directly or indirectly and may go through several changes in structure or appearance.

User: Any individual agency or division for which interest in the use of spatial data is implied.

User Friendly: Direction of the operation of the computer through the use of English language commands.

User Programs: Simplified computer programs designed to be used by nonprogrammer users and usually designed to facilitate the repetition of a series of closely related operations.

BIBLIOGRAPHY

I. *Overview of Spatial Data Handling*

Adams, Victor W. *Earth Science Data in Urban and Regional Information Systems: A Review.* U.S. Geological Survey Circular No. 712, 1975.

Calkins, Hugh West. "An Information System and Monitoring Framework for Plan Implementation and the Continuing Planning Process." Ph.D. dissertation, University of Washington, 1972.

Calkins, H. W., and Tomlinson, R. G. *Geographic Information Systems, Methods, and Equipment for Land Use Planning.* Ottawa: International Geographical Union Commission on Geographical Data Sensing and Processing, for the United States Geological Survey's Resources and Lands Investigations Program, 1977.

City of Des Moines. "Geoplanning Research Program - Systems Conceptualization Task 2 Report." Des Moines: City of Des Moines, 1973.

COMARC Design Systems. *A Workbook for a Course on the Successful Application of a Geobased Information System.* San Francisco: COMARC Design Systems, 1978.

Dueker, Kenneth, and Horton, Frank. "Urban Change Detection Systems in Urban and Regional Planning." Iowa City: Institute of Urban and Regional Research, University of Iowa, undated.

Dueker, Kenneth, and Horton, Frank. "A System Design Model for a Statewide Land Information System." Iowa City: Institute of Urban and Regional Research, University of Iowa, undated. (Photocopy.)

Dueker, Kenneth, and Talcott, Richard. "State Land Use Planning Process Issues: Geographic Information System Implications." Iowa City: Institute of Urban and Regional Research, University of Iowa, 1975.

Gordon, Kenneth. "Environmental Data Handling in Geographic Information Systems: An Evaluation Based Upon a Study of Applications in the Pacific Northwest States." M.S. thesis, Western Washington University, 1979, ch. 2, 3, and Appendix 4.

Honeycutt, Dale; Brooks, Kristina; and Kimmerling, A. Jon. *Geographic Information Systems: A Review of Selected Operational and Functional Capabilities.* Geography Department, Oregon State University for the Oregon Department of Forestry, 1980.

Kennedy, Michael, and Guinn, Charles. "Avoiding Systems Failure: Approaches to Integrity and Utility." Louisville, KY: Urban Studies Center, University of Louisville, 1975.

Kennedy, Michael, and Meyers, Charles R. *Spatial Information Systems: An Introduction.* Louisville, KY: Urban Studies Center, University of Louisville, 1977.

Muehrcke, Phillip. *Thematic Cartography.* Washington, D.C.: Association of American Geographers. Resource Papers for College Geography No. 17, 1972.

Peucker, T. K. *Computer Cartography.* Washington, D.C.: Association of American Geographers. Resource Papers for College Geography No. 17, 1972.

Redekop, David A. "A Theoretical Discussion and Empirical Description of Information System Design." M.A. thesis, University of Washington, 1974.

Schneider, Devon and Amanullah, Syed. *Computer-Assisted Land Resources Planning.* Chicago: American Planning Association, Planning Advisory Service Report #339, sponsored by the United States Geological Survey's Resource and Land Investigations (RALI) Program, 1979.

Shelton, Ronald L., and Hardy, Ernest. "Design Concepts for Land Use and Natural Resource Inventories and Information Systems." Ithaca, N.Y.: Resource Information laboratory, Cornell University, 1974. Prepared for the 9th International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, 1974. (Photocopy.)

System Development Corporation. *Urban and Regional Information Systems: Support for Planning in Metropolitan Areas.* For Department of Housing and Urban Development, 1968.

Tomlinson, R. F. "Geo-Information Systems and the Use of Computers for Handling Land Use Information." Ottawa: IGU Commission on Geographical Data Sensing and Processing, 1971.

Tomlinson, R. F., ed. *Environment Information Systems.* The Proceedings of the UNESCO/IGU First Symposium on Geographical Information Systems. Ottawa: IGU Commission on Geographical Data Sensing and Processing, 1970.

Tomlinson, R. F., ed. *Geographical Data Handling.* Symposium ed., 2 vol. Ottawa: IGU Commission on Geographical Data Sensing and Processing for UNESCO/IGU Second Symposium on Geographic Information Systems, 1972.

Tschanz, J. F., and Kennedy, A. S. *Natural Resource Management Information Systems: A Guide to Design.* Argonne, Ill.: Argonne National Laboratory, 1975.

Wellar, Barry S., and Graff, Thomas O. *Geographic Aspects of Information Systems: Introduction and Selected Bibliography.* Council of Planning Librarians Exchange Bibliography 316-317. Monticello, Ill.: Council of Planning Librarians, 1972.

II. *Spatial Data Characteristics and Data Decision Variables*

Computer Sciences Corporation, CSC/JM-79/6242. Spatial Data Integration vol. I: Concepts, Requirements and Current Capabilities, E. Knapp, et al., for NASA-Goddard Space Flight Center, 1979.

Dangermond, Jack. "A Classification and Review of Coordinate Identification and Computer Mapping Systems." In *The Proceedings of the Tenth Annual URISA Conference* (1972). Claremont, CA: Claremont College Printing Service, 1973.

Dueker, Kenneth J. "Geographic Data Encoding Issues." Iowa City: Institute of Urban and Regional Research, University of Iowa, 1975.

Dueker, Kenneth, and Noynaert, Evan. "Interactive Digitizing, Editing and Mapping: Software and Data Structure Considerations." Iowa City: Institute of Urban and Regional Research, University of Iowa, 1977.

Gale, L. A. "Recommendations on the Type of Coordinate System for Correlation of Files in a Data Bank System." *Canadian Surveyer,* vol. 23 (1969).

Greenhood, David. *Mapping.* Chicago: University of Chicago Press, 1975.

Meneley, G. Joseph. "Place Coding: Inventory, Analysis and Recommendations." Iowa City: Institute of Urban and Regional Research, University of Iowa, 1976.

Moyer, D. David, and Fisher, Kenneth Paul. *Land Parcel Identifiers for Information Systems.* Chicago: American Bar Foundation, 1973.

North American Institute for Modernization of Land Data Systems. *Proceedings of the North American Conference on Modernization of Land Data Systems (A Multi-Purpose Approach).* Washington, D.C.: North American Institute for Modernization of Land Data Systems, 1975.

Peucker, T. K., and Chrisman, N. "Cartographic Data Structures." *American Cartographer,* vol. 2, no. 1 (April 1975): 866-889.

Robinson, Arthur H., and Sale, Randall D. *Elements of Cargography.* 3rd ed. New York: J. Wiley and Sons, Inc., 1969.

Sinton, David. "The Inherent Structure of Information as a Constraint to Analysis: Mapped Thematic Data as a Case Study." In *Proceedings of the Advanced Study Symposium on Topological Data Structures for Geographic Information Systems.* Symposium ed. Cambridge, Mass.: Laboratory for Computer Graphics and Spatial Analysis, Harvard University Graduate School of Design, 1977.

Steward, H. J. *Cartographic Generalization, Some Concepts and Explanations.* Cartographica Monograph, No. 10. Toronto: University of Toronto Press, 1974.

Trewartha, Glenn T.; Robinson, Arthur H.; and Hammond, Edwin H. *Elements of Geography.* 5th ed. New York: McGraw-Hill Book Co., 1967.

Werner, Pamela A. *Survey of National Geocoding Systems.* Cambridge, Mass: Urban Systems Laboratory, Massachusetts Institute of Technology. Prepared for the U.S. Department of Transportation, 1974.

Ziemann, Hartmut. *Land Unit Identification - An Analysis.* Ottawa: National Research Council of Canada, 1976.

III. *Surveys of Systems, Data, and Data Handling*

Brooks, Kristina. *Requirements for a Statewide Geographic System: A Survey of Agency Data and Analytical Needs.* Geography Dept., Oregon State University for the Oregon State Dept. of Forestry, 1980.

Computer Sciences Corporation. CSC/TR-73/6019. *Landsat and Ancillary Data Inputs to an Automated Geographic Information System: Applications for Urbanized Area Delineation.* E. Knapp et al., for NASA-Goddard Space Flight Center, 1978.

The Council of State Governments. *Environmental Resources Data, Intergovernmental Management Dimensions.* Louisville, KY: Council of State Governments, 1978.

The Council of State Governments. "Land Use Policy and Program Analysis Report No. 2 - Data Needs and Resources for State Land Use Planning." Lexington, KY: Council of State Governments, 1974.

Gordon, Kenneth. "An Investigation of Digital Geographic Data Handling Activities and Digital Environmental Data Coverage in the Pacific Northwest." For NASA-Ames Research Center under University Consortium, NCA2-OR862-801, 1978.

Gordon, Kenneth. "Environmental Data Handling in Geographic Information Systems: An Evaluation Based Upon a Study of Applications in the Pacific Northwest States." M.S. thesis, Western Washington University, 1979.

IGU Commission on Geographical Data Sensing and Processing. *Computer Software for Spatial Data Handling.* Ottawa, Canada, 1976a.

IGU Commission on Geographical Data Sensing and Processing. *First Interim Report on Digital Geographic Data Handling Activities in the USGS.* Prepared under a grant from the USGS, 1976b.

Mutter, Douglas, and Nez, George. *Computer Mapping in the West - Results of a Survey.* Denver: Federation of Rocky Mountain States, 1977.

National Aeronautics and Space Administration. "Land Resource Inventory Demonstration Project." Informational Brochure published by the U.S. Government Printing Office, 1979.

National Council of State Legislatures. *Final Report of the Task Force on Uses of Satellite Remote Sensing for State Policy Formulation.* Denver: NCSL, 1976.

Power, Margaret A. *Computerized Geographic Information Systems: An Assessment of Important Factors in Their Design, Operation, and Success.* St. Louis: Center for Development Technology, Washington University, under grant NAS-5-20680 from NASA, 1975. Publication of M.A. thesis.

Tarrant, John R., ed. *Computers in Geography.* Norwich, England: Geo Abstracts, Ltd., School of Environmental Sciences, University of East Anglia, 1970.

Tarrant, John R., ed. *Computers in the Environmental Sciences.* Norwich, England: Geo Abstracts, Ltd., School of Environmental Sciences, University of East Anglia, 1972.

Tomlinson, R. F.; Calkins, H. W.; and Marble, D. F. *Computer Handling of Geographical Data: An Examination of Selected Geographic Information Systems.* Paris: UNESCO Press, 1976.

Salmen, Larry, et al. *Survey of Alternative Geographic Data Base Covering Montana and Wyoming.* Ft. Collins, Colorado: Information Systems Technical Laboratory, Federation of Rocky Mountain States, 1977a.

Salmen, Larry, et al. *User Needs Assessment Forms for an Operational Information System Within the U.S. Fish and Wildlife Service - Region 6.* Ft. Collins, Colorado: Information Systems Technical Laboratory, Federation of Rocky Mountain States, 1977b.

Westerland, Frank, and Wilson, Donald. "Final Report, Phase IV User Needs Study." Unpublished report prepared for the Pacific Northwest Regional Commission's Land Resources Inventory Demonstration Project under NASA-Ames University Consortium Interchange Agreement NCA-OR850-701, 1977.

Wilson, Paul M. "Resource Information Systems in California Local Government." For the Environmental Data Center, State of California, 1978.

IV. *Remote Sensing*

Bay, Sally M. *Final Report and Recommendations of the National Conference of State Legislatures' Task Force on Uses of Satellite Remote Sensing for State Policy Formulation.* Denver: National Council of State Legislatures, August 1976.

Hedrick, W., et al. "Landsat - Pacific Northwest Area Using Satellite Data for Planning, Resource Management." *Practicing Planner* (December 1976): 18-25.

Reeves, Robert G., ed. *Manual of Remote Sensing.* 2 vols. Falls Church: American Society of Photogrammetry, 1975.

Sabins, Floyd F. *Remote Sensing, Principles and Interpretation.* San Francisco: W. H. Freeman and Co., 1978.

Short, Nicholas M.; Lowman, Paul D.; and Freden, Stanley C. *Mission to Earth: Landsat Views the World.* Washington, D.C.: National Aeronautics and Space Administration, 1976.

Westerlund, Frank. "Modes of Application of Remote Sensing Technology and Media to Urban and Regional Planning, with Emphasis on Surface Classification and Alternative Problem-Oriented Approaches." Ph.D. dissertation, University of Washington, 1977.

Westerlund, Frank V. "Land Use Analysis for Urban Areas," Ch. 6 of Ford, Kristina, ed. *Planning Applications of Remote Sensing.* Unpublished draft.

V. *Reference*

Graphics Glossary Committee, Integrated Systems Division, Share, Inc. "Computer Graphics Glossary." Houston: American Congress of Surveying and Mapping/SIGGRAPH (1970).

International Cartographic Association. "Automation Terms in Cartograpy." English ed. Washington, D.C.: American Congress of Surveying and Mapping, 1973.

Nie, Normal, et al. *Statistical Package for the Social Sciences*. New York: McGraw-Hill Book Co., 1970.

Rosenberg, Paul, et al. *Digital Mapping Glossary*. Prepared by Keuffel and Esser Co., for U.S. Army Engineer Topographic Laboratories, For Belvoir, VA, 1974.

VI. *Personal Communications*

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