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STATE ENVIRONMENTAL MANAGEMENT:
INFORMATION SYSTEMS FOR RESOURCE PLANNING

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ABSTRACT

Two major objectives were identified at the beginning of the thesis. The first was to examine recent trends in state planning, focusing on environmental and natural resource management programs. Numerous planning initiatives, both internally developed programs and those established in response to federal mandates were identified. Mechanisms employed by states, largely to coordinate the proliferation of resource planning and management programs, were discussed. The state planning process as it pertains to land and resource management was presented. The role of data and information in planning and program coordination was examined.

The second objective was to provide an overview of computerized data and information management systems utilized by states in environmental resource programs. A framework for the evaluation of state information systems was constructed that consisted of institutional factors, integration of satellite remote sensing technology, and coordinated system utilization. The issues surrounding these evaluation criteria were discussed. Case studies of four state environmental resource information systems were presented and an evaluation of each system was made based upon the pre-determined set of criteria.

The general conclusion of the research was that state governments have developed computerized techniques for the collection, analysis, and distribution of data in support of environmental resource programs. It was found that satellite remote sensing was being utilized for a limited number of program applications and that information

systems can provide focal points for coordination of both resource data and resource management programs. It was also found that certain institutional considerations are critical to the successful implementation of a state environmental resource information system.

Recommendations were made to strengthen the ability of states in resource planning through improved information management and coordination.

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CHAPTER I

INTRODUCTION

This thesis examines the planning and management of environmental resources¹ by state governments using spatially-oriented, computerized information and data systems. The study concentrates on current and potential future developments in the integration and coordination of environmental resource data to meet the requirements of state programs. To provide a proper framework for the study, a summary of recent trends in federal and state land use planning and environmental controls will be presented.

I. PROBLEM DEFINITION

The first half of the 1970s marked a period of unprecedented activity by state governments to become directly involved in land use decisions. States began to exercise those regulatory powers that had been traditionally passed on to local governments. Using such phrases as "critical areas" or "areas of greater than local concern," a number of states established a land development control process. Oregon, Florida, Vermont, Maine, and Minnesota provided notable examples of this newfound attention to state planning and development controls.

The second half of the decade witnessed a reversal of this

¹The term "environmental resources" as used in this thesis encompasses those program activities in environmental protection, e.g. air, water quality or solid waste, and in natural resource management, such as forestry, fish and wildlife or water resources.

trend and an apparent decrease in state-initiated land development controls. It has been noted that the term "state land-use planning" has gone out of fashion.² In recent surveys of state planning directors, responses indicated that 24 states had not contemplated a statewide land classification³ and that nearly 70 percent of the states were moving away from a state comprehensive plan approach.⁴

On the surface it appears that state land-use planning has diminished in importance and been replaced perhaps with the more immediate concerns of reduced government spending. A closer look, however, reveals that a shift has occurred in which federal legislation has prompted states to conduct process oriented planning for specialized regulatory programs. "Environmental control legislation increasingly requires the preparation of a plan or planning policy at the state level which serves as the basis for state development controls in environmentally threatened areas."⁵

These federal programs, and the statutes which authorize them, have titles which make no mention of "land-use." Yet the planning and regulatory processes conducted under these various titles are creating

²Mike Miles and Richard Mann, "Impact of Federal Programs on State Land-Use Planning," State Planning Issues, Summer 1978, p. 33.

³Miles and Mann, "State Land Use Planning: The Current Status and Demographic Rationale," Journal of the American Planning Association, January 1979, p. 56.

⁴Tilden J. Curry, "Relevance of a State Comprehensive Plan: Attitudes of State Planners," State Planning Issues, Summer 1978, p. 29.

⁵Daniel R. Mandelker, Environmental and Land Use Controls Legislation (Indianapolis: Bobbs-Merrill Company, 1976), p. 35.

a new and stronger role for states in land management. "If these trends in federal initiatives continue, the determination for intergovernmental responsibility in planning and land development control programs will largely be shifted to the states. . . ."6

In assuming responsibility for management of resources, states must act to effectively coordinate their environmental and natural resource programs. A key element in this coordination is information and data handling. Increased state participation in the planning and regulation of environmental resources has led to a demand for the collection and use of a variety of data. Environmental activities have increased the number of agencies with a need for natural resource data, as well as expanding the volume of the data and the level of detail necessary for analysis. New demands for accurate, relevant, and timely information have created problems in acquisition and use. Difficulties have often resulted in the unavailability of data, delays and duplication in data collection, inefficient use of manpower and fiscal resources, and improper methods to index, store and disseminate data. As a consequence, the capacity of states to implement environmental programs, and achieve national objectives, has been hampered.⁷

Many of the problems states are experiencing with the management of natural resource information can be attributed to an absence of effective coordination and a lack of knowledge of the tools available. These are issues to be addressed on both interstate and intra-

⁶Ibid., p. 396.

⁷Council of State Governments, Environmental Resource Data: Intergovernmental Management Dimensions (Lexington, Ky.: 1978), p. 1.

state levels. Personnel directly responsible for planning and implementation of specific environmental/natural resource programs are often unaware of management techniques being successfully applied in adjacent states--states having problems very similar in nature. Technicians charged with the development of complex and costly computer methods for data processing may do so without the knowledge that others, often in the same state, are pursuing a like objective. In short, staff time and effort is being unnecessarily spent on duplicative functions.

More apparent are the institutional problems that exist between policymakers and technicians. The program manager and immediate staff are well versed in the requirements for state compliance under a given federal law. However, the agency administrator and the elected official who must make decisions about appropriations, political viability and public acceptance of a potentially controversial program are often ill-informed about the consequences of delay or non-compliance. This gap between technician and decision-maker surfaces frequently with respect to data management issues. Proposals to develop consolidated, computerized natural resource information systems commonly fail to receive administrative level approval. Coordination of environmental/natural resource programs within a state is virtually impossible without an agreed-upon source of baseline data which enables program compatibility.⁸

In addition to problems of interagency coordination and intra-

⁸Leonard U. Wilson and L.V. Watkins, State Planning: Intergovernmental Policy Coordination (Lexington, Ky.: Council of State Governments, 1976), p. 37.

agency communication, other issues directly impact state data management efforts. The organizational location of a mechanism for information coordination is often critical to the success of state data management. Involvement and commitment of legislative and executive branches of state government in the creation of a data management scheme may help ensure user acceptability. Ongoing evaluation of user needs could assist in maintaining the effectiveness of the information system. Federal agencies may play a key role in the development of the states' capacity to better manage environmental resource data.

II. DESCRIPTION OF THE STUDY

This thesis is an examination of the issues in state environmental resource data management and an identification of the planning context in which information needs currently exist. Various research methods will be employed in combination to document institutional and policy considerations that surround state use of environmental resource information. The experiences of four states in utilizing new technologies for resource management will be described in detail. The performance of states will be evaluated and recommendations for improved data handling will be made.

The thesis will contain two basic descriptive elements. Chapter II is an examination of recent state land use planning trends. The impact of federally mandated environmental controls and federal-state cooperative programs will be discussed. The purpose of this review is to establish a state planning framework based on current directions within the 50 states. The states' response to increased federal atten-

tion to environmental protection and natural resources will be described.

The second element is a description of state activity in data management efforts that support the previously discussed environmental resource programs. This will be presented in Chapter III. The information needs of state resource planning will be briefly addressed, and problems relating to collection and use of data will be explored. Primary to this discussion is the rationale for coordinated information management and mechanisms being employed by states to facilitate interagency cooperation. The use of environmental resource information systems as a concept for centralized data handling will be examined. A discussion of the salient features of computerized information systems will be undertaken to construct a framework which will be used in later chapters to evaluate actual state experiences and to develop recommended approaches for improved data management.

This chapter will examine the use of a new technology, satellite remote sensing, to determine if integration of federally developed data systems within a state data management scheme has occurred. State perspectives on the utility of satellite-derived data will be presented. Other recent initiatives in federal/state data coordination will also be described.

In Chapter IV, the study will examine the actions taken by four states (Arizona, Georgia, North Dakota and Texas) in environmental resource data coordination and in the integration of Landsat, satellite remote sensing into a computerized information system. The opportunities for and constraints to state use of this federally developed technology within a land-use planning framework will be examined. These case studies, conducted by on-site interviews, will highlight many institutional issues surrounding environmental resource information systems use. The detailed analysis will seek to determine if new

technology has been successfully applied, what factors program managers consider with respect to data management, if Landsat technology has stimulated improvements in data handling, and to what extent satellite data has become an integral part of ongoing state data requirements. An analysis of the case study findings will be performed to identify each state's accomplishments and shortcomings in information system development and its impact upon resource planning and management programs.

The conclusions and recommendations of this research will be presented in Chapter V.

III. METHOD

The methodology for this thesis consisted of the following components:

Literature Review. A reconnaissance of recent publications was performed to provide the author with a conceptual framework for the study. The literature search examined trends in state land use planning and environmental resource data management.

Descriptive Research. An evaluation of current environmental resource information management activities, issues and problems was conducted. This research identified coordinating mechanisms and new technologies being utilized by the states. This research method was based on discussions and interviews with numerous state and federal officials conducted by the author over the past eighteen months. Because of the author's extensive work experience in resource data management, portions of this thesis contain generalized statements that would, under normal circumstances, require a citation. These statements, however, represent information acquired from and confirmed by varied sources; they are considered general knowledge in the

field, and therefore, do not lend themselves to specific reference.

Strategy Development. Based on the survey of literature and descriptive research components, a set of issues that surround the successful implementation of an environmental resource information system were developed. These largely institutional considerations provided a foundation for the case study examinations.

Case Studies. Arizona, Georgia, North Dakota and Texas--states having operational environmental resource information systems--were examined by the author in site visits. The development of each system was traced and the integration of Landsat data analysis capability was explored. An evaluation of each system based upon the strategies developed for its effectiveness was performed.

IV. PURPOSE

The research documents state activity in environmental resource data management. The need for a coordinated approach to information collection, maintenance, and use is established. Data management is treated as an integral element to effective environmental and natural resource programs, which in turn reflect state land use policy. In-depth investigations of four states are utilized to illustrate the various techniques available for improved data management. The author's working relationship with the 50 states provides nationwide perspectives on environmental resource priorities and data management issues.

Two major objectives guide the research effort: first, to identify recent trends in state planning with respect to environmental resource data management, and; secondly, to provide multi-state information about data

management methods that can be shared by elected officials, administrators, program managers, and technicians. It is felt that other states can benefit from the knowledge and understanding developed by a few, thus creating the potential for improved capabilities, efficiency, and decision-making in land management.

It is the aim of this research to examine the policy decisions, inter-governmental cooperation and institutional structure necessary for states to carry out an effective data and resource management strategy. The effort is not an examination of the technical aspects of computerized information systems or satellite remote sensing technology. The results of this research should be of interest to a broad range of state personnel: planners, technicians, and policy makers. It seeks to establish linkages between these groups plus allow for interaction among states to achieve environmental objectives.

CHAPTER II

STATE LAND USE PLANNING AND ENVIRONMENTAL CONTROLS

I. RECENT STATE LAND USE PLANNING TRENDS

Historical Background

Although not formally recognized as such, states have been engaged in planning activities since their inception. Wilson and Watkins contend that "modern state planning has evolved out of a long history of state attempts to stimulate growth or to manage growth in a manner beneficial to state constituents."¹ In the nineteenth century, state government investment in the construction of canals and railroads required planning to mobilize resources for these massive public works projects. The twentieth century saw state planning move toward management and conservation with some few states recognizing the relationship between planning and economic development.

Out of the Depression came the National Planning Board in 1933.² Shortly thereafter, "efforts were initiated to encourage the formation of parallel boards at the state level."³ Eventually, all but three states established planning bodies.

¹Leonard U. Wilson and L.V. Watkins, State Planning: Inter-governmental Policy Coordination (Lexington, Ky.: Council of State Governments, 1976), p. 132.

²Originally created in 1933 as the National Planning Board by the National Industrial Recovery Act and merged with the National Resources Board by executive order on June 30, 1934.

³Wilson and Watkins, p. 134.

Curiously, these state planning boards focused largely on rural problems:

The state boards appeared to accept the premise that their logical sphere of action included everything except the major cities. In part, this may have arisen because city planning had preceded state planning, so that a presumption was made that the cities were already doing an adequate job of development planning.⁴

The decision by these state boards to exclude urban issues may have also been based on the earlier delegation by most states, of planning and zoning authority to localities modeled after the Standard State Zoning Enabling Act.

A decrease in federal public works funding and the coming of World War II led to the dismantling of many state planning agencies. Others were absorbed by state economic development agencies. It was not until the 1960s that state planning would re-emerge, influenced by federal grant programs.

"Between 1960 and 1968 states with active state planning programs increased from thirteen to thirty-nine."⁵

Coupled with the growth of Federal grants-in-aid was a general rise in planning capability. Planning in state agencies expanded, frequently stimulated by Federal requirements. Federal funds also provided direct support for agency or functional area planning.⁶

Individual federal grant programs and the states' response to them will be discussed later in this chapter. The remainder of this section is devoted to an overview of state land use planning trends from the 1960s to the present.

The Quiet Revolution

"From 1961 to 1975, a veritable flood of state land-use legislation

⁴Ibid, p. 135.

⁵Ibid, p. 137.

⁶Ibid.

swept across the country from Hawaii to Maine to Florida to Oregon to Minnesota to Colorado."⁷ Bosselman and Callies dubbed this phenomenon the "quiet revolution."⁸ They believe it was a revolution which "resulted from a growing awareness on the part of both local communities and statewide interests that states, not local governments, are the only existing political entities capable of devising innovative techniques and governmental structures to solve . . . problems which are not widely recognized as simply beyond the capacity of local governments acting alone."⁹

The techniques employed by each state to regulate land-use were varied. Hawaii, which in 1961, became the first state to enact a comprehensive land-use control system, developed a "statewide zoning" concept.¹⁰ The Vermont Environmental Control Act (Act 250) grew out of a second home "development crisis" and established state-administered environmental criteria used to review projects exceeding a certain size.¹¹ The steady migration of people to Florida's warm climate led to the passage of the Environmental Land and Water Management Act in 1972.¹² This legislation allows the designation of

⁷Thomas G. Pelham, State Land-Use Planning and Regulation (Lexington, Mass.: D.C. Heath and Company, 1979), p. 3.

⁸Fred Bosselman and David Callies, The Quiet Revolution in Land Use Control, Summary Report, (Washington, D.C.: Council on Environmental Quality, 1971), p. 1.

⁹Ibid, p. 3.

¹⁰The Hawaii Land Use Law (Hawaii Rev. Stat. Ch. 205) created a State Land Use Commission to divide the entire state into four districts--conservation, agricultural, rural and urban.

¹¹10 Vt. Stat. Ann. Ch. 151 (1970).

¹²Ch. 380, Florida Stat. (1972).

"areas of critical state concern" and regulates "developments of regional impact."

Concurrent with activities in individual states, several efforts with national scope stimulated the new-found interest in land-use regulation. The National Land Use Policy and Planning Assistance Act was debated in Congress for almost five years.¹³ Many states saw this bill as an "eventuality" and began "gearing-up" for grant funds to be made available. Another national innovation was provided by the American Law Institute's Model Land Development Code.¹⁴ Seen as a policy shift away from the local government orientation of the Standard State Zoning Enabling Act, the ALI Model Code set forth the responsibilities of a state land use planning agency and proposed state land development regulation, including the concepts of "critical areas" and "development of regional impact."

Academicians and practitioners were responsible for much literature on the state land-use regulatory trends. Bosselman and Callies,¹⁵ Healy,¹⁶ Mandelker¹⁷ and Pelham¹⁸ each presented case studies of individual states in

¹³Land Use Policy and Planning Assistance Act, S. Rep. No. 93-197, 93d Cong., 1st Sess. 47-9, (1973) is representative of the national planning legislation considered.

¹⁴American Law Institute, "A Model Land Development Code," (1975).

¹⁵Bosselman and Callies, The Quiet Revolution.

¹⁶Robert G. Healy, Land Use and the States (Washington, D.C.: Resources for the Future, 1976).

¹⁷Daniel R. Mandelker, "Critical Area Control: A New Dimension in American Land Development Regulation," Journal of the American Institute of Planners, January 1975, pp. 21-31.

¹⁸Pelham, p. 3.

their approach to statewide land-use controls. Mandelker,¹⁹ the National Resources Defense Council,²⁰ and the Council of State Governments²¹ provided an overview of national land-use considerations and explored the roles of state governments.

A Recent Shift

Despite this high level of state activity, it now appears that the movement has lost much of its momentum:

Is the quiet revolution dead? While it is too early to invite the obituary of the reform movement, it cannot be denied that the quiet revolution is presently quiescent.²²

The current slowdown can be attributed to a mellowing environmental militancy in the face of inflation/recession and "tax revolt." The failure of Congress to pass National Land Use Planning legislation is another factor in the waning of state legislative support. Others feel that "increased political and ideological opposition to the centralization of land regulatory power at the state level undoubtedly has slowed the state reform movement."²³

While it is clear that comprehensive state land use control activity has diminished in popularity, there are indications that the quiet revolution has managed to maintain its momentum under the guise of numerous federal/state programs, each containing land-use planning components designed for specific

¹⁹Daniel R. Mandelker, Environmental and Land Controls Legislation (Indianapolis: Bobbs-Merrill Company, 1976).

²⁰Natural Resources Defense Council, Land Use Controls in the United States, ed. Elaine Moss, (New York: Dial Press, 1977).

²¹Council of State Governments, Land: State Alternatives for Planning and Management (Lexington, Ky.: 1975).

²²Pelham, p. 3.

²³Ibid.

control functions.

Not all planners may be completely aware of the prominent position assumed by the federal government in facilitating the newly emerged state role. Few federal programs possess titles sounding anything like land or real estate; yet collectively, they provide an impressive array of financial incentives for state-level land-use activity.²⁴

State agencies, exercising responsibilities delegated by federal legislation are, therefore, in a position to develop land-use regulatory programs. The following section examines federal programs in natural resources and the environment that impact state control over land.

II. FEDERAL PROGRAM SUMMARY

Program Classification

The numerous pieces of federal environmental and resource protection legislation that combined do much to shape state land-use regulatory programs can be classified according to the types listed in below.²⁵

1. Cooperative Assistance Programs for Planning and Management
2. Review of Environmental Impacts of Development Projects
3. Grant Programs Requiring State Control of Land Development
4. Environmental Control Programs.

Each type of legislation carries with it certain levels of federal influence over state participation. Of the legislation types presented, cooperative

²⁴Mike Miles and Richard Mann, "Impact of Federal Programs on State Land-Use Planning," State Planning Issues, Summer 1978, p. 33.

²⁵The division of federal programs requiring control over land development into types is suggested by Mandelker, Environmental and Land Controls Legislation, p. 15.

assistance programs are least stringent in terms of the controls mandated. The programs are generally administered on a matching-grant basis, the state share usually being one-third to one-half the total cost of the effort. Examples of this type program are the Land and Water Conservation Fund Act of 1965, as amended in 1976²⁶ and the Housing and Community Development Act of 1974.²⁷ The former authorizes federal payments to the states to cover up to 50 percent of the costs for planning, acquisition, and development of land and water areas for outdoor recreation needs. The program is the responsibility of the U.S. Department of Interior, Heritage Conservation and Recreation Service. Section 701 of the Housing and Community Development Act provides grant funds to assist in comprehensive planning in both urban and rural areas. A broad range of land-use planning activities are eligible for funding through the U.S. Department of Housing and Urban Development (HUD) for up to two-thirds of the project cost.

A second type of federal legislation relating to land-use control is that requiring the review of adverse environmental impacts of development projects. The National Environmental Policy Act of 1969²⁸ (NEPA) established the environmental impact statement (EIS) as a mainstay in the land-use decision-making process. Originally intended by Congress "as a means of improving environmental assessment procedures of federal agencies,"²⁹ NEPA led to the creation of "little NEPAs" at the state level, many of which exert statutory

²⁶16 U.S.C. 460 et seq.

²⁷42 U.S.C. 5301 et seq.

²⁸42 U.S.C. 4321 et seq.

²⁹Mandelker, Environmental and Land Controls Legislation, p. 15.

control over public and private development projects.³⁰ The Act also established the Council on Environmental Quality (CEQ) to oversee the EIS process. CEQ guidelines state that an EIS must consider the following:

The relationship of the proposed action to land use plans, policies, and controls for the affected area. This requires a discussion of how the proposed action may conform or conflict with the objectives and specific terms of approved or proposed Federal, State and local land use plans, policies, and controls.³¹

Another example of environmental impact review in federal law can be found in The Intergovernmental Cooperative Act of 1968³² and the subsequent issuance of Circular A-95 by the U.S. Office of Management and Budget to implement sections of the law relating to "the evaluation, review, and coordination of Federal and Federally assisted programs."³³ The A-95 "Project Notification and Review System" allows for the review of federally subsidized public and private development projects by state and sub-state level clearing-houses. Nine specific areas in which comments can be made regarding the proposed project's consistency with State, regional, and local comprehensive plans are listed below:

(1) appropriate land uses; (2) wise development and conservation of natural resources; (3) balanced transportation systems; (4) adequate outdoor recreation and open-space; (5) protection of areas of

³⁰As of June 1, 1979, California, Connecticut, Hawaii, Indiana, Maryland, Massachusetts, Minnesota, Montana, New York, North Carolina, South Dakota, Virginia, Washington, and Wisconsin had comprehensive statutory requirements. Twelve other states had adopted EIS requirements on a limited basis or through administrative orders. From Council on Environmental Quality, Environmental Quality 1979 (Washington, D.C.: 1979), pp. 595-603.

³¹40 C.F.R. Part 1500, Section 8 (a) (2).

³²42 U.S.C. 4201 et seq.

³³Advisory Commission on Intergovernmental Relations, Regional Decision Making: New Strategies for Substate Districts (Washington, D.C.: 1973), p. 140.

unique natural beauty and historical and specific interest; (6) properly planned community facilities; (7) high design standards; (8) environmental impact; (9) balanced settlement patterns and delivery of services to all sectors of population, including minority groups.³⁴

Negative comments by a clearinghouse on the proposed project can lead to modification of the project by the applicant, or a refusal by the funding agency to approve the project.

Perhaps unique in the spectrum of types of federal legislation relating to land-use control is the Coastal Zone Management Act (CZMA) of 1972, as amended in 1976.³⁵ Administered by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, the law "has probably resulted in more detailed land planning and land regulation than any other federal program."³⁶ CZMA differs from federal environmental control laws, to be discussed next, in that the Act "is considered to be a comprehensive planning law"³⁷ which "represents the first national effort to take land and resource management planning on private lands out of the exclusive realm of individual localities and to establish a coherent state planning program supported by explicit federal policy."³⁸ And, unlike many federal laws which address a specific environmental problem, state participation in the Coastal Zone Management program is voluntary without the threat of federal enforcement actions.

³⁴Ibid, p. 145.

³⁵16 U.S.C. 1451 et seq.

³⁶Miles and Mann, p. 36.

³⁷Aspen Systems Corporation, Land and Natural Resources Management: An Analysis of Selected Federal Policies, Programs and Planning Mechanisms, Report to the President's Interagency Task Force on Environmental Data and Monitoring Programs, (Germantown, Md.: 1979), p. IV - 18.

³⁸Ibid.

CZMA authorizes grants-in-aid to states for development of planning and management strategies of coastal areas. Federal funds of up to 80% of the program cost are available for both planning and administration. If a state is not in compliance with standards contained in the Act, federal aid may be withheld. Of the 35 states and territories eligible under the CZMA program, it is estimated that 27 will have a federally approved program by the end of FY 1980.³⁹

Federal legislation having the least amount of flexibility for state participation comes under the heading of environmental control. This type of land-use related program calls for the development of state planning mechanisms designed for specific pollution control objectives. The responsible federal agency may delegate pollution control authority to a state agency only if "that agency's program is consistent with federal statutory requirements, and the federal agency may re-assume control in those instances in which state control is found inadequate."⁴⁰ A major stumbling-block to state program approval by the federal government has been the unwillingness of many state legislatures to enact the necessary statutory components.

Examples of this type of federal legislation are found in the Clean Air Act of 1970, as amended in 1977⁴¹ and the Surface Mining Control and Reclamation Act of 1977⁴² (SMCRA). Under the Clean Air Act, the U.S.

³⁹U.S. Department of Commerce, Office of Coastal Zone Management, "CZM Information Exchange," September 21, 1979, p.10.

⁴⁰Mandelker, Environmental and Land Use Controls Legislation, p. 15.

⁴¹42 U.S.C. 7401 et seq.

⁴²30 U.S.C. 1201 et seq.

Environmental Protection Agency (EPA) is authorized to provide financial assistance to the states for development of a State Implementation Plan (SIP) for implementation, maintenance, and enforcement of national ambient air quality standards within its borders. Grants can cover up to two-thirds of the planning costs and one-half of the program maintenance costs. State programs are to include "emission limitations, schedules and timetables for compliance with such limitations, and such other measures as may be necessary to insure attainment and maintenance."⁴³ One controversial "other measure" would establish a virtual moratorium on construction of new generators of air pollutions, if these facilities prevent the attainment or continued maintenance of national standards. Failure to have an approved SIP can subject a state to severe sanctions which include the cutoff of federal highway and sewage treatment construction funds.

Perhaps more significant in terms of land-use control are the Clean Air Act's guidelines for the "prevention of significant deterioration (PSD). This rule applies to areas currently meeting national air quality standards by establishing a land classification system based on the existing air quality. "The sum effect of PSD is to limit development in pristine areas under the guise of protecting clean air."⁴⁴

Land-use regulation is also an integral part of the Surface Mine Control and Reclamation Act. This comprehensive national legislation provides for extensive federal control of surface coal mining on private lands. Typical of recent environmental control laws, SMCRA, the responsibility of the U.S. Department of Interior's Office of Surface Mining, establishes a permit

⁴³Miles and Mann, p. 35.

⁴⁴Aspen Systems Corporation, p. IV-33.

system of regulation. The permit system must be implemented by states according to federal standards to avoid federal enforcement. In addition to the permit system, SMCRA calls for the designations of certain "land unsuitable for mining."

The state must establish a planning process enabling it to determine which areas may be unsuitable for mining because, among other reasons, mining would adversely affect fragile or historic lands, renewable resource lands and natural hazards lands.⁴⁵

SMCRA contains a site-specific land-use control mechanism that requires mined lands to be restored to a condition capable of supporting the land use in existence prior to mining, or a better use:

If the mining operator plans a post-mining use that is different from the actual or potential use prior to mining, he must demonstrate consistency with all applicable Federal, state and local land use plans. However, he must, also, as a separate requirement demonstrate that his proposed use will be compatible with all adjacent land uses.⁴⁶

Program development grants of up to 80% in the first year are available to the states from the Office of Surface Mining.

The list of federal land-use related legislation presented here is only a sampling of the broad array of incentives and mandates enacted by Congress that provide states with development control opportunities. Each type of legislation described previously requires a state response which varies from review and comment to stringent regulatory mechanisms. The following section discusses the impact of these federal programs on state land-use planning activities and summarizes state level efforts to formulate a coordinated approach to resource management working through these seemingly fragmented tools.

⁴⁵Ibid., p. IV-28.

⁴⁶Ibid.

III. STATE RESPONSE TO FEDERAL PROGRAMS

The most immediate and visible state level response to federal initiatives in environment and resource management has been the proliferation of state agencies with planning and/or regulatory powers. The majority of federal laws creating these programs require that the Governor designate a single agency to assume responsibility for administering the program at the state level. In most every state, numerous divisions, offices, commissions, bureaus, boards, etc., have been set up as a result. This sudden growth in the bureaucracy, while creating the potential for states to more effectively manage growth and resources, also has led to "considerable criticism of the duplication and delay already resulting from the proliferation of agencies with planning and regulatory powers."⁴⁷

Another, more positive result of state government's assumption of an increasing number of land regulatory programs "is that a number of states are beginning to create comprehensive programs for planning and control by putting together powers that already exist in the state government structure instead of passing new laws."⁴⁸ Thus, there is a need to correct problems in program duplication and fragmentation, coupled with a growing desire to combine existing programs for more effective environmental and resource management. The state's response to both of these issues has been the initiation of efforts to integrate and coordinate land use related programs.

Coordination of state land use activities has occurred in various forms

⁴⁷Robert G. Healy, "Coordination: The Next Phase in Land Use Planning," Management and Control of Growth Vol. IV (Washington, D.C.: The Urban Land Institute, 1978), p. 170.

⁴⁸Ibid., p. 171.

and at several levels. Parker, Peddicord and Beyle⁴⁹ have shown that integration and coordination of certain environmental functions can be accomplished through both organizational and non-organizational techniques. Organizational methods for improved coordination are governmental reorganization and agency consolidation. Non-organizational techniques cited are policy planning, coordinating councils and review activities.

Wilson and Watkins suggest that "coordination requires a process through which the governor, in cooperation with agency heads and other public officials may analyze issues, resources, and organizational alternatives for action." The authors believe that "the first requirement for effective interagency and intergovernmental coordination is a policy framework." After that, a mechanism is needed to insure coordination within and between agencies and programs. That mechanism is provided, they assert, through "emphasis on the coordination function in the planning process."⁵⁰

This contention that the planning process can affect the coordination of state level land management activities is supported by a recent survey of state planners' attitudes. Over 90% of the responding practitioners agreed that state planning should take a "mixed scanning approach":

This is where high-order fundamental policies which set basic growth strategies are formulated and adopted within the framework of state plan and sufficient flexibility is maintained for incremental decisions to be made concerning fundamental project and program matters.⁵¹

⁴⁹Thad L. Beyle, Thomas E. Peddicord and Francis H. Parker, Integration and Coordination of State Environmental Programs (Lexington, Ky.: Council of State Governments, 1975).

⁵⁰Wilson and Watkins, p. 125.

⁵¹Tilden J. Curry, "Relevance of a Comprehensive Plan: Attitudes of State Planners," State Planning Issues, Summer 1978, p. 32.

This approach to the planning process enables individual, functional programs to operate within established policy guidelines, wherein the potential for conflict and duplication are reduced.

The following chapter discusses the state planning process as it pertains to land and resource management. Key elements of this process, data and information requirements, are examined for their role in promoting program coordination.

CHAPTER III

STATE DATA AND INFORMATION REQUIREMENTS

I. RESOURCE PLANNING AND INFORMATION NEEDS

As suggested in previous chapter, coordination of state environmental resource programs can occur through the planning process. A planning process for environmental resource planning and management involves six basic steps:

1. inventory;
2. demand analysis;
3. resource analysis;
4. plan formulation;
5. plan implementation;
6. plan monitoring.¹

According to this process, information gathering is the starting point for resource planning activities and informed decision-making.

Increased state government responsibility for resource management has created a heavy demand for information. A major U.S. Department of Interior study concludes that "the primary task of state agencies in resource management is to move rapidly and efficiently to identify the resources that require management and to see that they are protected." This same study claims that states need information about: (1) the resources to be managed; (2) the expected impact of development on those resources; and (3) the availability of management tools.²

Access to the needed information by state agencies has been achieved

¹U.S. Department of the Interior, Information/Data Handling: A Guidebook for Development of State Programs, draft, July 1975, pp. 11-12.

²U.S. Department of the Interior, Information/Data Handling Requirements for Selected State Resource Management Programs, draft, July 1975, p. 5.

with only limited success. A study conducted by the Council of State Governments found that "the necessary information is frequently absent, sometimes is is improperly formatted or inconsistent, and often it is not effectively managed."³ A survey conducted by that organization of some 500 state officials in natural resource agencies found that over 50 per cent of those responding regularly or occasionally experienced the following problems in the use of data:

1. Duplication of data-gathering activities by state agencies;
2. Difficulty in identifying data sources;
3. Inaccessibility to data holdings of other state agencies;
4. Nontransferability of data among users due to differing standards and formats;
5. Weakened decisionmaking due to delays in assembling relevant data.⁴

Other issues surfaced by the Council of State Governments' study deal with state-federal relationships in data exchange. Federal agencies, frequently data-producers, provide little opportunity for states as major users, to impact decisions on data types and format. Data products of federal agencies are often limited in flexibility and incompatible with other products. Interagency coordination of data production is also a problem at the federal level.⁵

Research conducted by federal agencies also points to problems in data collection for resource management. A report sponsored by the Council on Environmental Quality found that:

Just as planning responsibility may be delegated to a state or local entity, so too may data collection be delegated. Coordination is needed, however, since data collected at the state and local

³Council of State Governments, Environmental Resource Data: Intergovernmental Management Dimensions (Lexington, Ky.: July 1978), p. 1.

⁴Ibid., p. 8.

⁵Ibid., p. 34.

level may prove useful in local planning but be duplicated or remain unused at the federal level.⁶

In response to, and often in spite of, intrastate and interstate data needs and problems, state management agencies have established new mechanisms, both in the coordination of data gathering efforts and in the compilation, storage and manipulation of data. The following sections of this chapter will examine several of these mechanisms. First, the use of new technologies will be reviewed. Then, the important factor of coordination will be discussed.

II. INFORMATION SYSTEMS

Challenged with establishing mechanisms to compile and analyze tremendous amounts of environmental resource data, many states have built computerized systems and experimented with new technologies to meet their information requirements. Computerized techniques are widely used by state governments in the management of environmental and natural resources.⁷ These automated approaches to information handling are given various titles. Most often they are referred to as a "data base" or "information system."⁸ More than likely their names contain the words "geographic," "resource," "land resource," or "natural resource." All have two basic characteristics: they are spatial

⁶Aspen Systems Corporation, Land and Natural Resources Management: An Analysis of Selected Federal Policies, Programs and Planning Mechanisms, Report to the President's Interagency Task Force on Environmental Data and Monitoring Programs, (Germantown, Md.: 1979), p. I-4.

⁷A 1979 survey by the National Conference of State Legislatures indicates that 18 states have information systems for resource management in operation. An Additional 8-10 states are in various stages of system development and implementation.

⁸A detailed discussion of data base and information system concepts can be found in Michael Kennedy and Charles Meyers, Spatial Information Systems: An Introduction (Louisville, Ky.: Urban Studies Center, 1975), pp. 5-12.

and relate to specific locational or geographic coordinates, and they are automated, which means that electronic data processing is used to store and manipulate data elements.

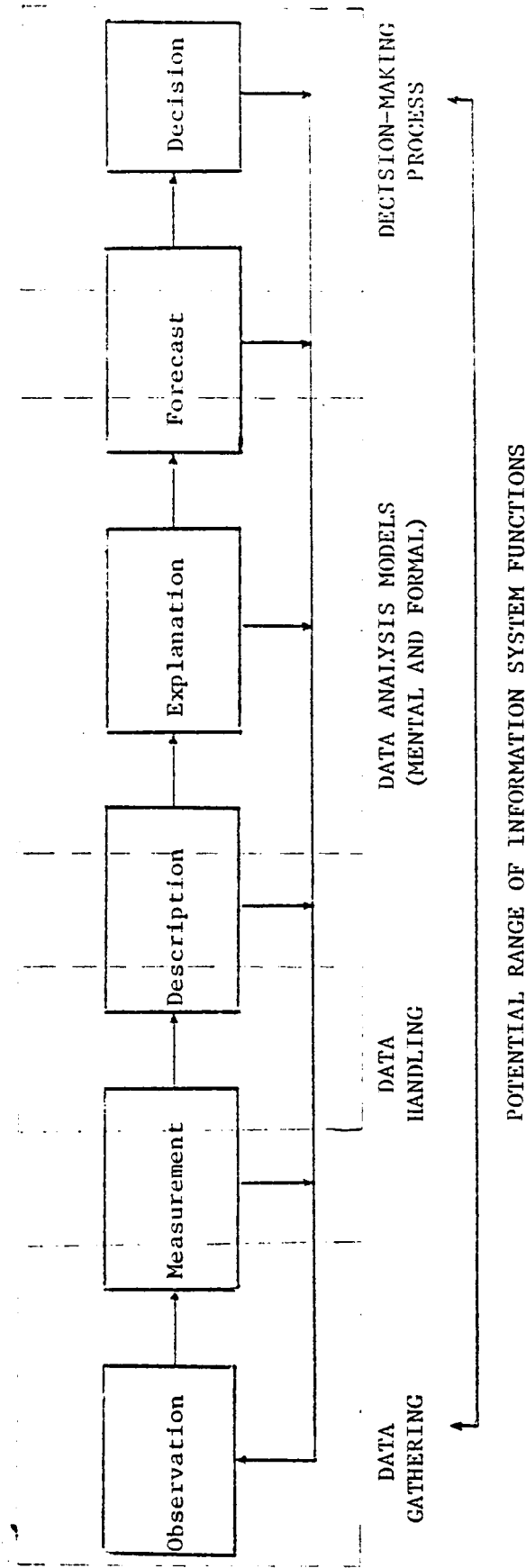
For the purposes of this research, the term "information system" will refer to spatially-oriented, automated data bases for resource management. An information system can be a simple, manually-operated data file such as a library card catalog. However, this thesis deals exclusively with computerized techniques.

An information system can be an integral component of the state resource planning process. Figure 1 illustrates the potential range of information system functions. These functions are similar to the steps of the previously identified resource planning process in that they "include observation and collection of data through their analysis to their use for some decision-making process."⁹ Figure 1 also depicts a feedback mechanism.

The structure, function and design of information systems have been reported on by people such as Dueker and Talcott, Kennedy and Meyers, and Petrey.¹⁰ Each has presented a model or set of guidelines for the development of a computerized system. From these works, and others, it is possible to develop a set of issues that surround the success or failure of an environmental resource information system at the state level.

⁹USDI, Information/Data Handling Guidebook, p. 10.

¹⁰See for example; Kenneth Dueker and Richard Talcott, "An Incremental Approach to the Design of a Geographic Information System," 1977 URISA Proceedings, pp. 298-305; Michael Kennedy and Charles Meyers, Spatial Information Systems: An Introduction (Louisville, Ky.: Urban Studies Center, 1975); R. Claybourne Petrey, Jr., "State Land Planning Information Systems: An Evaluation of the OLDMAN System in the Tennessee State Planning Office as a Critical Areas Information System,": (unpublished Master's thesis, The University of Tennessee, 1977).



Source: U.S. Department of the Interior, Information/Data Handling: A Guidebook for Development of State Programs, draft, July 1975, p. 10.

FIGURE 1

SPATIAL INFORMATION SYSTEM FUNCTIONS

Although technical features of an information system such as computer processing capabilities are important to its implementation and continued utilization, this research does not dwell on technical issues; rather institutional aspects are considered of primary concern. "System failure is sometime the result of technical barriers; however, these can generally be overcome in time. Failure is more often due to an inability to surmount management and institutional barriers."¹¹ The institutional factors to be discussed, and the issues and problems relating thereto, are:

1. Origin
2. Official endorsement
3. Organizational setting
4. User needs
5. Data elements
6. Products
7. Financing
8. System design/construction
9. Management

These factors provide a framework to be used in the evaluation of resource information systems. Specific case study evaluations will be presented in Chapter IV. The following sub-sections describe each institutional factor.

Origin

Dueker suggests that the impetus for development of a resource information system comes from a response to a specific planning function. These are:

¹¹Paul A Tessar and Loyola M. Caron, A Legislator's Guide to Natural Resource Information Systems, final draft, (Denver, Co.: National Conference of State Legislatures, February 1980), p. 27.

(1) policy planning; (2) program planning; (3) land inventory; (4) impact analysis; and (5) regulatory activities.¹² Maryland's Automated Geographic System (MAGI) was originally developed to assist in preparation of a state land use plan. The New Jersey Geographic Base File was established in response to the need for water quality data. South Carolina's automated mapping system evolved from the requirements of the Coastal Zone Management Act. More recently, states are designing systems to conduct statewide natural resource inventories.

Information systems for resource management may grow out of a crisis situation. The Texas Natural Resource Information System (TNRIS) evolved from the Texas Water-Oriented Data Bank, established after a period of severe drought followed by heavy flooding in the 1960s. The energy crisis of the early 1970s made possible massive coal-related development in North Dakota, which led to the establishment of the Regional Environmental Assessment Program (REAP).

Whether borne out of a specific programs data requirements or in response to an impending crisis, successful system operation ultimately depends upon the utility of the information management tool for a broad range of resource program needs. Kennedy and Guinn cite inability of a system to adapt to new processes as a common cause for failure.¹³ Information demands of a single program often serve as a catalyst for system development, but systems designers should build in flexibility because of the continual shift in programs and

¹²Kenneth Dueker, Geographic Data Encoding Issues (Iowa City, Ia.: University of Iowa Institute of Urban and Regional Research, 1975), p. 8.

¹³Michael Kennedy and Charles Guinn, "Avoiding System Failure: Approaches to Integrity and Utility" Information/Data Handling Issue Papers, draft, (Washington, D.C.: U.S. Department of the Interior, July 1975), p. 30.

priority issues at the state level.

Official Endorsement

Establishment of an information system will inevitably affect the status quo. Therefore, the most critical step in forming the institutional arrangements for a state level system may be to establish the mandate for data coordination from the legislature and/or Governor.¹⁴

Several information systems were established or approved by formal legislative action. Arizona, Nebraska, and South Dakota, among others, have enacted laws which describe the mission of their resource management systems. The North Dakota Regional Environmental Assessment Program was established by the legislature in 1975. Legislative support for several information systems currently in the design phase was provided in 1980 sessions in Colorado and Virginia. Gubernatorial interest in these states has also been a positive factor in system development.

Organizational Setting

Trends in the location of an information system within state government are recognizable. Of systems presently in operation, the organization setting appears to be evenly divided between the state planning agency and the natural resource agency. The exceptions to this are systems in Mississippi, New York, and North Dakota where other institutional arrangements were established. The university research center provides a setting for natural resource information management in Mississippi. In New York, the Department of Commerce is responsible for the Land Use and Natural Resource (LUNR) System. North Dakota's REAP was unique in its placement as a research arm of the legislature.

Kennedy and Guinn state that location is a critical aspect of system

¹⁴Tessar and Caron, p. 28.

success. Often several agencies within the state will fight for control of the system or rival groups will resist its implementation.¹⁵ Other studies advocate placement of the system as an independent entity.¹⁶ Whatever the location, a key to long term survival is that the system not be bound by specific program requirements that limit its varied applicability and that the system gain a reputation as an impartial handler of information.¹⁷

User Needs

The Council of State Governments recommends that the information system function "be as directly responsive to its users as possible in the types of data and services it provides."¹⁸ Communication between users and producers is necessary to reduce duplication in data collection and, more important, to prevent the proliferation of discrete and competing computerized data systems within state government. An awareness among users is vital to make sure that limitations of the data are recognized and that the information produced by the system is properly used.

Continued operation of a resource information system is dependent upon support from users of the information. State appropriations for information management activities may be severely reduced without constituent backing. System operators are well aware of false starts and failures in other states which resulted from a concentration on technical capability rather than user service.

¹⁵Kennedy and Guinn, p. 15.

¹⁶Council of State Governments, p. 36.

¹⁷Ibid.

¹⁸Ibid.

User needs are being taken into consideration by system designers and operators. Many systems, such as those in Arizona and Texas, provide facilities for public and private users to request data and maps. Others, including the Ohio Capability Analysis Project (OCAP), perform resource evaluations for local governments. Nearly all systems provide environmental resource data management services to various state agencies. The Texas Natural Resource Information System is the most notable example in this regard. Thirteen state agencies participate in a task force which decides on data management priorities and services.

Data Elements

The data itself is quite obviously the heart of an information system, but assembly of the relevant data presents its own set of problems.

Difficult choices regarding how and what data should be collected and used are inherent in natural resource protection programs. These choices are made more difficult, not only by the pressures of time and money, but also by the possible loss of precious resources that can occur while decisions are being made.¹⁹

System managers are faced with making decisions about the utility and quality of data elements. And since it is felt by some that "more than enough data already exists for use in policy planning than most state agencies can possibly absorb,"²⁰ this task becomes a crucial one. The information system developer must be able to recognize the link between user needs and data elements. Limited knowledge of the user's application may lead to an information system with data of insufficient detail and improper scale.

¹⁹USDI, Requirements for Selected State Programs, p. 6.

²⁰Ibid.

Products

Kennedy and Guinn believe that one of the ways an information system can fail is by "not proving success and relevance along the way during the development process."²¹ Therefore, an information system must be able to generate products to substantiate its usefulness. System managers should be wary of an undue concentration on data collection:

The accuracy, timeliness and relevance of the information product are, of course, functions of the data and the way they are handled. But the product and its use are the 'raison d'etre' for the information system.²²

A recent primer on information systems suggests that the utility of a product is dependent upon the knowledge that it is available, understandable, and worth the user's time to determine how to use it. Other key elements are the provision of assistance to aid in the understanding of the product, the availability at the time required and its relevance to the area of concern. Accuracy and integrity of the product are also important: "if the product lets the decisionmaker down, a long time will elapse before he again depends on such information."²³

Financing

Costs for development of an information system to support state environmental resource programs are substantial. It has been estimated that

²¹Kennedy and Guinn, P. 30.

²²Kennedy and Meyers, p. 35.

²³Ibid., p. 36.

one of the oldest and most successful systems, the Minnesota Land Management Information System (MLMIS), required an investment of \$1.8 million and ten years to achieve operational status.²⁴

Financing of information system operation is generally provided through user charges, general fund appropriations, and federal assistance. A state may rely upon one or a combination of these funding sources for system upkeep. User fees vary from state to state with many systems offering differential rates to government and private users. In some states, only costs of computer time are assessed. Many systems apply user charge revenues to costs of operation. Others must forward all revenues to the state's general fund.

The most common form of system financing is by budgetary appropriation. An information system may receive operating funds as part of a total agency budget, or it may be a specific item subject to scrutiny by the legislative and executive decisionmakers. General tax revenues are the primary source of funding, but special funds have been set up to support resource information systems, such as a surtax on coal to support North Dakota's REAP or a cigarette tax in Minnesota which provides funding for MLMIS.

Funding assistance also comes from federal agencies. Many state environmental resource programs that receive federal dollars include planning components that require data collection and analysis. These federal funds can be passed on to the information system for task performance. Other federal agencies, such as NASA and the Department of the Interior, have provided indirect assistance in the form of data, equipment, facilities use,

²⁴David J. Cowen, Alfred H. Vang and James M. Waddell, Jr., "The South Carolina Information System: The Role of the State and University in System Implementation," paper presented at Harvard Computer Graphics Week, July 1979, p. 18.

and technical guidance that supplement state funding sources. Some states, including Georgia, Nebraska, and South Dakota, contract with universities for use of computer facilities. Cooperative development and operation of environmental and natural resource information systems represent a cost-effective choice by state governments in many instances. Personnel and equipment costs for an agency-staffed, state-owned system often exceed the budgetary limits set for information system development and maintenance.

System Design/Construction

While the design of an information system involves all of the factors previously discussed, it is actually the combination of those components into blueprint for the system from which an operating unit can be constructed. Building of a system involved the selection of equipment, or "hardware" and the computer programs and procedures, or "software," which enable the various pieces of equipment to function. While this step requires extensive technical ability, it is often the non-technical aspects of system design and construction that create the most serious problems.

A problem that often occurs at this stage is when construction of the system fails to keep pace with the design. Thus the system plan is not implemented on schedule and credibility suffers. Poor or inadequate design is also the cause of many information system ills. Some system designers will delude themselves into believing that technology will solve their problem and make an impossible task feasible. But even a sound design can encounter difficulties because of technical problems. Often this is beyond the control of the designer. Computer hardware and software manufacturers have, in some cases, oversold the capabilities of their products. A state may invest

thousands of dollars in equipment that is either obsolete or unable to perform the needed function.

Management

The operation of an environmental resource information system is the process of making the system available to the user for decision-making.²⁵ Once the system is operating it must be managed. Kennedy and Guinn indicate that management includes making decisions about staffing of the system, feedback and monitoring functions, and distribution and marketing techniques.²⁶

Staffing is an all-important activity which requires the assemblage of personnel from a variety of disciplines:

Basic to the organization of this staff is requirement that many different skills such as land analysis, cartography, remote sensing, computer programming and system analysis be brought together in one relatively small staff. The operating group must have these skills onboard--nothing less will do.²⁷

Staff should also possess a thorough knowledge of users and their needs.

Good management requires the understanding of how the system is being used and an awareness of its problems. Feedback is also important to keep abreast of changing information needs. Another vital activity is to stay attuned to state-of-the-art improvements in computer capabilities and program applications.

Management of an information system also calls for marketing and distribution of its utility and products. Often, system managers assume that

²⁵Kennedy and Meyers, p. 65.

²⁶Kennedy and Guinn, pp. 66-69.

²⁷Ibid., p. 67.

the system will market itself. A sound management strategy should be adopted which continually seeks new users and applications.

III. LANDSAT DATA ANALYSIS CAPABILITY

In addition to institutional features of a state's data management capability, this research will report on the ability of states to obtain information about the land surface from earth orbiting satellites. Landsat, as these satellites are called, provides a data-gathering tool worthy of consideration. This section examines state utilization of satellite remote sensing within a comprehensive resource management scheme. It focuses on the attention given this new technology in resource information system development.

State Use of Landsat Data

The existence of an information system for resource data management provides a foundation upon which more specialized analytical tools can be built. Some states have chosen to develop sophisticated graphic capabilities using interactive display terminals and pen-plotters which can illustrate various data items in mapped or charted form. Others have sought to link up with any of several national, federally supported data banks that contain numerous environmental and natural resource data inventories. The use of satellite remote sensing data by states can also be tied directly to the presence of an information system for resource management. In fact, in several states the development of an information system can be directly attributed to Landsat data analysis programs.

Information derived from Landsat can be acquired in either digital or imagery forms. Imagery has the appearance of high-altitude aerial photography,

and techniques of photo interpretation are used to analyze a "scene" from Landsat. Digital data from Landsat is available on computer compatible tapes which enable the user to perform a more precise computer processing of a view from space.

The majority of states have had some experience with Landsat-produced data. Many applications have been one-time demonstrations or limited tests. Satellite remote sensing data has been used in conjunction with land cover analysis for forest and crop inventories, wildlife habitat mapping, water quality management, flood damage assessment, geological mapping, and numerous other applications (see Table 1). However, this thesis considers the ultimate test of Landsat's utility to state resource management to be its continued use and integration with other forms of data to constitute an information system suited to the needs of various resource programs.

Development and continued application of Landsat data by states have been achieved according to recent surveys. The Intergovernmental Science, Engineering and Technology Advisory Panel report on the use of Landsat by state and local governments observed that "seven states are considered to have independent on-going operational Landsat analysis and application capabilities" and that nine others "are likely to have operational programs under way within several years" of the June 1978 release.²⁸ In a recent National Conference of State Legislators document, "operational or quasi-

²⁸Intergovernmental Science, Engineering and Technology Advisory Panel (ISETAP), State and Local Government Perspectives on a Landsat Information System (Washington, D.C.: Executive Office of the President, June 1978), p. 11.

TABLE 1

SUMMARY OF LANDSAT APPLICATIONS IN THE STATES*

A. Water Resources Management - surface water inventory (7) - flood control mapping and damage assessment (7) - snow cover mapping (3) - water resources planning and management (2) - irrigation demand estimation (2) - determination of runoff from cropland (2) - watershed or basin studies - water circulation - lake eutrophication survey - irrigation/saline soil - geothermal potential analysis - ground water location - offshore ice studies B. Forestry and Rangeland Management - forest inventory (6) - forest productivity assessment (3) - clear cut assessment (2) - forest habitat assessment (2) - wildlife range assessment (2) - fire fuel potential - fire damage assessment and recovery C. Land Resources Management - land cover inventory (18) - comprehensive planning (4) - corridor analysis (2) - facility siting (2) - floodplain delineation - lake shore management	D. Fish and Wildlife Management - wildlife habitat inventory (9) - wetlands location and analysis (3) - vegetation classification - snow pack mapping - salt exposure E. Environmental Management - water quality assessment and planning (16) - environmental analysis or impact assessment (4) - coastal zone management (3) - surface mine inventory and monitoring (2) - wetlands mapping - lake water quality - shoreline delineation - oil and gas lease sales - resource inventory - dredge and fill permits - marsh salinization F. Agriculture - crop inventory (7) - irrigated crop inventory (5) - noxious weeds assessment - crop yield prediction - grove surveys - assessment of flood damage - disease monitoring G. Geological Mapping - lineament mapping (9) - geological mapping (6) - mineral surveys (4) - power plant siting - radioactive waste storage
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*The number in () indicates the number of states for each application, where greater than 1.

Source: ISETAP, State and Local Government Perspectives on a Landsat Information System, June 1978, p. 12.

operational Landsat capabilities" were identified in six states.²⁹

Capability vs. Use

The use of the term "operational" in reference to a state's ability to process and utilize satellite remote sensing data has generated much discussion. An ambiguous term, "operational" means different things to different people. As will be shown in the case studies in Chapter IV, some state officials are reluctant to designate their Landsat capabilities as "fully operational" and feel more comfortable in designating them as "quasi-" or "semi-" operational. The conflict, it would appear, results from a distinction between "operational capability" and "operational use."

Operational capability, for purposes of this thesis refers to a state's ability to convert raw satellite remote sensing data (either by imagery interpretation or computer processing of digital tapes) into a form that can be applied to environmental resource management activities. Since some states have elected to contract with private vendors to supply Landsat data products, this capability need not be an in-house procedure. The key element to reaching operational capability is the possession of a Landsat-derived data base applicable to a variety of land-related information needs.

On the other hand, this thesis defines operational use as the actual application of the converted satellite data in a continuing mode for functional resource management programs. Under this definition, a state information system may possess the operational capability to produce Landsat-derived land

²⁹Paul A. Tessar and Becca Smith, State Institutional and Technical Approaches to Landsat Utilization, final draft (Denver, Co.: National Conference of State Legislatures, August 1979), p. 1.

cover maps and tabular data summaries; but for these products to be put to operational use, a functional agency must apply them to ongoing data requirements and management decisions. Operational use implies continued application and product refinement. Therefore, a one-time application of generalized land cover map for water quality planning does not fulfill the definition of operational use.

This distinction must be clarified in the the discussion of state utilization of satellite remote sensing data. The cost of generating Landsat products can rarely be justified for a single-purpose application. The value of Landsat data lies in its repetitive characteristics and wide-area view.³⁰ Landsat coverage of the same geographic area is every nine days with the two satellites currently in operation. The ability to detect changes in land activity over a period of time is one of the major advantages of Landsat data over conventional data collection methods. However, the shortcomings of satellite remote sensing data have inhibited some states from making the step from operational capability to operational use.

In North Dakota, for example, the capacity was built in REAP, but the products generated by Landsat failed to command much interest among potential users. Several applications were tested, but demand for new or refined utilization of the data did not exist. A similar situation occurred in Ohio. The accuracy and level of detail of Landsat-produced land use inventory were not sufficient to include it as an element of the Ohio Capability Analysis Project. Other states have recently developed the capability to process digital Landsat

³⁰
Ibid., pp. 4-5.

tapes. However, the use of the data is still in the experimental stage and is confined to only a few agency users.

Federal Viewpoint

The National Aeronautics and Space Administration (NASA), the agency responsible for development of earth observation satellite technology, recognizes the contrast between capability for and actual use of Landsat data. One objective of its Regional Remote Sensing Applications Program is to transfer to states the operational capability to use remote sensing technology for resource and environmental quality management. NASA officials have indicated in discussions with the author that experimental or demonstration uses of Landsat will not provide sufficient rationale for establishing a permanent satellite remote sensing program. Only through development of a significant base of repeat users will the Landsat program become institutionalized.

In promoting state use of Landsat-derived data, NASA places emphasis on the integrated use of various data forms, i.e. that the optimum value of Landsat can be achieved when in conjunction with other more conventional data forms. This integration of data sources is provided by a state resource information system.

State Approaches

The states now putting Landsat data to operational use do so within an overall framework of an information system. In states such as Arizona and Georgia, a Landsat data analysis program provided a strong impetus for the development of a geographic information system. Texas has made Landsat data files a component of an ever-expanding data base for resource management. Other states, including Kentucky and South Carolina, have recently made major

investments in computer equipment to integrate satellite-derived data into developing resource information systems.

Not all state information systems have sought to take advantage of Landsat data as a management tool. It is interesting to note that the forerunners in state resource information systems--Maryland, Minnesota, and New York--have, until recently, experienced minimal integration of Landsat with their data bases. Other states have viewed Landsat data as a lower-level acquisition priority. North Carolina's Land Resource Information System, one of the newer systems, did not develop Landsat analysis capability in its initial implementation phase.

In interviews conducted with state officials, the feelings expressed about Landsat data use ranged from enthusiasm to cautious optimism to reluctance. A few who had successfully employed Landsat as a resource management tool were confident of the product's value. Others approached the use of Landsat incrementally and were willing to undertake demonstrations of the technology. Still others were skeptical about the reliability and cost-effectiveness of the data. Reluctance and uncertainty among officials toward utilization of Landsat data stem from two basic issues. First, many officials have yet to be convinced of the true applicability of satellite remote sensing data in a "real world" program setting. Several officials that were contacted characterized NASA's original efforts to promote use of the data as an "oversell" of the tool's capability. Problems in the timely delivery of data continued to plague the technology. Some states have paid relatively large sums of money to private consultants for Landsat data products only to be disappointed by their utility. Second, state officials that are

satisfied with the usefulness of the data are concerned about the lack of federal support in establishing permanent satellite remote sensing programs. These officials do not wish their state's investment in equipment and trained personnel to be lost if the federal government ceases to provide funding for the still experimental Landsat program. Many states are unwilling to make commitments to data systems which change with each successive satellite launched into orbit.

Some of the problems encountered by states in the application of Landsat data are internal. Political differences are often unavoidable. Loss of strategic personnel can seriously affect the continuity of a state's Landsat program. Reductions in state budgets can prevent acquisition of equipment and staff necessary to implement a satellite remote sensing capability.

On the other hand, the increase in state natural resource and environmental programs has created a demand for data that many feel can be supplied, in part, by Landsat. The advent of compact, low-priced computer equipment has made Landsat data use a more attractive option. Recent NASA programs for technology transfer have led to an increase in the number of states that are now participating in Landsat demonstration projects. The effectiveness of these projects can be measured partially through the state's commitment in terms of computer hardware and software purchase, information system implementation, staff training, and redirection of personnel. There is reason to believe that this broad exposure to satellite-derived data will add to the number of states using Landsat in an operational context.

IV. COORDINATED INFORMATION MANAGEMENT

This thesis now turns to a discussion of coordination, its role in the development of information systems, the improvement of state planning and management capacity, and the increase in state/federal interaction.

Information System Coordination

In the previous discussion of information systems, the institutional factors that were examined each had an implicit, if not expressed, relationship to the element of coordination. While it is not deemed necessary to review these factors individually, it should be noted that coordination plays an important role in the success or failure of an information system. Without the continued use and support of an information system by its user agencies, fragmentation and duplication in data collection will reoccur.

Program Coordination

Active concern for interagency coordination in the establishment of a resource information system can provide a planning tool for coordination of resource planning and management programs at state level. This coordination of functional programs may yield benefits. Wilson and Watkins state that "the purpose of coordination is to harmonize relations, activities and objectives within and between governmental units to improve the intergovernmental delivery of services."³¹ Coordination affects not only interagency and intraagency relationships, but they contend, also bridges policy and program activities

³¹Leonard U. Wilson and L.V. Watkins, State Planning: Intergovernmental Policy Coordination (Lexington, Ky.: Council of State Governments, 1976), p. 99.

both vertically and horizontally.³² Vertical coordination between technician, program chief, and administrator is recognized as a vital element of successful resource management. There has been an increasing awareness that horizontal coordination is necessary to avoid jurisdictional conflicts and policy differences among state entities responsible for individual resource programs.

Multi-agency use of an information system can encourage coordination, both vertically and horizontally. Analysis and display capabilities of a computerized system can improve the program manager's ability to communicate issues and critical information to agency decision-makers. Various agencies which draw upon a common data base as contained in a spatial information system will find a higher degree of continuity among their program objectives and project activities.

State-Federal Coordination

Numerous federal laws enacted during the 1970s contained mandates for federal agency collection and analysis of environmental resource data. The Environmental Protection Agency, Department of Agriculture, and Department of Interior are engaged in massive environmental quality assessment and renewable resource inventory activities. Often these data gathering efforts directly involve the state counterparts of these federal agencies. Much of the data collected by federal agencies is needed by states to perform environmental resource planning and management. Unfortunately, the data is often in a format, or at a level of detail which is of little value to state programs.

Recently, by directives of Congress and the President, federal agencies have begun to coordinate data collection efforts, to exchange inventory

³²Ibid.

information among agencies in a consistent manner, and to use common multi-resource inventory and analysis procedures. Examples of such efforts on the federal level are the Interagency Agreement Related to Classifications and Inventories of Natural Resources³³ and the President's Interagency Task Force on Environmental Data and Monitoring Programs.³⁴

The Interagency Agreement Related to Classifications and Inventories of Natural Resources involves participation of five federal agencies: the Bureau of Land Management, Fish and Wildlife Service, Forest Service, Geological Survey, and Soil Conservation Service have agreed to work together for greater standardization and cooperation in resource inventories. Through coordination with national organizations representing state governments and state resource management professionals, these federal agencies are attempting to involve state requirements into their data collection and data production efforts.

The President's Interagency Task Force on Environmental Data and Monitoring requested the assistance and participation of 19 federal agencies that had expertise, responsibility or interest in environmental data or monitoring. In its final report, the task force found that "improved coordination is at the heart of environmental data and monitoring programs and (it) encourages increased coordination within and between all monitoring and

³³"Interagency Agreement Related to Classifications and Inventories of Natural Resources," U.S. Government memorandum, June 1978.

³⁴President Jimmy Carter's 1977 Environmental Message directed the Council on Environmental Quality (CEQ) to establish a Interagency Task Force to review environmental data and monitoring programs and to make recommendations that would improve their effectiveness.

data programs."³⁵ The report specifically addresses federal/non-federal coordination and integration of land use and natural resource data activities, and suggests that federal data gathering agencies "develop a plan to introduce non-federal data users to federal environmental data coordination activities."³⁶

Development of environmental resource information system capabilities at the state level has put the states in a more favorable position with regard to participation and impact on federal data-related program decisions. Federal officials are aware of the expertise available in state governments to manage resources and, therefore, to articulate information needs. The extent to which individual states capitalize on this newfound credibility will be examined in the next chapter as a component of information system development and utilization.

Summary

This chapter has discussed the use of information within the context of state planning and resource management. The recent technological advances in computerized information management and satellite-derived data applications have been examined. Coordination of information system development and data use has also been addressed. The following chapter will evaluate environmental resource information management in four states, considering these system development strategies, components and issues.

³⁵Council on Environmental Quality, Interagency Task Force on Environmental Data and Monitoring, final report, (Washington, D.C.: March 1980), p. 27.

³⁶Ibid., p. 31.

CHAPTER IV

CASE STUDIES: FOUR STATE INFORMATION SYSTEMS

This chapter describes the development and current status of environmental resource information systems in four states: Texas, Georgia, North Dakota, and Arizona. The states selected for case study had operational systems. Other selection criteria were geographical variation, differences in system design and capability, and experience with the use of Landsat-derived remote sensing data.

The framework used for analysis of the four state systems is comprised of the discussion elements presented in Chapter III. The general characteristics to be evaluated are the institutional factors (origin, official endorsement, organizational setting, user needs, data elements, products, financing, system design/construction and management), integration of satellite remote sensing capabilities in an operational mode, and coordination of system utilization among and between agencies within the state. A description of each system will be followed by a summary of findings based upon this framework.

The case studies were accomplished by site visits and interviews with information system personnel conducted in the spring and summer of 1979. Documents produced by the system staff and follow-up telephone discussions were also utilized to perform the analyses.

I. TEXAS NATURAL RESOURCE INFORMATION SYSTEM

One of the most widely known state data coordination systems is the Texas Natural Resources Information System (TNRIS).¹ Its beginnings can be traced to 1967 when the legislature charged the Texas Water Development Board with establishing a "centralized data bank incorporating all hydrological data" collected by state agencies and boards. Through the Water Oriented Data Programs Section of the Interagency Council on Natural Resources and the Environment (ICNRE), a coordinating body of resource agency heads chaired by the governor, an inventory of water-related data available from eight state agencies was compiled and the Texas Water Oriented Data Bank (TWODB) was established.

It was apparent to TWODB agencies that water resource management required other types of data in addition to water resources data. In 1972, a recommendation was made by the TWODB task force to the Interagency Council on Natural Resources and the Environment to establish TNRIS, with TWODB as a major subsystem. The TWODB task force was expanded to pursue the development of TNRIS. A conceptual design for the system was completed in late 1974, and in 1975 ICNRE approved the implementation scheme and endorsed the appropriation of operating funds by the legislature. Legislative support for TNRIS has been continuous.

¹The information about the Texas Natural Resource Information System used in this section comes from: personal interviews with David Ferguson, John Wilson and Sam McCollough, all of TNRIS staff; "Texas Natural Resource Information System Progress Report," for the period of September 1, 1978 through November 30, 1978; John Wilson and Charles Lancaster, "Texas Natural Resources Information System: Geographic Information System," a paper presented at Harvard Computer Graphics Week, July 1978; "Texas Natural Resources Information System: Water Oriented Data Bank, System Capabilities," August 1977.

Organization and Utilization

Thirteen agencies participate in and guide the activities of TNRIS: Department of Water Resources, General Land Office, Air Control Board, Bureau of Economic Geology, Railroad Commission, Department of Agriculture, Forest Service, Industrial Commission, Department of Health, Department of Highways and Public Transportation, Parks and Wildlife Department, State Soil and Water Conservation Board, and Coastal and Marine Council. TNRIS Systems Central is administratively located in the Department of Water Resources. Although funding for TNRIS is included in the DWR budget, participating agencies also contribute staff time.

Initial TNRIS work identified six major categories of data: Base Data, Biological, Meteorological, Geologic and Land, Water, and Socioeconomic. Machine-readable data held by TNRIS member agencies was inventoried and catalogued in a "File Description Report" as one of the first efforts of the expanded system. Data is contained in the report by category. Each file is accompanied by a brief narrative description including source, geographic coverage, frequency of collection, units of measure, frequency of update, and a publications list.

The primary function of TNRIS is to provide users with a coordinating point for access to natural resources and related data. TNRIS maintains an inventory of natural resources data and provides a central index. The system has links to federal data banks and many other organizations in the public and nonpublic sectors. Computer processing and limited analytical capabilities are available through TNRIS. System Central stores selected data deemed of general utility to member agencies. However, TNRIS is not a unique centralized data

base. Participating agencies are still responsible for collection and maintenance of data to fulfill statutory requirements.

The initial focus of TNRIS services was to assist in meeting member agency requirements for information and processing. It has long been evident that the TNRIS user community is much broader than the 13-agency consortium. TNRIS facilities are available to users in all levels of government, education, and the private sector. The system charges a fee to all nongovernmental users to recover costs of computer time and products. No charge is made for staff time. All fees are returned to the operating budget.

TNRIS serves as a source for primary data rather than analyzing and making interpretations on data. The TNRIS staff is not charged with performing actual analytical work; rather, the data is provided in various formats so that the user may do the analysis and interpretation. This "neutral" stance, according to system staff, improves the ability of TNRIS to maintain vital interagency cooperation.

Use of TNRIS is increasing as participating agencies and others become aware of its wide variety of services. In fiscal 1978, the system reported a 114 percent increase in the number of requests handled over that of fiscal 1977. There were 3,375 data inquiries from 795 different federal, state, regional, and local government units, educational institutions, and private concerns.² Information requests were filled by computer-printed reports, published data and documents, magnetic tape files, punched card files, computer-generated plots, aerial photographic products, and microfilm copies. TNRIS distributes a newsletter on a quarterly basis to provide users with information about current system activities, acquisitions, and services.

²"TNRIS Newsletter," October 1978.

TNRIS data and information are used in statewide resources planning, environmental assessments, enforcement activity, regional and local land use planning, and energy conservation. TNRIS has benefited state government by reducing duplication in data handling, equipment needs, and personnel. A report for the first quarter of fiscal 1979 showed that users from state government made over 45 percent of TNRIS requests.³

System Development

TNRIS represents a comprehensive approach to data management. The automated portion of TNRIS, the Geographic Information System (GIS), is considered only as a component of the total information network, illustrating the broad range of functions TNRIS seeks to perform. However, GIS will facilitate the use of data from the various categories either singularly or in combination; that is, computerized storage, retrieval, manipulation, and output of data can be achieved from one or more of the six data categories using GIS. Analysis can be performed by user agencies which requires that information be accessed from two separate categories and then combined into, for example, map form for graphic display. The existence of GIS will likely cause an increase in the centralized information base and, as a result, demands for data services should continue to rise.

The computerized GIS is closely associated with the Base Data category. This category includes maps, aerial photographs, satellite imagery, and digitized files, and is supportive of the other five data categories. GIS provides TNRIS with capability to store and process this map-related data by computer and to produce maps at various scales in any of several different geographic

³"Progress Report," p. 20.

projections. Specialized hardware includes digitizers, plotters, and interactive graphics terminals.

TNRIS Base Data files contain both imagery and digital tapes from Landsat. Equipment is available for imagery interpretation and computerized classification of satellite data. TNRIS can produce grey-scale maps using digital processing of Landsat tapes.

Landsat-produced data was first used in an operational setting by state government in a project designed to update the state's inventory of water impoundments. At about the same time, multiagency use of Landsat was investigated for inventorying and monitoring coastal wetlands and land uses in the Texas coastal zone. The long-term objective of this effort, not yet fully realized, is to establish a "quasi-operational" system using Landsat data to monitor activities and detect changes in coastal wetlands and land uses for decisionmaking purposes.

Satellite remote sensing data has been used by other state agencies to inventory dams, investigate transitory shallow lakes, and map wildlife habitat. The last application, undertaken by the Parks and Wildlife Department, is considered fully operational by staff who have developed procedures for processing digital Landsat data into vegetation type maps.

Landsat data has generated much interest among TNRIS users. The integration of Landsat-derived data within the system's information base is being facilitated by the multiagency aspect of TNRIS. Systems Central staff is currently testing digital processing of Landsat for utility and accuracy in several applications. Plans call for the implementation of a computerized interface between land cover maps from Landsat and GIS. Staff members speculate that the "optimum utility of Landsat may be reached when digitally processed

data is used in concert with imagery, aerial photography, and other conventional forms of geographic information."

Much of the current testing of Landsat digital data analysis is being conducted under a three year cooperative program between TNRIS and NASA designed to improve existing capabilities and establish new ones for processing and analysis of remote sensing and natural resources data. The objective is to support ongoing needs of state agencies by establishing a capability from which user agencies can generate products on both a routine and per-request basis. Although there is no direct transfer of funds to TNRIS, it is estimated that NASA will contribute about \$600,000 in personnel time and equipment use to be matched by \$750,000 in staff and computing costs from TNRIS agencies. Evaluations of Landsat utility to provide operational support to programs in coastal monitoring, public lands inventory, and the identification of critical areas will be conducted.

Summary Evaluation

The Texas example is one of success in coordinated resource information management. The growth and acceptance of TNRIS by state agencies and other users were achieved with only a limited mandate from the legislature. However, support from the legislature and the executive branch is reflected in continued appropriations and supporting agency enablements.

TNRIS has a formal mechanism of interagency cooperation and a user-oriented approach to system development. This combination has produced an information system widely known and extensively utilized by state government in a genuinely operational mode. A conscious effort to avoid conflict by not performing analytical functions has further strengthened the position of TNRIS

as a service agency. The "coordinating council" approach to system management insures interest and participation by a varied user community.

Landsat used by TNIRIS has been slowly increasing. Satellite remote sensing data is now part of an extensive library of base data contained in TNIRIS files. Participation by TNIRIS member agencies in a NASA-sponsored program will likely succeed in making state agencies more aware of and more likely to use Landsat data to meet selected information needs.

II. GEORGIA RESOURCE ASSESSMENT PROGRAM

In 1972, reorganization in Georgia state government combined a multiplicity of separate units into a single agency, the Georgia Department of Natural Resources (DNR). Structured as a consolidated natural resource and environmental protection agency, DNR has broad responsibilities for resource management. A program was established to create a manual data base comprised of mapped information.⁴ However, it was determined that existing data sources were insufficient for many functional applications.

As a result of activity by the Southern Growth Policies Board, NASA's Earth Resources Laboratory (ERL) sponsored a demonstration of Landsat land cover analysis capability at the National Space Technology Lab in October 1974. Subsequently, NASA and the state of Georgia participated in what could be described as an early prototype of the current Regional Remote Sensing Applications Program. Using ERL facilities to analyze satellite-derived information

⁴Information used in compiling this section about the Georgia Resources Assessment Program comes from the following sources: personal interviews with Bruce Rado, Head, Resource Assessment Unit; "The Georgia Resource Assessment Newsletter," April 1978; "Remote Sensing at Georgia Tech," brochure, undated.

state agencies will be testing the feasibility of using the data for developmental planning and reforestation projects.

Federal agencies operating in Georgia also perceive the need for Landsat land cover analysis. The Soil Conservation Service will utilize the data to determine areas of change relating to water quality and prime agricultural lands. The Army Corp of Engineers, Savannah District, wants to make satellite remote sensing information a part of its data base pertaining to dredge-and-fill permits and environmental studies. The Department of the Army, Fort Benning, envisions using Landsat data to identify certain land cover characteristics for forestry and wildlife management areas of the army base. Regional agencies are looking to apply Landsat digital products for HUD 701 Comprehensive Planning programs. At present, some 70 state and federal personnel from Georgia have been trained in the use of Landsat data and analysis techniques.

System Description

NASA has contributed computer software to the program. The Georgia Institute of Technology has been instrumental in the digital processing of Landsat data tapes on a contractual basis. The Environmental Protection Division, DNR, is presently readying the finished products for distribution to the user agencies. An evaluation of the data products and their applicability to ongoing data requirements will be conducted by program staff following distribution.

Coinciding with the development of Landsat digital processing capabilities in Georgia was the implementation of a computerized data base for manipulation of natural resource information. This data base was developed to merge satellite remote sensing data with other machine readable natural and cultural resource data. Under the data base concept, Landsat-derived information was

a demonstration was conducted on two areas of the state in 1976. This first phase sought to determine the feasibility of using Landsat digital data for resource management. Processing of the two 100-square-mile "scenes" was conducted using nine categories of land cover.

This test application was designed for general use by state agencies. The land cover categories selected amounted to an "all things to all people" approach, the rationale being that agencies would receive an overall picture of the technology and desire more specific program applications. However, consensus among the state users was that total coverage of the state in general land cover categories was most wanted.

The second phase of the program included, therefore, the processing of all or part of 14 Landsat scenes to provide coverage of the entire state. The effort was coordinated by DNR as the lead agency in a consortium of 12 user groups that included four federal agencies, six state-level users, and two regional planning and development agencies. Of these 12, eight users contributed funds toward the \$75,000 project while the others offered in-kind services.

The objective of this phase was to establish an operational capability in Georgia to process Landsat data and generate products required for specific resource management applications. Mapping of the entire state at a 1:250,000 scale has been recently completed. Statistics and land cover for the 159 counties and 198 water quality management units have been aggregated on an acreage basis. In addition, color and cover maps of all counties of the state have been produced.

Product Use

The Environmental Protection Division of DNR is using statistical Landsat data for elements of its water resource management program. The use of satellite data to identify potential solid waste disposal sites is being explored. Other

only one of many data sources used in performing computer analyses for land and resource management. This combination of manual and computerized data files, and the merging of remote sensing data, provided the basis for the Georgia Resource Assessment Program.

The automated data base and digital processing capabilities were developed for the program by the Georgia Institute of Technology on an interactive minicomputer system. This system, operated by the Georgia Tech Engineering Experiment Station, utilizes a minicomputer, color video display monitor, interactive terminal, printer, and other computer hardware. Software was modified and refined by the experiment station staff who had previous experience in digital data processing with NASA.

DNR contracts with Georgia Tech to provide data products. State government continues to operate a computerized storage and retrieval system of baseline data, including Landsat digital tapes. These in-house facilities perform various analytical techniques using spatial data files to carry out routine, operational program responsibilities. DNR will continue to utilize Georgia Tech services in a research and development mode. Private vendors may also be called upon to provide specialized services and products.

Georgia Tech has integrated Landsat and other natural resource data in several applications for DNR. One analysis, performed for the Army Corp of Engineers on a reservoir project, employed 18 different data items. Only one of the data items was Landsat-derived. Geographic data elements, such as soil type, slope, land use, hydrology, historic and archeological sites, and jurisdictional boundaries can be combined in a computer overlay to identify areas suitable for certain land activities. Areas susceptible to erosion and flooding can also be delineated. Output can be both graphic and tabular.

Staff Comment

Staff at Georgia DNR describe Landsat as the building block for development of its computerized data base capability. The multi-temporal nature of Landsat data is viewed as a positive factor in its continued use by state agencies. The use of Landsat by state government and federal agencies in Georgia within a operational setting is being achieved. The processing of Landsat digital data is feasible, but products generated by the DNR coordinated project are, as yet, untested by the user community. Evaluation and further development of the resource management tool are needed. As agencies receive data products and success of the specific applications are appraised, continuing reliability on Landsat as a data source is predicted by program staff.

DNR, in serving as the lead agency for the Landsat technology transfer project, is user oriented. However, because of manpower constraints, this service orientation must be directed toward state agencies and other entities that can provide funds to support production costs. The provision of Landsat-derived data products to regional and local units has been limited to land cover maps already in stock. DNR staff sees the development of low-cost computer hardware and software as having the potential to bring digital processing capabilities to local government.

Georgia Tech staff look upon their data processing capabilities as research and development functions. Although digital processing of Landsat data is operational from a technical standpoint, Georgia Tech staff would prefer to pursue alternate applications of the data base rather than to perform repetitive, operational tasks. In transferring the proven capabilities to other entities, the university staff could concentrate more on research and development aspects of data processing.

Summary Evaluation

The development of analytical tools for resource management using computer-processed Landsat data has been achieved in Georgia through a partnership between state government and university staff. DNR, a state agency, served to coordinate funding and data requests from various users at federal, state, and local government levels. The technical staff at Georgia Tech devised computerized techniques to integrate Landsat data and other conventional sources for producing maps and statistical information.

Landsat data products have been put to use in operational applications by system users. However, factors such as financial constraints and lack of recognition by executive or legislative leaders may limit the program's continued development and could keep the number of users relatively low. Development of information system capabilities in Georgia has proceeded, but further use of system products must occur before an evaluation of agency use can be made.

III. NORTH DAKOTA REGIONAL ENVIRONMENTAL ASSESSMENT PROGRAM

The energy crisis of the early 1970s made possible massive coal-related development in North Dakota. Recognizing the possible environmental and social impacts of rapid, large-scale growth in the energy industry, the 1975 state legislature established the Regional Environmental Assessment Program (REAP) to be funded through a special coal severance tax trust.⁵ REAP was designed

⁵Information concerning the Regional Environmental Assessment Program was taken from: personal interviews with Richard Giddings and Loyola Caron, former program staff; "REAP User Handbook," November 1978; John McKeon, "Land Cover Analysis of North Dakota," REAP Report No. 77-5, March 1977; A. William Johnson, "REAP in North Dakota: Alternatives for Action," State Government, Winter 1977, pp. 16-20.

as a research arm of the Legislative Council, governed by the Resources Research Committee, an assembly of state legislators, executive agency staff, university faculty, and private citizens.

REAP was given the legislative mandate to conduct research and to develop an information system regarding the state's natural resources "for the purpose of assisting in the development of new laws, policies, and governmental actions, and providing facts and information to the citizens of the state." A task force approach was undertaken involving technical experts from federal, state, and local government, and from the state universities and private industry. A total of 11 task forces identified existing data sources, data needs, organizations, and individuals able to assist in data acquisition, and further recommended system designs, future monitoring requirements, and modeling projects. Other system design work was performed by the Federal Systems Division of IBM.

The Resources Research Committee approved the conceptual design for REAP in December 1975. Four responsibilities were delineated:

1. To develop an adequate data base on the environmental, economic and sociologic characteristics of North Dakota.
2. To design and implement a computer-based information system capable of meeting the needs of and being used by decisionmakers.
3. To design and implement assessment and modeling systems capable of forecasting the implications of alternative development activities on the environmental and social characteristics of North Dakota.
4. To design and implement a mechanism for monitoring changes in the characteristics of North Dakota.⁶

⁶"REAP User Handbook," p. I-2.

System Development

In 1976, REAP staff began implementation of Resources Research Committee directives through four major efforts.

First was the development of the REAP Resource Reference System (R3S), a system designed to monitor and catalog North Dakota-related research, expertise, data sources, and documents. R3S is a computerized on-line information bank available to any user. Researchers can quickly identify previous studies on a subject-by-subject basis. Technical experts in a variety of fields can be located. Sources of reports or other documents are also contained. Access is by telephone or mail request. A staff person will respond to inquiries and return the desired information on a computer-generated listing.

Presently, the data base contains over 11,000 references. Numerous automated data banks and selected bibliographies were searched for information relevant to North Dakota. Federal and state publications and reports are included.

The second effort was the implementation of an econometric-demographic (E-D) model to perform impact analysis on selected development alternatives. The model was first applied to southwestern North Dakota, the area of the state most affected by energy-related development.

Base data collection was the third activity undertaken by REAP staff. Acquisition of data commenced in the following areas: air quality, geology, historic site identification, land cover analysis, meteorology, socioeconomic data, water resources, and wildlife. A total of 20 contracts were made with outside consultants to collect the data. The cost of these contracts was in excess of \$1.2 million.

The first data collection effort to be completed was the land cover analysis. REAP contracted with the Bendix Corporation to provide statewide coverage using Landsat digital data tapes. Color-coded maps were produced for each of the 53 counties, and for the entire state, designating 10 land cover categories. Ground-truth information required in the processing of Landsat data was provided by the Institute of Remote Sensing at the University of North Dakota. In addition to mapped data, tabular summaries of land cover data was generated by township and aggregated to county and state levels.

Data acquired through these initial contracts with state agencies, private firms, and universities was converted into machine readable format for inclusion in REAP's computerized information system.

Design and implementation of a system capable of meeting decisionmakers' needs with respect to environmental research was the fourth major activity. Development of computer capabilities included the purchase of computer hardware and software, digitizers, plotters, and interactive graphic terminals. Many innovative system concepts have been developed internally by REAP staff. The information system is user oriented and operates on a keyword basis. Users may request information by broad topics and are given more specific options by the system in order to further identify desired data. Output is available in a variety of forms: maps, charts, graphs, tabular data, and text.

REAP accomplished much in four years. Progress could partially be attributed to its budget: \$2.1 million in each of the two bienniums. This figure represented a substantial portion of the state's total budget of approximately \$600 million.

The relationships between REAP, state agencies, and universities also contributed to the program's achievements. In addition to the multidisciplinary

composition of its advisory committee and formative task forces, REAP's original staff was assembled largely from state university faculty. For the first 30 months of operation, the position of director was held by faculty members; on leave or part-time, from the University of North Dakota. Staff size increased rapidly during development stages, but was reduced to a state complement of 11 full-time employees.

Institutional Changes

The organization and service structure of REAP had undergone near continuous change since its inception in an attempt to "depoliticize" its activity. REAP was unique in that it was established as a legislative information service. However, there was an ongoing controversy over which branch of government should control REAP. From the beginning, REAP conducted research and data collection in conjunction with state agencies. The executive branch leadership saw REAP as becoming an operational agency. The legislative branch maintained its requirement of an independent information source.

As a provider of information, REAP experienced difficulty in remaining neutral. A problem surfaced when REAP-produced data was a key element in a legislative debate over a major state issue. Opposing sides in the debate supported their positions using different interpretations of the same data.

As a result of amended legislation in 1977 and internal program modifications, REAP's primary charge was the promotion of research development: that is REAP applied its expertise to specific research efforts in order to provide users with the tools to perform analyses rather than conduct the analysis in-house. REAP developed the capacity but turned the continued operation over to the user.

REAP divested itself of the computer hardware it once possessed. Day-to-day operation of the information system was transferred to a centralized data processing agency of state government. The State Library has taken over responsibility for the R3S.

Program Termination

Program administrators initially resisted changes to redefine REAP as a research and development unit. However, they felt that the survival of the program may have been at stake. A proposed research and development effort was drafted for fiscal 1979-81 that contained 36 individual programs. To further underscore the position that it was not moving toward operational agency status, the proposed program budget stated that REAP would "attempt to contract for work with existing state entities, rather than . . . increasing the number of in-house staff." The staff supported the idea of contracting for research, but feared that REAP would be forced to provide "grant" money to agencies to perform operational responsibilities. The legislation necessary to reauthorize REAP for the 1979-81 biennium included a provision to rename the agency. The new title of Scientific and Technological Research and Development Program was proposed, along with a budget of \$2.6 million. The legislature passed the bill, but reduced the authorization to \$1.6 million. However, the governor vetoed the bill, effectively terminating the agency as of June 30, 1979. The governor, in a statement about his actions, cited legislative attempts to gain too much control over REAP activities as a reason for the veto.

Political conflict was not the sole reason for REAP's dissolution. System staff claimed that the legislature could have saved REAP if it had desired. The REAP director contended that "the average legislator never knew what REAP was and never really cared."

Use of Landsat

Land cover data was identified as a base data priority need for a variety of state program areas. However, the contract with Bendix to provide maps and tabular summaries was only one of 30 projects executed during fiscal 1975-77. The decision to use private consultants for the analysis was due primarily to time constraints and the initial cost of acquiring the necessary computer facilities. Both state universities and a state agency had proposed in-house development of Landsat digital processing capabilities. Some problems were encountered in putting together the individual Landsat scenes in mosaic form, but these difficulties were resolved by Bendix to the general satisfaction of REAP staff.

Land cover products were received from Bendix in January to September 1977. During 1977-78, over 100 users requested Landsat-generated data from REAP. Workshops were held by REAP staff on the potential uses of the land cover maps and tabular data. Software was developed to make Landsat data more applicable to 208 water quality planning by combining land cover digital tapes with drainage basis files. Other state agencies and commissions employed maps and data summaries for a variety of uses.

REAP staff followed up on the use of Landsat products by conducting a user survey. Findings indicated that there were high expectations among user groups, but that, overall, the materials had low applicability. The multi-purpose continued use of Landsat data that had been anticipated by REAP did not occur. Staff noted a rapid decrease in requests for land cover products since the summer of 1978. REAP's inventory of Landsat data was described as a "pretty tool looking for someone who needs it."

REAP reported no further work with Bendix other than planning for follow-up activity. Bendix has since stopped processing Landsat data. Before program termination, REAP had begun an accuracy study of the land cover maps in conjunction with NASA's Regional Remote Sensing Applications Program.

However, despite a less than satisfactory first experience with Landsat, REAP staff stated that new applications for satellite remote sensing data were being explored for the coming biennium. It was felt that REAP should develop in-house capacity to best utilize Landsat data as a tool to get products of value. This development was planned to proceed cautiously. REAP staff intended to work with potential users to determine if further development of Landsat capabilities was appropriate. They stated that continued interest in Landsat did not stem from the belief that satellite-generated data was intrinsically more useful than previously shown, but once the information system's infrastructure was in place, the tool could be used in conjunction with alternate data sources.

Summary Evaluation

The rapid development and equally swift demise of REAP may provide a lesson for other states engaged in the establishment of environmental resource information systems. Its unstable position, dependent upon biennial renewal, and caught in a politically undesirable situation between legislative and executive branches, ended what could have been a model for comprehensive and integrated data management at the state level.

In North Dakota, limited integration of digitally processed Landsat data with a computerized information system had occurred. Private industry and in-house development of computer software were instrumental in establishing

a state land cover data base. The state universities also participated in this unique data management effort.

The investment of over \$4 million in REAP failed to overcome the lack of interest in the system by decision-makers. This can also be conceived as the inability of the program to provide users with needed products, i.e. too much effort went into building system capability, and too little toward servicing the needs of state agencies.

IV. ARIZONA RESOURCES INFORMATION SYSTEM

In 1972, the Arizona Resources Information System (ARIS) program was established within the governor's office.⁷ Its function was to coordinate the development and acquisition of an "orthophotoquad" base map series for the entire state. Orthophotoquads are composite high-altitude aerial photographs and USGS quadrangle maps. The orthophotoquad program was a cooperative effort by the state, USGS, and NASA. The base maps were designed for a variety of resource management uses, recreation, and transportation planning.

Mapping was completed in mid-1973. ARIS initiated efforts to distribute the products among public and private users. In-house application of the orthophotoquad maps was minimal; rather, ARIS concentrated on making maps available and assisted users in developing the information to suit specific needs. The information system gained recognition among state agencies and by executive order, was relocated within the Department of Revenue. Rationale for the move was that the Department of Revenue was a central point for

⁷The information contained in this section about the Arizona Resource Information System comes from these sources: personal interview with Michael S. Castro, Chief, Information Resources Division; Glen Goodwin, "Benefit and Impact of the Arizona Land-Use experiment," NASA CR-151986, January 1977.

information gathering and dissemination in state government.

However, the Department of Revenue initially made little use of ARIS, which resulted in a reduced budget for the program. Subsequently, executive and legislative review of ARIS revealed that the information system performed a valuable function and had user support. ARIS was given the directive to investigate the use of Landsat by state government and to assume the functions of the EROS Applications Assistance Facility in Phoenix, namely, accessing U.S. Department of Interior imagery from both aircraft and satellite.

ARIS undertook an increased role in the collection, maintenance, and distribution of spatial data. Building on the orthophotoquad program, the information system staff began developing expertise in the use of Landsat satellite imagery. Landsat data was used to monitor changes in land use. This "future change detection" application is an important resource management tool that is particularly suited to Arizona, which is sparsely populated with rugged terrain and large government land holdings, but experiencing rapid population growth and development in a few urban regions.

Recent Development

During the 1978 legislative session, a bill was passed which established a Resources Division within the State Land Department, the natural resource agency. This statute had the effect of establishing ARIS as one of seven functional divisions in the Land Department. ARIS personnel, equipment, and funds were transferred intact. The legislation contained certain mandatory provisions to be carried out by the Resources Division, which included:

1. Provision of an information data bank for the State Land Department by computer composing the data from remote sensing technology, other technical sources and the orthophotoquad program.

2. Change detection by remote sensing.
3. Production of maps and inventories for various geographic and governmental units.
4. Classification of state trust lands to assist in valuation.
5. Function as the state's affiliate for the National Cartographic Information Center (NCIC).
6. Coordinate state and local use of Landsat data for agriculture, wildlife, forestry, land minerals, water and other resources.⁸

Additionally, the law permits the Resources Division to establish a liaison with local government for collection, maintenance, and distribution of resource information.

Legislative commitment to ARIS further reflected through an authorization to develop in-house computer capability. Like many states, Arizona has a computer centralization policy which reserves the purchase or operation of automatic data processing to a single state agency. However, ARIS was able to overcome this policy barrier and receive appropriations for acquisition of a minicomputer, digitizer, drum plotter, and other hardware and software.

According to staff, the use of computers will enable ARIS to operate with a minimum staff and stay within a relatively tight budget. The division has an average of six full-time employees with an annual budget of approximately \$250,000. Legislation that limits property tax increases to 7 percent annually has forced administrators to make tough spending decisions and to seek economically sound techniques.

⁸Senate Bill 1307, State of Arizona, 1978, amending Title 37.173, Arizona Revised Statutes.

System Utilization

ARIS provides a centralized source of maps, aerial photography, and satellite imagery for Arizona users. Federal, state, and local government users have obtained data products from ARIS for a variety of land use applications. The State Land Department, which administers about 9 million acres of state land, employs Landsat imagery to determine land cover and monitor use changes. The Office of Economic Planning and Development has applied Landsat to locate remote subdivisions throughout the state. The Water Commission identifies watersheds, vegetation, and flood-prone areas using satellite imagery. Landsat has been used to complement high-altitude photography and other conventional data sources in most applications. The advent of digitally processed Landsat data in Arizona will likely promote increased use of satellite remote sensing in state government.

Federal management agencies in the U.S. Department of Agriculture and Department of the Interior have utilized Landsat to a lesser extent and have relied more heavily upon the orthophotoquads. Private users, primarily consultants, utilities, and extractive industries, represent a large segment of the ARIS user community. These private companies have used both imagery and high-altitude photography in their applications.

Although ARIS is a centralized supplier of information, its data base is for the most part restricted to maps, orthophotoquads, and imagery. At present, ARIS does not possess a computerized file of spatial data which describes various geographic units. However, ARIS staff has achieved integration of Landsat with other data sources and has aided users in performing analyses for specialized applications. Products obtained through ARIS,

contend system staff, have made an impact on governmental programs and public and private decision-making.

System Future

At the time of the site visit, ARIS was acquiring additional hardware and staff was building the capacity to process digital Landsat data. System staff felt that computer processing of satellite data tapes would enable them to undertake more detailed analysis of land use changes and to better monitor activities on public lands than could be achieved by photo interpretation of Landsat imagery. ARIS personnel considered, however, that information produced from Landsat had been used in an operational mode for the past several years. This contention was based primarily on the combined utilization of imagery and the orthophotoquad maps; that is, the repetitive nature of Landsat enabled ARIS to monitor changes since 1972-1973 when the high-altitude photography was taken.

Digital analysis will prove to be an even greater resource management tool for state government and other users, according to ARIS staff. The improved resolution of future satellites, plus the technological advantages of computer processing, will make satellite data more attractive to primary users in the Land Department and other state agencies, and also to universities, private users, and the federal government. ARIS personnel believe that Landsat is the answer for Arizona. From a cost standpoint, Landsat represents the only economical alternative to update the orthophotoquad coverage of the entire state. Satellite-derived data can be substituted for the more costly high-altitude aerial photography which can be conducted at five- or 10-year intervals, if the funding is available. The staff also stressed that increased acceptance

and use by state agencies is a continuing educational process and that federal agencies, which own or administer about 45 percent of the land in Arizona, need more economical ways to collect data.

Federal Agency Role

Initial capability to utilize Landsat data was developed with no direct assistance from NASA. More recently, Ames Research Center has been requested to modify software for use on a newly acquired minicomputer system. The center is also coordinating a demonstration project to produce a geocoded mosaic of digital Landsat data for the entire state. ARIS staff will soon be involved in NASA's Regional Remote Sensing Applications Program with other Arizona state agencies to investigate the utility of satellite data in several ongoing state program applications.

According to ARIS operators, the federal government should take a lead role in helping states implement ongoing utilization of Landsat for resource management. They are skeptical of private industry's ability to provide reliable support to government agencies wanting to acquire Landsat analysis capability and feel that NASA should work with the private sector to develop hardware and software which are both affordable and able to be maintained by agency staff. In the opinion of ARIS staff, the private sector is not operational. They stated that no firm that marketed Landsat products has remained in business longer than five years and that products from a private vendor were not practical from a price standpoint.

Performance Audit

The views of ARIS staff on the achievements, both past and future, of the information system varied greatly from findings of the State Auditor

General in a March, 1980 report to the legislature.⁹ Requested by a resolution of the Joint Legislative Budget Committee, the performance audit concluded that:

Both historically and currently the scope and goals of the Arizona Resources Information System have been inconsistently stated, accepted and applied. Although identified as essential nine years ago and again in 1978, ARIS has not documented justifiable user-need for the system and currently has no plan to guide and coordinate system development, to define data needs and uses, to justify equipment needs or to determine priority of system applications. The combination of unclear goals, unidentified user needs and the absence of a system plan has resulted in confusion in the legislative and equipment-acquisition processes with resulting lack of legislative support, indefinite system direction and the unjustifiable use of sophisticated computer equipment to perform rudimentary record-keeping tasks.¹⁰

The report recommends that the Legislature appropriate funds to allow for acquisition of additional computer equipment necessary to build a complete spatial information system, that a user needs study be conducted and a system plan be developed. Further, the performance audit suggests that the Legislature "clearly define the scope, goals and users of such a system."¹¹

Summary Evaluation

It is evident, from the findings of the performance audit, that ARIS has been unsuccessful in serving as an environmental resource information system. The system failed with respect to many of the institutional factors despite having initial executive and legislative support, and a seemingly

⁹Office of the Auditor General, "A Performance Audit of the Arizona Resources Information System," Report 80-1, March 1980.

¹⁰Ibid., p. 28.

¹¹Ibid., p. 29.

proper location within the state's resource management agency. Financing for the system, approximately \$1.5 million since 1972¹², should have been adequate to achieve operational status and serve users from various state agencies.

Many potential uses of the system had been identified throughout state government, yet ARIS was able to serve only several divisions within the State Land Department, and then only in a limited manner. No coordinated agency utilization of a resource information base has occurred in Arizona.

ARIS has yet to accomplish complete integration of Landsat data processing for operational government applications. Staff can presently interpret satellite imagery, but digital capability is still in the early stages of development.

V. ENVIRONMENTAL RESOURCE INFORMATION SYSTEMS -- COMPARATIVE EVALUATION

The examination of resource information systems in four states affords this research a few examples with which to evaluate the performance of state government in resource information management.

Institutional Factors

The four systems exhibited considerable differences in system origin; two, North Dakota and Texas, growing out of crisis situations while the others evolved with no apparent single impetus. System origin was not a determining factor in its success or failure. Flexibility to serve a variety of user needs, regardless of circumstances under which the system originated remains a developmental and operational objective.

¹²Ibid.

Official endorsement was evident in all cases except for the Georgia Resource Assessment Program. This factor does not appear to be a critical institutional element based on the case studies. In fact, information presented in this thesis would suggest the opposite. Systems in Arizona (ARIS) and North Dakota (REAP) were created by the legislature. However, ARIS was recently scrutinized by the legislature for poor performance and REAP was abolished by the Governor.

As for organizational setting, the Texas Natural Resource Information System (TNRIS) functioned as an independent entity, REAP was unique in its legislative research location, and systems in Arizona and Georgia were located in consolidated natural resource agencies. No conclusion can be drawn with respect to an optimal location within state government for placement of a resource information system. Successful system development is more likely to be dependent upon the freedom that a particular location affords a variety of system users. Improper location is one in which the system is bound to a single agency or one which restricts its widespread utilization by resource management agencies.

With regard to user needs, TNRIS was most active of the four systems studied by virtue of its 13 agency coordinating council. In North Dakota, REAP user needs were identified at the program's outset, but subsequently limited, and after the fact evaluation of user reaction to products occurred. In Georgia, evaluation was also performed following the generation of data products. The study of Arizona's system found no activity in the area of user needs assessment. This factor must be considered primary to continued system operation. A definition of user needs establishes priorities for data

collection and product generation. User needs assessment should be a continuous process.

User needs translate first into data base construction. In Texas, the system was able to draw upon a variety of data bases from member agencies. REAP used its substantial funding to collect numerous inventories and construct many data files. Georgia dealt almost solely with spatial data elements while the Arizona Resource Information System (ARIS) was limited to maps and remotely sensed photography and imagery. The data elements contained in an information system must be appropriate for user demand and must be kept up-to-date if they are to retain their usefulness.

Data products generated by the information systems were a reflection of the data elements contained in the system. The Texas Natural Resource Information System responded to thousands of requests annually. Its products were in many different forms. Products of the Georgia Resource Assessment Program consisted of graphic, tabular and mapped outputs. In North Dakota, many products were still under development when the program was abandoned. ARIS distributed maps and imagery and generated only routine reports. Demand for system products is dependent upon the utility of its products. The demand for TNIRIS products indicated that its services and outputs are useful. The direct relationship between user needs, data elements and products is one which deserves much attention by the system manager.

The financing of these four systems ranged from a \$4.2 million, four-year budget in North Dakota to the \$1.5 million spent in Arizona. Because of numerous matching and in-kind agreements, it was not possible to determine system expenditures in Texas and Georgia, but it can be estimated that TNIRIS funding falls between totals spent for REAP and ARIS, and that the Georgia

Resource Assessment Program has received significantly less than any of the other systems. It can be determined through the case studies that financing alone will not lead to a successful system. Funding must be adequate to allow for continuity in services and to meet changing user demands. Financing is provided for state information systems from a variety of sources. A positive factor would be the existence of broad-based funding, so that withdrawal of support from any few sources would not cripple the system.

System design and construction appears to vary greatly from state to state. Differences in equipment, facilities, contracts with private consultants and university research staff give each system its singular character. It is essential for computer hardware and software to be compatible with the design of the system, however, it cannot be determined from this study if certain system configurations are superior to others.

Finally, management offers several clues to a successful system. In Arizona, system staff was unable to achieve operational capacity even with sophisticated computer hardware. In North Dakota, the inability of staff to involve and educate legislators and to smooth political differences led to REAP's demise. In both Georgia and Texas, management was able to satisfy the demands of various users while avoiding political conflicts. Management not only means providing the necessary skills and staff resources to service users, but also requires a political orientation which is critical to survival of the system. Not only must system products meet requirements of technicians, analysts, and program managers; a system's value must also be demonstrated to decision-makers.

Integration of Landsat

Environmental resource information systems in all four states were experienced in the use of Landsat information. Georgia and North Dakota have both produced statewide land cover maps. County level maps and tabular land classification summaries were also developed. In Georgia, product generation occurred in-house while REAP contracted with a private corporation.

In Arizona, experience with satellite remote sensing data was limited to imagery interpretation. Digital processing of Landsat data has not been achieved. Texas is perhaps the most familiar with Landsat-derived data. TNRIS has used imagery and digital products for a variety of applications.

Integration of Landsat data with conventional data forms in an information system has occurred in Georgia, North Dakota and Texas. In Arizona, integration did not occur because imagery and photography were virtually the entire data base, i.e. there were no conventional data sources with which to integrate. North Dakota, after achieving the ability to integrate Landsat remote sensing data into REAP ceased using the information prior to the program's termination.

Georgia and Texas continue utilization of Landsat as a data source valuable for change detection and monitoring of land use and land cover. Texas is testing several specific applications of the technology for operational use in state programs.

The case studies indicate that although there is widespread experimentation with satellite technology, difficulties in making the transition to operational use within state agencies are being encountered. Integration of Landsat derived data into state information systems will not occur unless there is a sufficient demand for satellite remote sensing products, and

assistance by federal agencies in the development of sophisticated processing capabilities.

System Coordination

Of the four case study states, system coordination was highly successful in one state (Texas), and moderately significant in another (Georgia). However, coordination of the user community in North Dakota, although attempted, did not produce the desired results because of legislative/executive branch conflicts. Coordination of various user groups was apparently not seen as a necessary element to success in Arizona.

In Texas, multi-agency use of TNRIS services has led to increased cooperation among agencies that have identified common data requirements and in many cases utilized common data files of the Geographic Information System component. The formal mechanism of the 13 member TNRIS interagency council insures coordination of user services and identification of needs.

Housed in the Department of Natural Resources, the Georgia Resource Assessment Program has coordinated participation by various user agencies in several demonstration projects using Landsat data. The coordinated, multi-agency approach made possible the funding of program products which were then made available to agencies throughout state government. And, coordination with university researchers at Georgia Tech enabled the development of computer processing techniques which enhanced system capabilities.

North Dakota attempted to establish coordination between users in both the legislative and executive branches. However, the committee appointed to oversee its design and implementation could not foresee problems such as the use of a REAP produced analysis by opposing groups of legislators, each

claiming that the data substantiated their contention. Other coordination efforts were hindered by the fact that REAP was a legislative research arm, and its use by executive agencies was somehow tainted by this fact.

In Arizona, the information system did not gain status as a coordinated service provider even within its own agency, the State Land Department. Its claim as centralized supplier of maps and photography is valid, but ARIS was not able to generate information products required by state management agencies.

In all case study states, the information systems has a positive working relationship with federal agencies. Each state had received some form of assistance from NASA in developing or evaluating the use of Landsat as a data source. Other federal agencies participated in specific data projects or were regular system users. This use of state level information systems by federal agencies has led to greater cooperation between state and federal users and producers.

Outlook

The case studies of state environmental resource information systems presented in this chapter illustrate that the collection, maintenance, analysis, and distribution of a variety of program-related data have been centralized. Numerous agencies have participated in cooperative data-sharing efforts. The benefits of such an approach are a reduction in duplicative data collection and its associated costs, the establishment of a consistent resource data base, and a closer working relationship among participating agencies.

This chapter has shown that state interest in environmental resource information systems exists in various regions of the country and at different

stages of development and sophistication. The data demand of environmental resource programs should continue to provide the impetus for more states to establish computerized data management systems. If these case studies provide a representative sample, future system development will occur in a variety of locations, have a wide range of technical capabilities, fulfill various user needs, expand upon cooperation with users at the federal, state and local levels, and generate data products required by numerous resource planning and management programs.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

The following sections contain the conclusions and recommendations of this research. Conclusions are made with respect to state environmental resource planning and management programs and the requirements these programs have for data and information. Conclusions and recommendations are made for the development and continued utilization of information systems that complement state programs. It is felt that recommendations for the state resource planning and management function are inappropriate within the context of this thesis.

I. CONCLUSIONS

State Environmental Resource Planning

1. New comprehensive state land use control initiatives are virtually non-existent. This is due, in part, to the failure of National Land Use Planning Legislation. It also appears that comprehensive planning approaches are being replaced by functional planning and management programs developed in response to numerous federal mandates.
2. With the creation of new state level programs in response to federal initiatives has come the recognition of the need to better coordinate these various programs. States are integrating land use related programs through various structural and non-structural methods. Paramount to these coordination efforts is the need for an overall policy framework which guides functional planning programs.

3. Information collection and analysis plays a key role in the state resource planning process. Because of problems related to data gathering, processing and distribution, state governments are developing mechanisms to more effectively and efficiently serve their resource information needs.

Resource Information Systems

1. Computerized techniques for environmental resource data management are gaining popularity in state governments. They are integral components of the resource planning process in many states.
2. State initiatives in the development of computerized information systems for resource planning are faced with numerous barriers to their implementation and continued operation. Issues surrounding a successful information system include institutional considerations, utilization of new technologies, and coordinated use by state agencies.
3. With respect to institutional factors, the case studies indicate that origin, official endorsement, organizational setting, financing, and system/construction are not, considered individually, critical elements to information system success. This research can reach no conclusions that there exists a model approach to these elements.
4. The institutional factors of greatest significance are user needs, data elements, products and management. This study suggests that these elements are the crucial performance measures of an information system. The critical path for system development/operations is to define the information and analysis requirements, collect the needed data, and generate the requested product in a timely manner.

5. The utilization of satellite remote sensing data in conjunction with state information systems is occurring. However, there are problems which prevent a fully integrated and operational use of the technology. These problems include the experimental status of the Landsat data system and present lack of user demand for products.
6. Coordination of system utilization is an issue which permeates all aspects of its operation. Coordination among user agencies reduces duplication in data collection, provides a consistent resource and promotes interagency relationships.
7. Recognition of state government data needs by federal agencies is improving and coordination between these levels is occurring. However, states have not achieved the status of active partners in federal data-related decisionmaking.

II. RECOMMENDATIONS

Resource Information Systems

1. To better meet the information requirements of state environmental resource planning and management program, and to gain the benefits of data coordination, states should establish computerized information systems for collection, storage, manipulation and distribution of data and data products.
2. The information system should serve as the centralized repository and processing point for environmental resource data within a state. It should be housed in a location which allows the system to serve a variety of user groups and not be bound to a single agency or set of users.

3. In developing and operating the system, foremost attention should be given to the definition of user needs. The requirements of individual users sets the standards for data collection and products. Determination of user needs should be a dynamic process of feedback.
4. A key element to system success is flexibility. The information system must be able to adjust to changes in demand, endure budgetary restrictions, combine multiple sources of funding and staff time and accept technological advances.
5. The manager of an information system must be politically-wise. He must be able to detect potential problems and "defuse" them effectively. He must be able to provide executive and legislative decisionmakers with ample evidence of his systems value to state government operations.
6. To ensure operational use of Landsat by a state resource information system, the federal government must act to make the satellite remote sensing system operational. It must provide states with the necessary training and technology transfer programs in order to justify expenditures for equipment and staff necessary to utilize Landsat data.
7. States should strive to promote even greater coordination of data collection and processing. The establishment of a coordination group to oversee the development and operation of an environmental resource information system is recommended.
8. Increased participation of states in federal data-related decisions is needed. Federal/state working groups and advisory committees should be established to identify common data issues and to suggest possible actions for meeting agreed upon needs.

States have made substantial progress in the 1970s toward meeting the challenge of resource planning and management. Information has played a pivotal role in this progress. In the coming decade, state governments will continue to improve on their coordination mechanisms and enhance their ability to plan. Computerized information systems should assist states in this regard by acting as a focal point for resource data collection and distribution.

In the 1980s, the growth of resource planning and management functions within state government will likely slow, and if current economic conditions persist, state agencies may face budget and staff reductions. Many environmental resource programs conceived in the previous decade will reach maturity and thereafter consist largely of administrative and monitoring activities. State-federal relationships will also undergo changes that could provide state governments more flexibility in program direction and emphasis. And as the nation and the world place greater demands upon this country's forests, croplands, energy and mineral resources, and fisheries, states will assume an increased role in the mediation of environmental and economic conflicts.

As these changes occur, state officials will increase their dependence upon information systems as reliable and cost-effective tools for analytical and monitoring tasks. Planning and decisionmaking will require the instantaneous delivery of information products. Computerized data processing and display techniques will be further refined to meet the challenges posed by environmental resource management.

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