DESIGN AND IMPLEMENTATION OF DECISION SUPPORT SYSTEMS FOR ENVIRONMENTAL MANAGEMENT

by

STEPHEN THOR JOHNSON

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Signature of the Author _____
Department of Urban Studies & Planning
May 17, 1988

Certified by _____
Philip Barnard Herr
Adjunct Professor of City Planning
Thesis Supervisor

Accepted by _____
Donald A. Schön
Director of the Master's Program

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ABSTRACT

The issues influencing the design and implementation of a microcomputer-based decision support system (DSS) for a public environmental agency are analyzed. A case study of the design and implementation of a land information system (LIS) for the Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement (DFWELE) is presented. The LIS in this case is to be used to improve the efficiency and effectiveness of decision making in the DFWELE Land Acquisition Program.

The case specific decisions affecting the design of a LIS are discussed with reference to published theories and guidelines for design and implementation of information systems. The critical dimensions of this problem are classified as: 1.) sound and stable system design, 2.) analysis of the organizational setting to insure a good fit between the system and the organizational setting, and 3.) appropriate and effective use of decision support methodologies for decision making. Each of these dimensions is analyzed with respect to the design, implementation and use of a LIS for land acquisition and conservation.

Thesis Supervisor: Professor Philip Barnard Herr, M.C.P.

Title: Adjunct Professor of City Planning

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I. Toward Effective Environmental Management

Effective environmental management is the key to the health, even the survival of our society. We have so altered the natural environment to serve our material needs; for agricultural production, water supply, energy exploitation, mineral resources, for human settlements; that society is at a juncture where it is not possible to stop modifying the environment if the human species is to survive. However, it is even more important that we as a society protect a sizeable fraction of the few remaining undeveloped natural biological communities in a natural state. We need to leave this critical fraction of the earth's natural communities in a whole, functioning state. These natural ecosystems provide a homeostatic force more powerful than our technological society can maintain through technological interventions and attempts to manage the environment. Therefore, a major objective of environmental management must be to identify and protect these natural communities in sufficient extent and variety that the health and prosperity of our society is ensured. In this sense, we all have a responsibility to contribute to the job of environmental management: moreover it is in our own interests to do so.

Environmental management is not a single discrete academic discipline, nor is it a unified professional field. The scientific basis for environmental management derives from each of the natural sciences, but environmental management is also a social process. The ability and techniques to effect changes in the ways that we interact with the natural environment derives as much from the social sciences of economics, political science and sociology as from our scientific knowledge and technological interventions. Ultimately, our efforts to manage the environment are only as effective or enlightened as the organizations and institutions that alter the environment.

The unifying characteristic of all these approaches to environmental management is a common need for accurate, up to date, information about the spatial distribution of natural resources and human activities across

the land. The environment is heterogeneous, and our use of the land has been heterogeneous in response to the spatial variation of the natural resource attributes of the land. In order to guide our use of these resources and insure that we can sustain our quality of life we must be able to manage a tremendous amount of data, spatially referenced, about these natural resources and human activities. These data must be organized in such a way as to provide us with relevant information which will enhance our ability to make effective decisions regarding our use of the land.

Effective environmental management is predicated on effective land-use planning. Environmental considerations must be central to our land use planning decisions. It is essential to integrate explicit analysis of the natural resource attributes of a place when making land use decisions so as to ensure the continuing viability of our existing land-uses; especially, water supply watersheds, farmland, parklands, swimming areas, fisheries; many of which are fixed by the location of natural resources such as aquifers, fertile soil, undeveloped landscapes, sandy beaches, and wetlands.

We need to know where these resources and existing land-uses are, but it is difficult to obtain reliable information about the land that is usefully organized so as to inform land use decision making. There is too much information that is difficult to keep up to date, and typically the responsibility for maintaining data about the land is divided among many different public agencies.

Making sense of this information for land use planning is hard because of cumulative and interactive effects of different land uses. Certain types of land use are patently incompatible, such as underground storage tanks and aquifer protection districts for protection of public water supply wells. Land use planning is particularly hard because of change over time, and uncertainty about the future demands on the land, or even about the nature of past uses of the land. Love Canal, NY presents but one instance of a bad land use decision-- development of a housing

subdivision-- resulting from of inadequate information about incompatible land uses in the past.

The temporal problems in land use planning are exacerbated by the current development context, which is characterized by explosive change. The extreme pace of development is especially severe in Massachusetts, but broad regions of the country have also been affected by rapid growth in the 1980s. For example, building permits for new housing in Massachusetts jumped nearly 200 percent between 1982 and 1986, from 15,455 to 45,215 units authorized. This development and the associated growth in industrial and commercial land uses, and the infrastructure to support this growth, consumed 112,000 acres between 1981 and 1987, with almost 30 percent of this growth occurring in 1986 alone (Greenbaum and O'Donnell 1987).

Explosive growth such as this means that land use decisions must be made rapidly, in a rapidly changing environment, without sufficient time to evaluate the impacts of previous decisions. As a result, the cumulative and interactive effects can cause the basic environmental support mechanisms to unravel. This has been dramatically demonstrated in the case of public water supply wells in Massachusetts. In the area served by the Metropolitan Area Planning Council (101 communities in the metropolitan Boston area), 62 communities rely on groundwater for their public water supply. But due to contamination from inappropriate land use practices, 45 municipal wells have been closed resulting in the loss of 20 percent of the total public water supply capacity from wells throughout the region (MAPC 1987).

One of the resources most threatened by growth, by definition, is our supply of open space. While we depend on open space to provide a measure of balance to our intensive uses of the land, as well an endowment of resources for the future, the rapid pace of development is consuming open space at a much faster pace than the state and environmental groups have been able to purchase and preserve it. One estimate puts the rate of development or loss of open space in units of Boston Commons lost per

week. At a rate of 600 acres developed per week in 1987, we are losing the equivalent of 12 Boston Commons each week. (Greenbaum and O'Donnell 1987). Last year the Massachusetts Audubon Society convened a conference to address the problem of protecting open space. A report prepared by Audubon summed up the situation:

> ...with the unprecedented economic growth has come unprecedented pressure on the open spaces of the Commonwealth -- its farmlands, forests, wetlands, water supplies, and wildlife habitat. In some areas of the state, open space is disappearing at such a fast pace that it is becoming an increasingly rare commodity. In other areas of the state, the growth has just begun. And as open space disappears, so do many of the amenities -- the clean beaches, the parklands, the uncontaminated water -- that have made Massachusetts such an attractive place to live and work (Greenbaum and O'Donnell).

By protecting open space, we preserve many of the environmental amenities that contribute to a desireable "quality of life," but we get much more than that. Strategic acquisition of open space can be an effective way to buffer incompatible land-uses such as; water supply aquifers from industrial parks, industrial parks from residential neighborhoods, commercial districts from rivers and streams, and critical wildlife habitat from developed land.

How can we make rational and strategic decisions about acquiring open space in this context of explosive growth? Effective open space planning is really just a special case of land use planning, and there is a body of theory and an array of techniques for land use planning. Despite the limitations of many of the traditional methods of land use planning, these are a point of departure for developing more specialized techniques for open space planning. Open space planning is not a unique problem; however, as yet the methods of land use planning have not been used as widely or effectively as is needed to identify and protect open space.

The process of open space acquisition and protection is similar to the process of identifying and acquiring a parcel of land for siting any other facility. It involves looking for certain attributes of the place that make it an attractive or feasible location for that particular use. There

is a collection of land use theory and methodology called suitability analysis, and it can apply to open space siting as well as to siting an office park or other built land use, albeit with different criteria used for evaluating suitability.

Despite the existence of theory and techniques, suitability analysis is difficult for at least three reasons:

Time Frame: past and future land use decisions bear on the current decision,

Values: subjective estimates of the significance of characteristics of the land and the interaction effects with other land uses are involved,

The unstructured nature of the problem: suitability analysis is hard because the decision is unstructured with respect to the scope of the problem; which attributes, what scale of impacts, and what alternatives are to be considered.

These factors can trigger a reaction by decision makers in which they attempt to study every aspect of the problem before making a decision. This comprehensive study of options and alternatives is laudable, but impractical. In the face of many different types of uncertainty; over the relevant time frame, different subjective estimates of significance, and scope of options to consider; there is a temptation to collect more information than can be meaningfully used in making a decision. The result is information overload.

The increasing availability of computer tools for assisting in organizing and synthesizing this information for land use planning has increased the tendency towards information overload. On the other hand, these computer tools present the possibility for productively incorporating more relevant information into the decision making process. The challenge lies in the effective use of these computer tools.

Computer Tools for Land Use Planning

What are the computer tools available for land use planning, and how might they be used for open space planning? What potential do they have for improving land use decisions, and what are the difficulties associated with the use of these computer tools?

The tools that I will discuss fall into two classes; those designed primarily to increase the efficiency of managing information about land, and those designed primarily to increase the effectiveness of decision making. This is an important distinction to make in principle, as the systems may have rather different structures. However, there is considerable overlap between these two classes of systems. Both types of system have their origins in the corporate data processing tradition, and I will define the two systems in that context, and then discuss the adaptation of these paradigms to land use planning systems.

Management Information Systems for Structured Tasks

Generally speaking, the computer systems that focus on increased efficiency of information processing for management are called information systems, or Management Information Systems (MIS). Various types of computer systems have been developed to provide managers with information relevant to the decision making tasks that they face daily in business situations. The vast literature on MIS indicates the importance of this branch of management science. The essential characteristics of a Management Information System are a database of data related to the operational activities of the organization, with various summary reports for providing information to managers for increasing the efficiency of decision making. Recently, corporate information centers have facilitated the manager's interactive access to the data in addition to reports. Over all, the focus of MIS has been on improving access to information needed for relatively well structured tasks.

Decision Support Systems for Unstructured Tasks

The other principal class of computer systems for management is known as Decision Support Systems (DSS). For a variety of reasons, computer systems increasingly are being designed to provide assistance to less routine decision tasks by providing the decision maker with more control over the analysis of data and over the presentation of the information. The advent of these new approaches toward system design has focussed on improving the ability of upper level managers to make decisions about corporate strategy and other unstructured problems in a rapidly changing business environment. These systems are characterized by a high degree of interaction between human decision makers and computer systems which provide a flexible analytic framework for exploring alternative decisions. A Decision Support System is: "an interactive computer-based system that is structured around analytic decision models and a specialized management database directly accessible to managers, that can be used to assist management at all levels of an organization with decisions about unstructured and nonroutinized problems" (Rubin 1986). The essential characteristics of a decision support system are a database of data pertinent to the decision making task, and decision models that enable the decision maker(s) to evaluate different options in a flexible, exploratory manner, with the purpose of improving the effectiveness of decision making.

Land Information Systems

Land Information Systems (LIS) have their origins in the tradition of Management Information Systems, and as with MIS have traditionally been oriented primarily toward increased efficiency of information processing. These LIS typically were first developed for large cities tax assessor's departments to increase the efficiency of processing parcel based information and doing such routine tasks as generating property tax bills.

The structure of these systems is usually centered around a database of records of information related to individual parcels, and includes as its distinguishing feature, some type of spatial information. The spatial

information may be as simple as the parcel address, or more typically may include a reference to the U.S. Census tract in which it is located. Increasingly, some more precise spatial information is included, such as the latitude and longitude, or the state plane coordinates of the parcel. These systems can summarize information based on the individual property records, or provide information specific to an individual property. The information output of the system is usually limited to numerical or textual reports, though some systems now provide graphic output of various types. An example might be a line graph of the increase in assessed valuation of a neighborhood, or the entire community.

Geographic Information Systems

A Geographic Information System (GIS) is a computer system for storing, retrieving, analyzing, and reporting both tabular data (as a LIS does) and geographic information in the form of digital "maps." The importance of this type of system is that it can relate either numerical data (assessed value, or number of rare species), or textual data (owner's name, or a description of vegetation) to a geographic feature or area, and can produce a map depicting these characteristics. A GIS can also manipulate data about the spatial relationships and geographic features of a place. For example, a GIS can display "overlays" showing the occurrence of combinations of features, such as industrially zoned land over an aquifer that contributes to a town well. A GIS can also enable complex queries about features and regions that satisfy complex combinations of spatial characteristics. A GIS can be queried to display all public water supply wells which have an underground storage tank within 100 feet of the well head. Of course, a GIS can also present information in tabular or other graphic form as well.

Decision Support Systems for Land Use Planning

Either a Land Information System or a Geographic Information System can provide decision support if the appropriate decision modelling features are developed in this framework. It is in this context that these systems become useful for effective land use planning. The objective is to

provide; 1.) the minimum essential information relevant to a land use problem, so as to avoid information overload; and 2.) to facilitate a flexible exploration of the important interactions and aggregate impact of different land uses.

This decision modelling must also take into account the different values people place on aspects of their environment.
The concept of the ideal design of a neighborhood open space might differ significantly among different people in the neighborhood. Some might prefer an active recreation area with tennis and basketball facilities, others might prefer a quiet park with benches and ornamental shade trees, while still others might desire a place for a community garden plot. The difficult nature of these unstructured, value-laden problems is well known.

> Unstructured problems, ..., tend to be ill-defined and open-ended with little agreement on what constitutes the problem, the type and quantity of information required, or the solutions sought. They are complex, multi-faceted problems generally not amenable to factual or empirical questions and require the sorting out of different value preferences among people as individuals, in groups, and in organizations (Zwart 1985).

A good decision support model will have the capability of utilizing these different value systems to highlight the different impacts of alternative policies, to help discover options that present the possibility of "joint gain" solutions that satisfy the desires of all interested parties.

General Considerations Affecting Automation

There are yet more considerations in setting up a computer system to assist land use decision making. The system can be built with microcomputer technology that is readily available at low cost and increasingly powerful. Modern microcomputer database management software with simple "application generators" allow even non-programmers to quickly develop small scale custom applications, using an ad hoc structure. Alternatively, the system can be designed in the traditional data processing paradigm, using a mainframe computer and large scale software

packages. This option offers greater assurance that as the system grows in scale, the computer environment can accommodate that growth, but the software, while more powerful, is not generally not as user-friendly. A third possibility is to combine the benefits of both types of systems using a microcomputer networked to a mainframe or mini-computer. Many GIS systems are built on this model. The GIS software is run on a mini-computer, and small specialized databases maintained by individual agencies are kept on local microcomputers with a network linking the two systems.

No matter what the configuration of machines and software; or whether one focusses on a LIS, DSS, or GIS; the first step is to automate what has previously been a manual system of information management. To begin the process of automation the minimum relevant essential information must be identified and then standardized. Ambiguity may be tolerated in a manual system, but in an automated system ambiguous data will severely compromise the utility of the system because the human judgement necessary to resolve the ambiguity will be one step removed from the data. Once these data have been identified and standardized, they then must be collected. Collection of data for an automated system is often a problem, especially in cases where the "essential" data include data that were not kept in the manual system that is being replaced. The data must finally be entered into the new automated system. All this must happen before any analysis or decision modelling can take place. And there are many potential problems to be encountered in even this preliminary stage of development of the information system.

The ambitious goal-- for decision support systems to have a positive impact on the effectiveness of land use decision making, can only be realized if several conditions are met.

1. **System Design** - First, the information system must be structurally sound, robust and stable over time. This alone is a difficult criterion to meet, but largely from a technological perspective.

2. **Implementation in the Organizational Setting** - Second, the system must be effectively implemented in an organizational setting. The system must supplement the existing resources available to decision makers in a way that is compatible with the structure of the decision making process used

by the organization, and with the power relationships within the organization. Procedures must be developed for acquiring and standardizing the data using personnel who are interested and able to ensure its accuracy, timeliness, and proper interpretation.

3. **Creative and Effective Use in Practice** - Third, the system must be used creatively by decision makers who are responsive to the interests and needs of the varied parties to the decision making process, and those outside the formal decision making structure, but who will be affected by the decisions.

In this thesis, I will examine these three criteria in detail as they relate to the design and implementation of decision support systems for more effective open space planning. I will give context to this discussion by analyzing these issues as they affected my choices about the design of a decision support system for the Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement (DFWELE) to assist the Department's Land Acquisition Program.

I had been working for DFWELE as a student intern for about three months when I was asked by the Deputy Commissioner to consider developing an automated parcel tracking system for the Land Acquisition Program. My internship working for the Riverways Program involved designing an information system for river conservation. Additionally, I had been a member of the Commissioner's working group on land acquisition policy, an adjunct member of the Department's Automated Data Processing committee, and I had also become involved with the advisory committee overseeing the development of a geographic information system for the Executive Office of Environmental Affairs (EOEA), of which DFWELE is a part. As a result of these experiences at DFWELE, I had a good sense of the dynamics of the organizational situation and the status of the computer expertise in the Department. In September 1987, I accepted the request and began preparing proposal for this work. The scope of services proposed not just a parcel tracking system, but a full fledged decision support system. The proposal was enthusiastically endorsed by the Deputy Commissioner and the Director of Planning.

I met with the Departmental ADP committee and proposed the purchase of computer hardware and software, and initiated the paperwork necessary for the purchase of this equipment. The basic components of the system include: two stand-alone micro-computers,[1] with standard off-the-shelf software.[2]

In early January 1988, the contract for the development of the Land Information System was finally authorized. At about the same time, I was informed that the first step of the computer acquisition process had been approved, but that there were still two steps remaining before the purchase order could be released. Two months had passed **without progress** because I did not know the right question to ask. Now, in May of 1988, the software has been delivered, but the hardware has still not yet arrived. In the meantime, I have developed a prototype system on my own microcomputer. As soon as the hardware is delivered to DFWELE, the hardware and software can be set up and the prototype system installed. A full discussion of the system development strategy from this point on is presented in Chapter IV.

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[1] Compaq 286 Model 40, with 40Mb hard disk, EGA color monitor, and near letter quality printer.

[2] The most important software package to this LIS development project is the database management system, in this case-- RBase System V. Other software available includes: word processing (WordPerfect), spreadsheet (Lotus 123), presentation graphics (Harvard Graphics), and a project management system (Microsoft Project).

II: The DFWELE Case

In order to give context to the problem of designing a Land Information System for assisting decision making on open space acquisition, I will give some background on the Massachusetts Department of Fisheries, Wildlife & Environmental Law Enforcement (DFWELE) and the Land Acquisition Program in particular.

The History of DFWELE

The first state agency concerned with either fisheries or wildlife was established in 1869 as the office of the Commissioner of Fisheries. The purpose of the office was to promote the economic management of the fisheries of the Commonwealth. By early in the twentieth century, several environmentally oriented agencies had been established to deal with concerns related to forestry, game, and animal industries, complementing the original Commissioner of Fisheries. In 1919, these agencies were consolidated in a single Department of Natural Resources. In the same year, other agencies were consolidated as well; the Metropolitan Parks Commission and the Metropolitan Sewer Commission were combined to form the Metropolitan District Commission, and the Board of Agriculture became the Department of Agriculture. By this point most of the currently existing environmental offices had been established, but the organizational changes were not over. In 1948, the Board of Fish and Wildlife was established to oversee the fish and game management activities of the Department of Natural Resources.

The Executive Office of Environmental Affairs (EOEA) was formed in 1969. The environmental agencies no longer reported directly to the governor, but to the Secretary of Environmental Affairs. Then in 1974, the EOEA agencies were reorganized. The Department of Natural Resources was split into two agencies. The Department of Fish, Wildlife and Recreational Vehicles was separated from the Department of Natural Resources and elevated to department status in response to strong lobbying from the sportsmen's community. The Department of Natural Resources was renamed the Department of Environmental Management.

The new Department of Fish, Wildlife and Recreational Vehicles was an uncomfortable marriage of several different divisions, each with its own mission and philosophy. The Division of Marine Fisheries and the Division of Fish and Wildlife each came to this new agency with their own citizen boards to which the divisions answered. These divisions were and remain subordinate to the Department in name only. Unfortunately, it is not an uncommon arrangement in Massachusetts to have a department level agency with no legal authority over its constituent divisions.

The Department's name was subsequently changed to the Department of Fisheries, Wildlife and Environmental Law Enforcement (DFWELE) to reflect the broader law enforcement responsibilities of the Division of Environmental Law Enforcement, formerly known as the Division of Recreational Vehicles (Anonymous 1987).

Funding for Land Acquisition

The Department of Fisheries, Wildlife and Environmental Law Enforcement has a mandate to acquire land as part of its mission to protect the floral and faunal resources of the Commonwealth. Historically, revenues from sales of hunting and fishing licenses funded the Land Acquisition Program, and the program focussed on acquiring lands most suited for hunting and fishing, and for maintaining sustainable populations of game and sport fish. Funding of open space acquisition from license receipts currently amounts to only about $250,000 per year, or about enough to purchase two house lots in metropolitan Boston. This money is specifically earmarked for acquisition of wildlife habitat. These funds are administered by the Division of Fisheries and Wildlife (DFW), one of three divisions within the Department of Fisheries, Wildlife and Environmental Law Enforcement (DFWELE).

More recently, funding for the Land Acquisition Program has come from the general funds of the Commonwealth through special bond issues, the so called Open Space Capital Outlay Budgets. These capital outlay budgets have provided money to each of the agencies within the Executive Office of

Environmental Affairs (EOEA) for open space acquisition[3]. These bond monies dramatically increased the fiscal resources of the Land Acquisition Program. Specifically, the appropriation of $24 million to DFWELE in 1983 represented a *100-fold increase* over the annual allocation to DFW for land acquisition. Incredibly, despite this phenomenal financial boost, the Land Acquisition Program did not initially add any new staff, or change the procedures for purchasing land. Then in 1987, DFWELE received an additional $30 million to supplement the approximately $16 million of unspent funds from the 1983 capital outlay. Finally, seven additional field staff were added to the Land Acquisition Program in 1987 to assist with identifying lands and negotiating sales with landowners. But still, the money for acquiring and conserving land was coming in faster than the Department could spend it!

To date, DFWELE has acquired 66 parcels of land with the 1983 funds, and has secured options on an additional 76 parcels, with 52 more options likely to be secured in the next 6 months as a result of on-going negotiations with landowners (see Table 1.). The Land Acquisition Program has accelerated rapidly in its pursuit of land; of these 66 parcels acquired over 4 years, 40 percent were acquired in 1987 alone (DFWELE, 1988).

The purposes for which these capital outlay budget monies are to be spent were specified by the legislature to include: Major Rivers, Rare and Endangered Species, Public Access, Farmington River, Cold Water Streams, and Adjacent Lands. These capital funds significantly expand the constituency that should be served by the DFWELE Land Acquisition Program. The fact that these monies come from a capital outlay budget, rather than from the hunting and fishing license proceeds, means that in an ethical sense, the mandate for using these monies requires that a broader set of values be represented in the acquisition of open space.

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[3] These Open Space Capital Outlay Budgets are also known as Chapter 723, Acts of 1983, totalling $162 million; and Chapter 564, Acts of 1987, totalling $564 million.

Table 1.

DFWELE LAND ACQUISITION APPROPRIATIONS & EXPENDITURES

Account		Appropriated	Spent[1]	Committed[2]
Chapter 723: Acts 1983				
Sect. 9A	Major Rivers	$6,000,000	$1,571,278	$1,405,200
Sect. 9J	Rare & Endangered	$4,000,000	$632,481	$225,000
Sect. 9K	Public Access	$500,000	*	*
Sect. 9I	Farmington River	$2,000,000	*	*
Sect. 9R	Cold Water Streams	$4,000,000	$982,700	$1,061,600
Sect. 9	Adjacent Lands	$7,500,000	$1,933,189	$2,991,500
	SUB-TOTAL	$24,000,000	$5,119,648	$5,683,300
Chapter 564 : Acts 1987				
Rivers, Stream Corridors, Rare and Endangered & Coastal Lands		$30,000,000		
	GRAND TOTAL	$54,000,000		

Current Status of Funds

7537 acres purchased	$5,119,648	
4683 acres optioned	$5,683,300	encumbered
5736 acres "probable"	$17,000,000	encumbered
Sawmill special project	$10,000,000	encumbered
Pisgah special project	$4,000,000	encumbered
TOTAL	$41,802,948	spent or encumbered
Administrative Costs	$2,000,000	
TOTAL FUND EXPENDITURES	$43,802,948	

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[1] Total amount spent as of March 8, 1988.

[2] Funds encumbered for purchases of optioned parcels.

The language of the Open Space Capital Outlay Budgets specifically designates the Commissioner of DFWELE as having authority to spend these funds. However, either as a matter of courtesy to, or negotiation with the Chief of Wildlife Lands, the Budget Bureau set up two of these accounts, Cold Water Streams and Adjacent Lands, under the Division of Fish and Wildlife. The remainder of the accounts authorized and appropriated under Chapter 723 of 1983 are under the control of the Commissioner. All of the accounts funded by Chapter 564 of 1987 are under the Office of the Commissioner of DFWELE. Traditionally, all land acquisition decisions have been cleared with the Fish and Wildlife Board before the acquisitions were finalized.

The Land Acquisition Vision of the Commissioner of DFWELE

Walter Bickford was appointed Commissioner of the Department of Fisheries, Wildlife & Environmental Law Enforcement in 1983, and he brought with him a new vision of the Department's mission. Bickford's goal is to provide *holistic ecosystem protection.* The cornerstone of Bickford's policy initiatives is a strategic program of land acquisition to develop contiguous corridors of conservation land along rivers. This focus on rivers, which Bickford terms the Commonwealth's environmental infrastructure, is based on solid ecological studies which have demonstrated that "islands" of protected habitat can not support the diversity of species that the can be supported if resources of various types are linked via corridors or dispersion routes (Diamond 1972, Simberloff 1976).

Walter Bickford is a former state legislator, and a politically active Commissioner. He is aware of the need to promote the programs of the department, and for effective lobbying in the state legislature to protect the budget allocation for DFWELE. He is constantly looking for specific information that he can use to support his message of holistic ecosystem conservation. He is eager to have the facts that will allow him to communicate the success of the Land Acquisition Program in terms of specific types and quantities of resources which have been protected by DFWELE. As a result, he has been a strong supporter of the Land

Information System, and of the development of a Geographic Information System (GIS) for the Executive Office of Environmental Affairs (EOEA), of which DFWELE is a part. The Commissioner's enthusiasm has caused DFWELE to be recognized as the most active of the environmental agencies in supporting the GIS development. The Department has supported this effort through organizational support, pilot studies and funding of the creation of a digital coverage depicting all protected open space in the Commonwealth. This GIS will be a powerful tool for open space planning and management when it is fully developed and accessible to the environmental agencies. At present however, the system is in an early stage of data development, and will not be able to offer services to the environmental agencies for at least one year.

Organizational Structure of the Land Acquisition Program

The Department of Fisheries, Wildlife & Environmental Law Enforcement has a statutory mandate for land acquisition, but this function has traditionally been carried out by the Division of Fish and Wildlife (DFW). Overseeing the activities of the DFW is the Fish and Wildlife Board, established in 1948. The Board retains hiring and firing power over the Director of DFW, as well as considerable influence over the policies of the Division. This board has remained in place despite several reorganizations of the DFW. The Board is comprised of seven gubernatorial appointees, who serve overlapping four year terms. By law the Board must represent several categories of interests in its membership: five sportsmen (representing the five DFWELE regions, each of whom must have held a combination sporting license for five consecutive years); one farmer; one wildlife biologist; and one non-game biologist. This board is very active and wields a considerable amount of political power, utilizing the constituency base of hunting and fishing groups.

Despite the tradition of the Division operating as the land acquisition arm of DFWELE, the Commissioner's Office retains the legal power to actually make land purchases. The responsibility for different aspects of the program are split between the Commissioner's Office and the Division of Fish and Wildlife, but the Commissioner does not have direct power over

the Division staff. This lack of vertical structure in the Department has a significant impact on the system of accountability in the Land Acquisition Program. See Figure 1. for a simplified version of the organizational chart of DFWELE as it relates to land acquisition. The important land acquisition staff in the Office of the Commissioner include: Director of Planning and Research, Legal Counsel, and the Right of Way Agents. The Land Acquisition staff in the Division of Fish and Wildlife include: the Chief of Realty, the Realty Administrative Assistant, and the District Managers. Their respective responsibilities for land acquisition are outlined below.

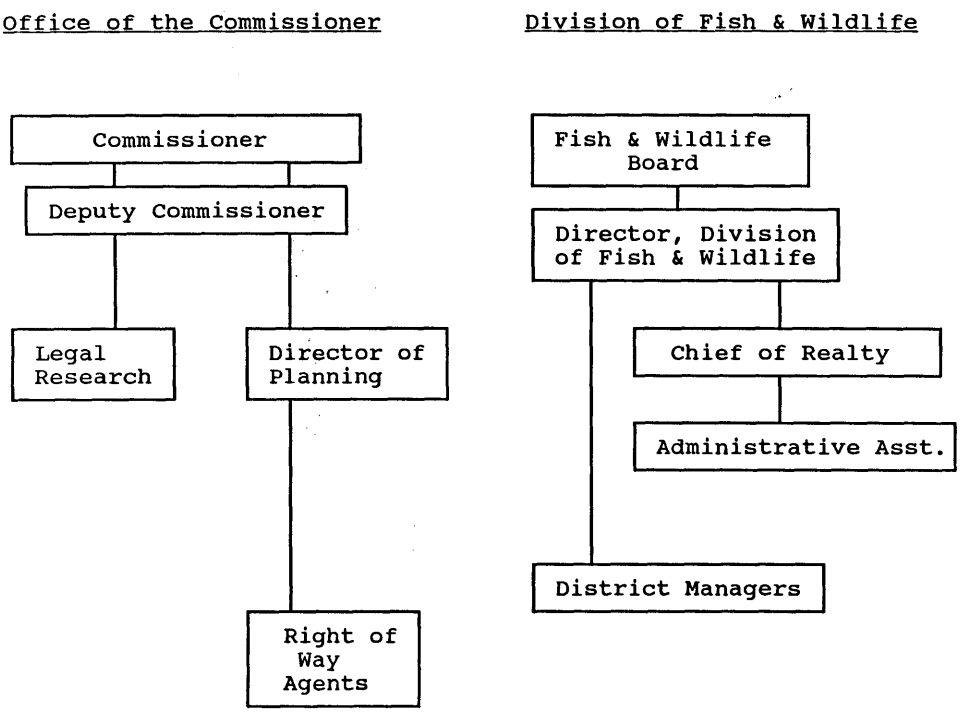
Program Staffing: Director of Research and Planning

General program oversight is given by the Director of Planning and Research in the Office of the Commissioner. The Director is frequently called on by the Commissioner and the public to answer questions regarding the goals and recent acquisition activity of the program. The Director is often asked about the progress of the program relative to its stated goals in resource-specific terms, such as; how many miles of riverfront has the department protected in the last year, or how many acres of wetland has the Department protected in Berkshire County.

About once a month, the Commissioner and the Director of Research address meetings of citizens from individual watersheds. These watershed meetings include representatives from the local planning boards, conservation commissions, watershed associations, and other environmental organizations. These watershed meetings are typically organized by the Department's Riverways Program, and although the focus is on strategies of river conservation, a large part of the message is news of the Land Acquisition Program and how it figures into river conservation. In these meetings, both the Commissioner and the Director are exposed to challenging questions about the program's activities. Some of these questions are quite specific about particular pieces of land that the citizens have mentioned to the department, or about land the citizens know that the Department has an interest in acquiring. Frequently however, neither the Commissioner nor the Director of Planning know the exact

Figure 1.

SIMPLIFIED ORGANIZATIONAL CHART
DFWELE LAND ACQUISITION PROGRAM



status of these specific cases; only the Right of Way Agent knows for sure.

The Director of Planning is the primary liaison person in all the cooperative acquisition activities involving DFWELE and other agencies. One account funded through the Chapter 564 bond monies provides $30 million specifically for cooperative acquisitions by the Metropolitan District Commission (MDC) and DFWELE of lands important for watershed protection in the Ware, Wachusett, and Quabbin watersheds. To organize this cooperative effort it was necessary to evaluate the significance of the existing DFWELE and MDC holdings, and to develop a strategy for maximizing the benefit of new acquisitions. The first step of this process involved redrafting the out of date maps of the protected lands in the watersheds. The second step, collecting information about the condition of those lands, is significantly more difficult because the information about those lands is kept in the District offices of DFWELE and is not standardized across all areas.

Program Staff: Legal Research

There are two lawyers associated with the Land Acquisition Program who perform a variety of tasks related to land acquisition. Most importantly they oversee the title research (performed by the Right of Way Agents in the field) to ensure that there are no outstanding title defects on land that the Department is acquiring. The legal staff take action to clear title to the property, including when necessary, going to Probate Court to resolve the case. Up to half of the properties that the Department seeks to acquire have some title defect that needs attention, however, only one or two parcels per year fail to be acquired because of unresolvable title problems.

Program Staff: Chief of Realty

The responsibility for land acquisition within the Division of Fish and Wildlife is in the office of the Chief of Realty, just under the Director of the Division. The Chief of Realty is the manager-administrator of the Land Acquisition Program. The current Chief has occupied this position for only six months.

The Chief has a variety of responsibilities related to making the Land Acquisition Program work smoothly. The Chief is the person who must intervene when the acquisition process gets snagged, either to close a deal with a reluctant landowner, or to deal with the Attorney General's Office over a procedural matter. The Chief also is responsible for responding to inquiries from citizens or environmental groups about lands that have been brought to the attention of the program but which have not been bought. This is a particularly challenging (and vexing) aspect of this job. The number of tips received by the Land Acquisition Program is enormous, particularly because of the Commissioner's policy of networking with citizens and environmental groups all across the state to identify worthwhile lands in need of conservation. In a typical week, the Chief may be asked about the status of 15 to 20 parcels that are not yet in the acquisition process; that is, parcels for which the Department does not yet have an option to purchase.

The individual Right of Way Agents have traditionally kept track of these tips, and they do the site visits to determine whether these parcels are of value to the Department. An individual Right of Way Agent may be pursuing as many as two dozen active tips. The Chief however, is generally aware of only the 10 or 15 tips that are particularly noteworthy either because of their outstanding qualities (natural resources or price), or because of their marginal value. The Chief is occasionally called upon to assist in the negotiations for the exceptional properties, or to help make the judgement call on whether the marginal properties should be pursued.

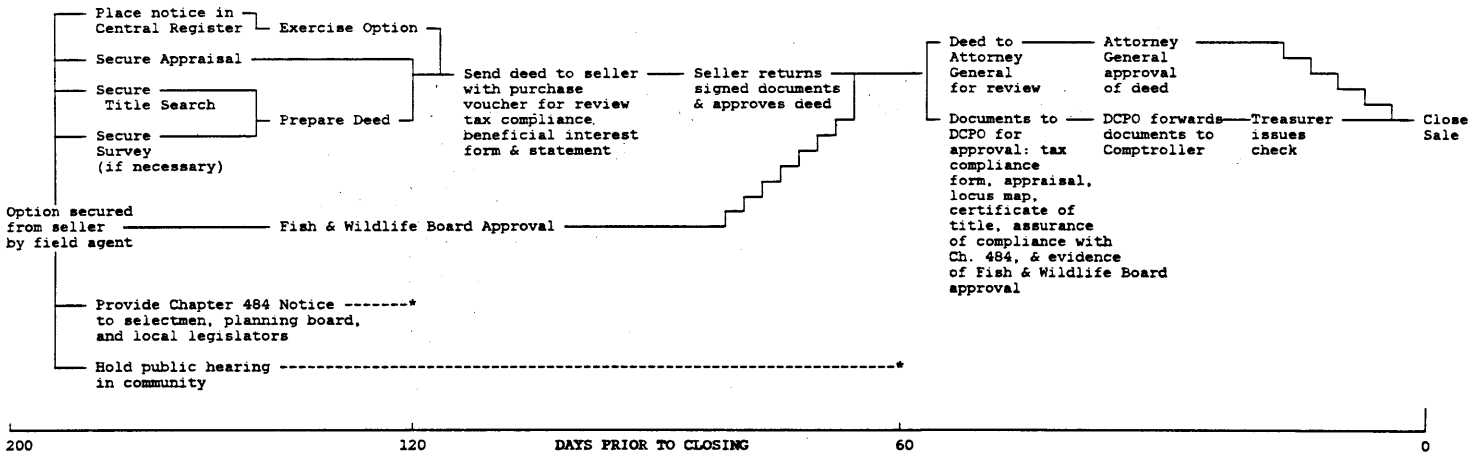
A large number of these tips end with the Right of Way Agent determining that the land is not of interest to the Department, but only the Right of Way Agent has this information or knows the rationale for this determination. At present, it is very difficult for the Chief to answer the queries from citizens about lands that have not yet been optioned, because typically the Chief does not have that information. If the Chief does know of the property in question, it is still difficult for the Chief to explain to a concerned citizen why their favorite wild spot is not of interest to the department if the Chief does not have immediate access to information about the resources or spatial context of the property.

The position of Chief of Realty was known as the Chief of Wildlife Lands up until June of 1987, when the incumbent Chief retired. The most recent Chief of Wildlife Lands was a very senior employee of the Division, who had both the personal style and the organizational support for running the Land Acquisition Program in a very autocratic manner. Nonetheless, the Chief was widely respected for his work identifying and protecting important wildlife habitat.

Program Staff: Realty Administrative Assistant

Assisting the Chief of Realty is one Administrative Assistant who is responsible for managing the complex paperwork and ensuring that the elaborate process of completing a purchase proceeds without undue delay. The complexity of the bureaucratic tasks involved in taking title to a parcel of land are staggering. There are over forty individual actions required in this process, many of which are interdependent, and many with specific time deadlines, resulting in a critical path for acquisition of 200 days. See Figure 2. for details. The manual procedures for managing this process are working adequately at present, due in large part to the skill and motivation of the Administrative Assistant. There are currently over 60 parcels acquired each year, with perhaps 200 additional parcels in some phase of negotiation. As the acquisition program accelerates with increased funding, this manual project tracking will become utterly unmanageable. This situation could cause the Department to again have

Figure 2. DFWELE LAND ACQUISITION PROCESS



significant unspent funds when the legislature next considers a capital outlay budget.

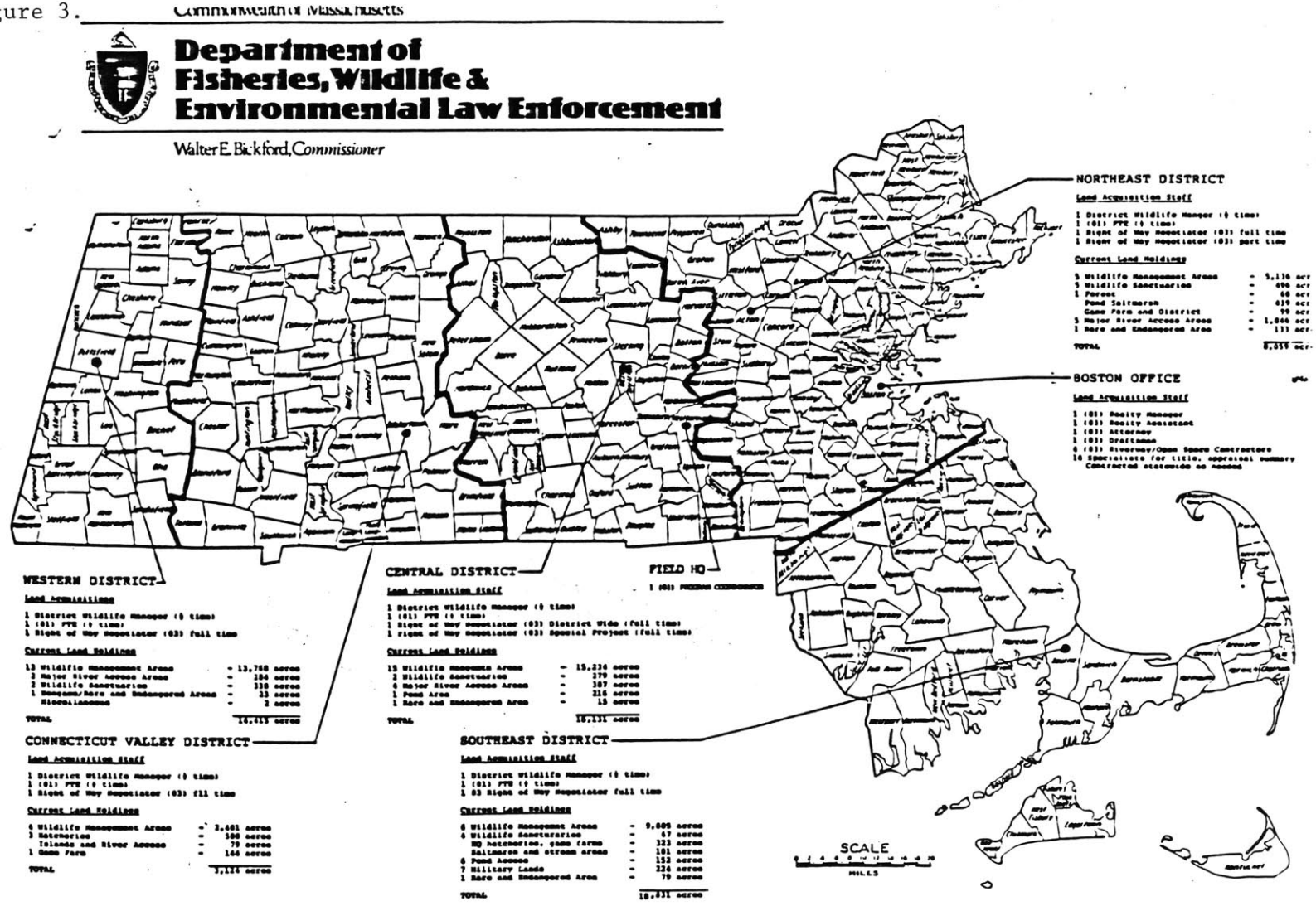
All of these staff positions, both within the Office of the Commissioner, and within the Division of Fish and Wildlife, are filled in the Boston offices of the DFWELE. The actual on the ground work is carried out through the five regional offices of the Division of Fish and Wildlife (see Figure 3.).

Program Staff: District Managers and Right of Way Agents

The five District Managers have historically handled all the field work related to land acquisition. They were the ones responsible for receiving tips from local citizens, visiting and assessing the value of parcels, and negotiating with the landowners for a sale. More recently, with increased funding driving an accelerating rate of acquisition, seven new employees have been hired. These new consultants have the title of Right of Way Agents. They were hired through the Commissioner's Office and are, in theory, answerable to the Commissioner. However, the Right of Way Agents work closely with the District Managers and, on a day to day basis, report directly to the District Managers.

When the District is interested in a property, the Right of Way Agent performs an extensive investigation of the resource attributes of the parcel, researches the title at the registry of deeds, and gathers information on comparable sales in the area to determine a reasonable market price for the property. Once the agents have this information in hand, they then begin to negotiate directly with the property owner. The Right of Way Agents have authority to secure options on land on behalf of the Department. An option does not cost the Department anything, and is not binding on the Department (only a purchase and sale agrement is binding, and then on both parties). The Agents are free to secure an option with a landowner without consulting the Chief of Realty or anyone else. They are guided by their understanding of what the Department is looking for in a property, and their sense of professionalism. In

Figure 3.



Open Space Acquistion Staffing and Current Holdings

practice, the vast majority of options are followed by a purchase and sale agreement, and are ultimately acquired by the Department.

Although the Right of Way Agents are mostly new, young employees, their socialization to the Land Acquisition Program has been through the District Managers, the Chief of Realty, and the Director of the Division of Fish and Wildlife. As a result, the Commissioner, and to some extent his staff in Boston, perceive that the Right of Way Agents' criteria for assessing the value of land parcels primarily reflects the perspective of the DFW Director and District Managers. This DFW perspective is perceived to reflect the narrow view that all lands acquired by DFWELE must be open to hunting and fishing, and must be of value primarily for these activities.

If the district is not interested in acquiring a property identified by a citizen's tip, the information on that parcel is referred to one of several non-profit organizations for their consideration. The information about this referral is not generally sent to Boston. For this reason, the ultimate disposition of tips is seldom recorded in a formal fashion by anyone at DFWELE.

General information is transmitted by the Right of Way Agents to the Chief of Realty periodically, so that the Chief has a minimum amount of information regarding which landowners have been contacted, and in which areas the agents are working. Once an option to purchase has been secured, these agents send to the Chief of Realty a detailed map of the parcel drafted on a USGS quadrangle.

A pair of new requirements have recently been added. The agents now must complete a short information form for each "tip" they receive or any parcel they identify for possible acquisition. The standard form was designed specifically to provide information for the Land Information System and asks for the owner of the parcel, the location, and a preliminary indication whether the district is interested in acquiring the parcel (See Appendix A). The purpose of this form is to share the

information on tips from the field with the program staff in Boston. This form will provide the Chief of Realty and the Director of Planning with the information necessary to answer inquiries about the Department's interest or lack thereof in specific parcels which have been recommended by citizens for acquisition by the Department.

Later, when an option is secured on a property, a second more detailed form must be completed. This second form details the types of natural resources associated with the parcel, and provides information about protected open space in the vicinity, whether adjacent to the optioned parcel or not (See Appendix B). This new requirement is also for the purposes of gathering data for the Land Information System. This information can be used to summarize the resource characteristics of parcels acquired under any category of interest; by bond account, by region, or for a specific time period.

Parallelling this new reporting requirement, the District Managers are completing information forms on each property already owned by DFWELE for the LIS. These forms are nearly identical to the resource information forms required for each optioned parcel. This information will allow a comparison between the lands already protected and those proposed for acquisition.

The Land Acquisition Policy Statement of DFWELE

During the summer of 1987, while the search for a replacement Chief of Realty was proceeding, the Commissioner convened a working group to draft a mission statement which would elaborate the guiding principles and policies of the Land Acquisition Program. The group included all the major stakeholders in the Land Acquisition Program as well as the other programs within DFWELE, and included a representative of the Fish and Wildlife Board. After much complex negotiation, a policy statement was drafted. Significantly, the group was not able to negotiate specific mechanisms for implementing these policies. However, it was presumed that because of the consensual approach taken to drafting the statement and diverse representation on the committee, the Land Acquisition Program

would change so that these policies would be implemented. Although implementation measures were discussed by this working group, the reason these measures were not ratified by the committee probably had to do with the disputed lines of authority for land acquisition[4].

Following the drafting of this policy statement, there have been a series of strategy meetings in each of the districts to determine areas which meet the criteria set down in the policy statement. These workshop sessions have included a broad spectrum of interested parties from the Commissioner's Office and from the Division. Relatively large areas were identified, areas which, in general, contained the types of resources of interest to the program and which provided the potential for developing corridors of protected lands.

Recent Change in the Land Acquisition Program

There was a dramatic change in personnel during 1987. The Chief of Wildlife Lands (the title has since been changed to Chief of Realty) retired, as did the Deputy Director of DFW; and the Director of DFW has been less involved with the Land Acquisition Program because of serious illness. With these changes in the Division of Fish and Wildlife, Commissioner Bickford had the opportunity to change the character of the Land Acquisition Program. The turnover of these critical personnel provided a chance to moderate the traditional values held over from the days when DFWELE was exclusively a hunting and fishing agency, and to inject some additional support for the new policy of holistic ecosystem conservation. Nevertheless, old values remain, supported by the Director of DFW and the DFW Board. Together they still represent a strong hunting and fishing orientation in considering lands for acquisition.

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[4] The text of the "Land Acquisition Policy of the Department of Fisheries Wildlife and Environmental Law Enforcement," drafted by the Commissioner's working group on land acquisition policy is included as Appendix A.

Unfortunately, the selection of a new Chief of Realty brought the Commissioner into direct conflict with the Fish and Wildlife Board over policy and control of the Land Acquisition Program. The Board asserted that they had the authority to hire and fire the Chief of Realty, and to control the Land Acquisition Program. They further asserted that the Board did not answer to anyone but the Governor. While this hardline position can be debated on strictly legal grounds, the point was complicated by the Governor's candidacy for President. The Board asserted its will, threatening to make the conflict over land acquisition public by enlisting the vocal hunting and fishing lobby in the struggle. However, because of the governor's candidacy, there has been a strong effort to avoid publicly airing dissention within the bureaucracy. As a result, the Board prevailed, deepening the rift between the Board and the Commissioner. The person who was ultimately hired to fill the Chief of Realty position was the Board's preference, not the Commissioner's. The new Chief was promoted from within the Division, and is a fairly traditional Fish and Wildlife staff person from the field headquarters of DFW.

The manifestation of this and other conflict between the Commissioner and the Board of Fish and Wildlife, is an ongoing struggle for control of the various bond accounts that fund the acquisition program. It may turn out that some of the land acquisition is carried out by the Chief of Realty, through the Division of Fish and Wildlife, with accounts specifically within the Division's control, while other lands are acquired through the Commissioner's Office using accounts specifically under the control of the Department (Office of the Commissioner).

Implications for Implementation of a Decision Support System

With this political power struggle as a backdrop, the decision making process of the Land Acquisition Program is very difficult to discern. The decision to acquire any particular parcel of land may come from any one of a number of players in the Land Acquisition Program. In the end, however,

if a decision over a particular parcel of land becomes particularly contentious, the matter may be decided by who holds the purse strings. If the account is under the control of the Division of Fish and Wildlife, then the consent of the Board is required, although this is usually a rubber stamp procedure. However, most of the accounts are under the legal control of the Office of the Commissioner, and technically do not need the consent of the Board. But the Commissioner is constrained; both by the Fish and Wildlife Board's influence through their constituency, and the historical precedent which has placed the locus of control and the organizational resources for land acquisition within the Division of Fish and Wildlife. In short, the decision making process has gone underground, and it may be continuing to change.

As a result, it is difficult to determine who the decision makers are whose decisions this system should support. It is perceived by some in the department that the Commissioner may be attempting to change the locus of control of the program.

Despite this political dissention, there is considerable support for the development of a Land Information System (LIS). Admittedly, most of this support comes from the Office of the Commissioner, and this factor will be discussed later.

The implementation of the first phase of the DFWELE Land Information System will begin as soon as the two microcomputers are delivered. It is planned that one of these machines will be located in the office shared by the Chief of Realty and the Chief's Administrative Assistant, the other in the office of the Director of Planning and Research.

The option of installing microcomputers in each of the District offices and connecting them by modem to the Land Information System in Boston was considered and rejected. The reasoning was that it would be too much of a burden on the Right of Way Agents and District Managers to impose this technological change on them in addition to the burden of completing detailed forms for every acquisition. The machines in the Boston offices will also not be connected initially, although a Local Area Network (LAN)

is expected to be installed as part of an EOEA computer acquisition within one year. At that point, the two Boston based machines will be able to communicate directly.

The EOEA computer acquisition will include a Geographic Information System. There is a great deal of interest in linking the DFWELE LIS to the EOEA GIS via the network, once EOEA has both the GIS and the network installed.

Three Purposes for the DFWELE Land Information System

There are three distinct purposes that a Land Information System can serve for DFWELE. These purposes are:

1.) parcel tracking through the acquisition process,
2.) summary reporting on the program's accomplishments, and
3.) decision modelling based on the natural resource characteristics of the parcels.

The most basic function the LIS could serve is parcel tracking. By this I mean, tracking each parcel from the identification of a potential for acquisition, through the signing of an option with the landowner, and through the 200-day process of filing legal notices, clearing title, and other paperwork tasks prerequisite to signing the check and taking title to the land. This function involves providing reports that serve as reminders for action needed to advance the progress of individual parcels through this process. Automating the tracking of parcels through the acquisition process will also facilitate the production of status reports that will give the Chief of Realty a good overview of the progress of the program, the level of activity in various districts, and the primary sources of delay in the process. These are well structured tasks which will increase the *efficiency* of the Land Acquisition Program for performing relatively structured tasks. These are functions typically served by a Management Information System (MIS).

The second function the Land Information System could serve which would improve the Land Acquisition Program is production of summary reports of the natural resources protected through land acquisitions. In as much as the resource data is irrelevant to the acquisition process tracking, the inclusion of resource data in the parcel tracking system is intended to provide a broader foundation for the Land Information System; including improving the ability of the managers to keep abreast of the program's accomplishments protecting resources, and anticipating the development of a decision model later in the implementation process.

These reports would summarize the resource characteristics of parcels acquired under a particular account, in a specified region, or during a given time period. This too is a function characteristic of a MIS. However, this function is made possible by requiring that the Right of Way Agents submit the resource data on parcels at the point of securing the option on the parcel. The benefits of summary reports extend beyond the operational requirements of the program, and will provide the Commissioner with the resource specific information that he desires for promoting the Land Acquisition Program. The LIS could also provide a useful audit trail. The system could substantiate the expenditure of bond funds for protecting specific important natural resources.

The third function the system can serve is decision modelling. This is based on the premise that different preferences exist for land acquisition, as a function of the natural resource characteristics of the land. In order to make decisions about the policies and procedures of the program, it is important to know what has been acquired. This third function of the DFWELE LIS will use resource information about lands in the DFWELE inventory and those under consideration for acquisition to support decision making. However, using this automated information system to make judgments about what lands or land characteristics are preferred involves different tools and issues. This preference modelling is but one example of a decision support feature. But this preference modelling has implications beyond individual decisions about specific parcels, and can

be used for assisting decision making about land acquisition policy and procedures.

These three functions of a LIS can improve the Land Acquisition Program of DFWELE significantly. However, the three functions differ considerably in terms of the technological complexity involved in designing these functions. More significantly, it is reasonable to predict that these three different purposes will elicit three different types and degrees of resistance to their implementation. These, however, are general presumptions which must be tested against a structured examination of the organizational setting. After presenting this organizational analysis, I will discuss how these factors influenced choices regarding the design and implementation of a Land Information System for the Department of Fisheries, Wildlife and Environmental Law Enforcement.

III. Organizational Assessment

If the proposed decision support system does not mesh with the existing organizational structure and take into account the existing power relationships and decision making dynamics, the system is doomed from the start. Many of the failures of such systems can be attributed to the failure of the designer to understand the organizational setting in which the system is to be used (Keen and Morton 1978, Markus 1983). However, it is often very difficult to decipher the inner workings of a public agency. It may not be possible to learn about critical power relationships from an organizational chart, and these relationships may still not be discernable from interviews with agency personnel. These issues of power dynamics may not crystallize until the information system tips a delicate power balance in the organization and causes the success of the system to be jeopardized. It is critical therefore, to perform a thorough organizational assessment to identify as many potential problems for implementing the system as possible, so that measures can be taken in the design and implementation strategy to eliminate or reduce the likelihood that the system will be rejected by the organization. To focus this examination of the organizational setting, I will refer to the theory of information system resistance put forward by Markus (1983), which she terms the "interaction theory."

Resistance to information system implementation can be ascribed to any of three different theories. First, people may reject the system because of factors internal to the individual. For example, individual resistance may be due to the premise that as a rule people resist any change, or because intuitive thinkers reject analytic systems. Second, people may resist the system because the system is not well designed. Inattention to the human factors in designing systems is the primary problem. A great deal of research has focussed on ways to make system design better serve the needs of people, but this has not been entirely successful in guaranteeing successful implementation of information systems. The third theory of resistance, the one promoted by Markus, is that resistance is not due to either characteristics of the people, or to characteristics of

the system, but rather to the interaction of the characteristics of the people and characteristics of the system. Markus describes two versions of this interaction theory of resistance. The first, the 'sociotechnical variant' posits that the resistance derives either from changes in the tasks required of various roles in the organization, or from changes in the communication patterns of the organization. The other version of the interaction theory, the 'political variant,' relates resistance to the changes in the intra-organizational distribution of power. Markus states that this redistribution of power may be either real or symbolic, but the result is similar, people resist the implementation of the system.

Each of these theories is based on certain assumptions about what is wrong with the system implementation, and each implies a different approach towards overcoming the resistance. I will discuss the DFWELE case with respect to these theories, and then describe the recommendations for overcoming the resistance.

Resistance due to the Characteristics of People

The people involved with the Land Acquisition Program have little or no experience with computers. The implementation of this system will represent a major change for them; both personally in terms of learning to cope with the technology, and professionally as their job requirements change.

The staff of the Land Acquisition Program are very skilled at what they do, within the limits of their jobs as they understand them. The staff, despite their skill, appear to make decisions on an intuitive basis. This is especially true of the District Managers and Right of Way Agents. Their assessment of land value for example, tends to be more of a gestalt process than a methodical assessment of habitat quality. To the extent that this is true, that the decisions and judgments made by the staff are intuitive, not analytical, an information system forces a style of reasoning on the staff that is contrary to their cognitive style. To put it more personally, the information system may be perceived to take some of the magic out of their jobs.

Resistance due to the Characteristics of the System

It is certainly possible for a bad system design to cause people to resist using the system. I have anticipated that certain aspects of the design of the system interface will be critical to accommodate first time computer users. My concern is not just to avoid resistance to the system, but also to insure that the prospective users of the system will find it comfortable and pleasant to use the system.

The most crucial concern is that the system perform well over time and with many updates of the data. Nothing could derail confidence in the system faster than a lack of trust in the integrity of the data. The methods employed to ensure that the data are reliably maintained are discussed in Chapter IV.

The system design for DFWELE is based on a detailed study of the existing data management procedures. The Land Information System will handle the types of tasks and data that the staff currently must manage, and will operate in conceptually similar ways. This technique is explained in more detail in Chapter IV.

The system will be introduced using a basic prototype of the system. Interaction with this prototype system will help the prospective users refine their specification of their needs. This process will serve to accommodate the system to the users, as well as the users to the system.

With these concerns and explicit strategies for providing a sound system design, I believe that the system design will not be a cause of resistance.

Resistance due to Interaction of System and Organization:

The Sociotechnical Variant

The sociotechnical variant of the interaction theory raises the question of the purpose of the system. If the purpose is to change the

information flows within the organization, then the system will likely be resisted. In the DFWELE case, the access to information about individual parcels of land is going to change, and this will probably be a substantial change, at least in the eyes of those who are being called on to share information which they previously controlled. It is the *operational level* staff in the DFW who are giving up control of information, and they may fear increased scrutiny of their performance. The fear of scrutiny, is a manifestation of the perception that the Commissioner's Office holds different values from those of the Division staff. The existence of different values or goals at different levels within the organization is mentioned by Markus (1983) as a factor contributing to this sociotechnical type of resistance.

The Political Variant

The political variant supposes that the purpose for implementing an information system, whether real or perceived, is to shift the balance of power from one part of the organization to another. The significance of this shift is that those who stand to lose power through implementation of the system will resist the system in order to retain their power.

There are two ways that those affected by the system might infer the purpose of the system, before the system is implemented. The first indicator of system purpose is the motivation of the chief proponent of the system, in this case, the Commissioner. Another way of inferring the purpose of the system is to look at the motivation of the system designer, or the relationship of the system designer to the prospective users.

The staff may infer that the purpose of the system is to serve the Commissioner's interests in the Land Acquisition Program. After all, it has been the Commissioner and his staff who have promoted the idea of a computerized parcel tracking and reporting system all along. The Land Acquisition Program staff in the Division of Fish and Wildlife perceive that the Commissioner wants to usurp control of the program from the Division, and is particularly interested in being able to spend the acquisition money more liberally. These purposes run contrary to the DFW

tradition of proceeding slowly, and negotiating long and hard for the best hunting and fishing lands at the lowest possible price. This would provide the DFW staff with the motivation to resist the implementation of the Land Information System.

The relationship between the system designer and the program staff is affected from the start by the fact that, I, the designer of the system, was hired by the Commissioner. I think that my motivation for tackling this difficult task is also reasonably clear to the program staff. I believe that a computer system can provide a variety of benefits to the Land Acquisition Program, and I am interested in broadening the criteria used for evaluating land for acquisition. I am known to be an advocate of corridors of conservation lands, strategically located to provide synergistic benefits to both wildlife and people. It was I who first promoted the concept of providing decision support models that incorporate the stated policies of the DFWELE Land Acquisition Program in the Land Information System. While I do not intend to impose my will on a whole group of professionals, who are doing a good job on a critically important program, there may be considerable suspicion that I would try. The only way to address these suspicions is to maintain an open and close relationship with the program staff, and to make clear my concern for their interests.

I firmly believe that it is not the purpose of the Land Information System to shift power towards the Commissioner's Office. Nonetheless, given the political upheaval within the organization, there is a real possibility that the perceived purpose is to redistribute power within the program, giving the Commissioner increased ability to exercise direct oversight of the Land Acquisition Program. I will assert however, that while this power shift may be an unavoidable effect of the system, this power shift *is a function of* the changed information flows. The significance of the power shift is accentuated by the different values perceived to be held by different people within the Land Acquisition Program. A closer examination of the changes in information flows is

necessary to determine the significance of these changes for causing resistance.

Current Information Flows

Until very recently, all the resource information about a parcel was retained at the Division of Fish and Wildlife District office level. The Chief of Realty received occasional updates on parcels that the District Manager was negotiating for, including name of the owner, address of the owner and the parcel, and the size of the parcel (See Figure 4). A map of the parcel was sent to the Chief of Realty at the time the option was secured; although there were cases where no map was prepared before the decision was made to acquire the land. The Chief of Wildlife Lands would occasionally enter in to the negotiations with a landowner to secure an option if the land was of great importance for hunting and the negotiations were particularly difficult.

Once the option was secured, the Chief of Wildlife Lands would brief the Fish and Wildlife Board in a periodic report on pending acquisitions. This appears to have been more a matter of courtesy than a requirement, but technically, the Board did have the authority to deny specific purchases.

In the usual case, the resource characteristics of a parcel were not quantified. The Chief of Wildlife Lands would make a decision to acquire a parcel based on the opinion of the District Manager, or on the basis of his own site visit, but without a formalized or systematic analysis of the land.

Change in Information Flows

As described earlier, data gathering for the Land Information System begins with the submission, by the Right of Way Agent, of a short paper form with information on any "tip" or potential for acquisition, whether identified by a Right of Way Agent or a concerned citizen. These data forms must then be transmitted to Boston on a regular schedule, to be entered into the system by the Administrative Assistant to the Chief of

Figure 4. CURRENT INFORMATION FLOWS IN THE DEWELE LAND ACQUISITION PROGRAM

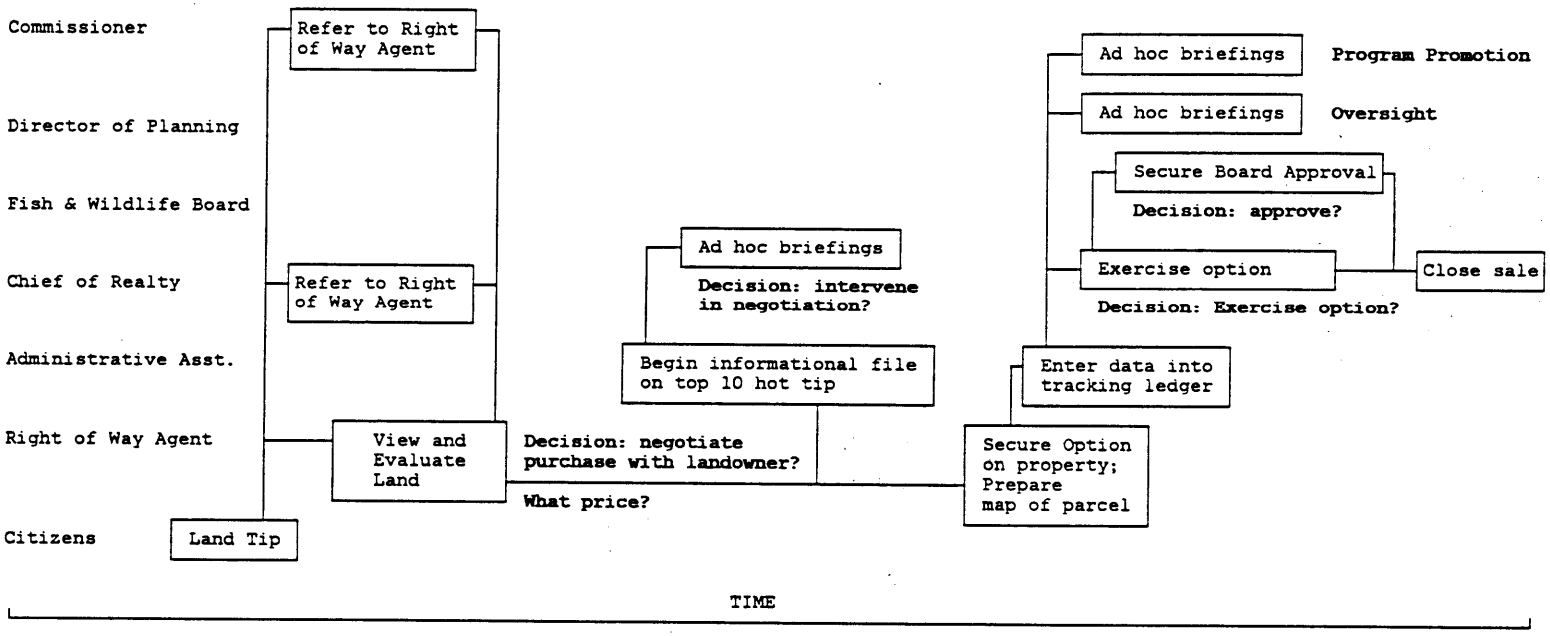
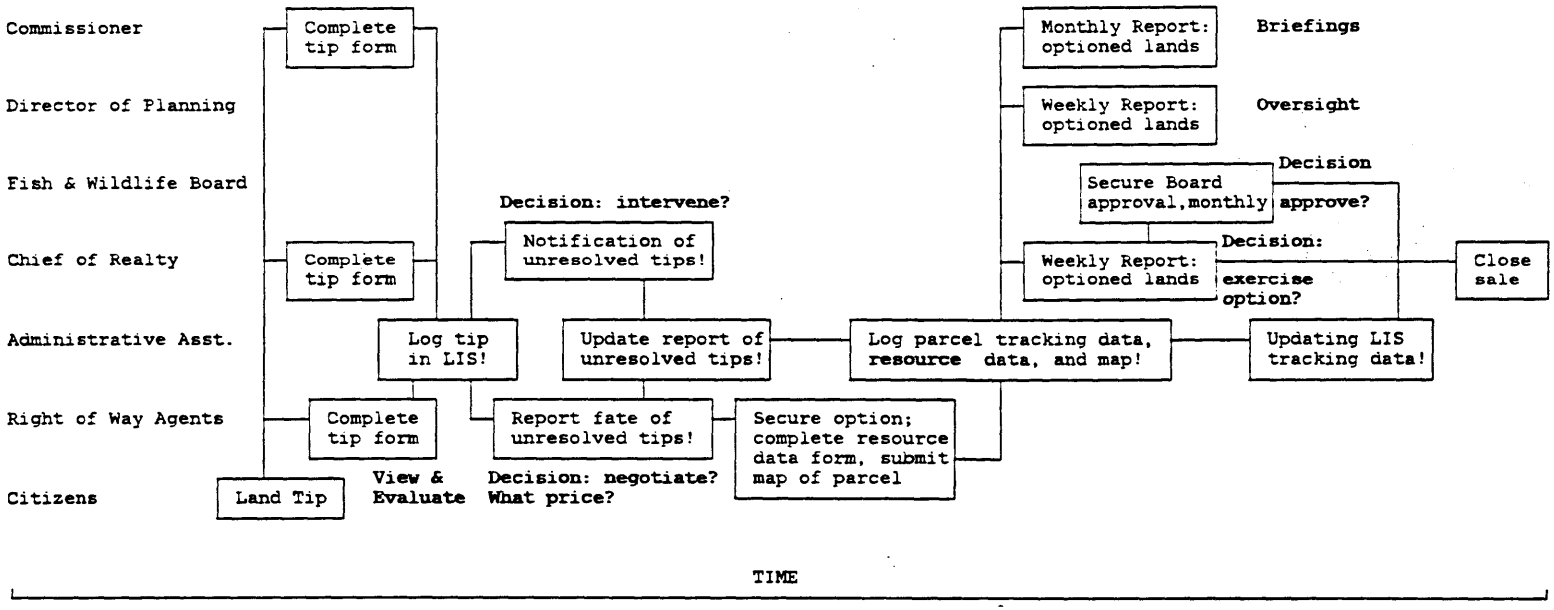


Figure 5. INFORMATION FLOWS WITH THE DFWELE LIS IMPLEMENTED



"!" Denotes a specific use of the LIS.

Realty (see Figure 5.). The data will be added to the relevant databases in the system, and these will serve as the master data files for tracking information about "potential acquisitions." These files will be used to update the data on the second computer system, located in the office of the Director of Planning.

After the Right of Way Agent has negotiated with the landowner and secured an option on a parcel, the decision to exercise that option and acquire the property is made by the Chief of Realty in consultation with others in the Land Acquisition Program. In fact, though, most every property on which the department can secure an option is purchased because of the current abundance of funds for land acquisition. This means that the *de facto* decision makers are the Right of Way Agents and the District Managers, because it is they who control the acquisition process by controlling the supply of options on property. The question of who ultimately decides which parcels are suitable for acquisition may not be clearly resolved until the accounts begin to run dry.

What is the significance of this change?

Clearly the District Managers and the Right of Way Agents will be sharing a lot of information which was not previously shared. Reporting on the progress of negotiations with the landowners is an added responsibility that may appear to be a bookkeeping burden. This alone might cause the agents to resist the new system because of its onerous requirements. The request for information on natural resources may be perceived to expose them to potential scrutiny in terms of their success or lack of success in securing options on lands in priority areas, or more generally on the types of parcels for which the Commissioner is looking (connecting "corridor" parcels). Completing the resource data sheets is a much more involved process of research and reporting than just filling out the tracking information. However, any data that could be feasibly filled out in Boston rather than in the field, has been left off the forms. Nonetheless, the data on acreage of different features on the site

(hardwoods, softwoods, wetlands, floodplain) may be difficult for the Right of Way Agents to obtain accurately.

These natural resource data are of a different nature and for a different purpose than the tracking data and the resistance to this part of the system can be expected to be more intense than the resistance to completing the tracking forms.

The Chief of Realty has cooperated to the extent that the Chief has reinforced the message sent out by the Director of Research and Planning that these forms must be filled out. This message is more persuasive coming from a supervisor (the Chief of Realty) within the Division of Fish and Wildlife, than if it came solely from a person in the Commissioner's Office. Nonetheless, there seems to be some resistance to this by some of the Right of Way Agents during the 2 months that this requirement has been in effect.

The fact that the Chief of Realty will have more information about the parcels at the point of making a decision on which parcels to acquire, may or may not change the basis on which the Chief makes decisions. Simply having the resource information available when deciding to exercise an option may not change the decision making dynamics. However, having to forward information to the Director of Planning and thereby indirectly to the Commissioner, may affect the decisions of the Chief. Certainly, the Chief will be subject to increased scrutiny because of this new information and reporting system. Again, this concern about having one's decisions scrutinized may cause the system to be resisted.

In as much as the hardware for the system has not arrived yet and the system has not been implemented, the resistance of people to the actual Land Information System can not be evaluated. However, I believe that these changed information flows cause the perception that the system will introduce more detailed scrutiny of the land acquisition process than has been possible previously.

Implications of Interaction Theory for Implementation

The most fundamental assertion that flows from interaction theory is that "computer-based [information] systems alone cannot accomplish the task of radical organizational change (Markus 1983)." The organizational changes should be addressed directly first, and then information system designed so as to reinforce those new organizational relationships.

A second implication of interaction theory is that system design should be a product of the relationship between the designer and the users. Together they should work out the specifications for the system. This helps makes explicit the purpose the system is to serve, it is the purpose of serving the goals of the organization, shared by the organization staff (the users), and the designer.

All these implications of interaction theory stress the importance of a thorough analysis of the organizational setting in which the system will be used. Identification of the potential problems of implementation is essential before attempting either to design or implement a system.

I have presented a thorough assessment of the organizational setting in which the land information system will be used. The implications of the organizational change that is currently underway at DFWELE are that there may be several different types of resistance to implementing an information system. The resistance to implementation due to characteristics of people and characteristics of the system can be addressed. The resistance encountered during implementation as a function of the system and the organization, is likely to differ according to the perception of whom is benefiting from the information provided by the system. To counter these types of resistance will require a careful management of the implementation process. It will be critical to keep the communication between the system designer and the users open so as to minimize suspicious perceptions.

The application of interaction theory and the prescriptions that it offers for implementation under these circumstances of organizational

change indicate that it is unwise to attempt to force a change in the decision making structure by introducing an information system. Rather, the decision making structure must be changed overtly, and then the information system implemented in such a way as to reinforce the new structure. However, the decision making structure is not clear at the moment. Therefore, it is advisable to defer the development of the decision oriented portions of the Land Information System.

The information flows and reporting obligations have been recently changed, and may be conducive to a more cooperative relationship between the Commissioner's Office and the Division of Fish and Wildlife. The Commissioner, in giving the Director of Planning the oversight responsibility over the Land Acquisition Program, has delegated the day to day involvement with policy making. Previously, one of the greatest sources of friction arose because of the Commissioner's involvement with the details of the program, details better left to those who were more familiar with the operation of the program.

This new reporting system will lead to a potentially workable relationship between the Commissioner's office and the Division which will permit the development of a limited information system. The development of the Land Information System will provide parcel tracking and reporting capabilities initially, with the development of decision support functions deferred to a later time. The parcel tracking and reporting system would primarily serve to improve the efficiency of the land acquisition process managed by the Chief of Realty. This strategy will also provide the resource specific information for the Commissioner's Office that is so important to its goal of promoting the program's success at protecting the natural resources of the Commonwealth. The rationale for taking this limited first step is explained in Chapter IV. The ultimate development of the decision support function of the system is conditional on the success of the implementation process for the parcel tracking system. Having taken measures to insure that initial parcel tracking system will be successfully implemented, there is reason to believe that the decision support system features can subsequently be implemented as well. A

methodology for developing and implementing these decision support features is presented in Chapter VII.

IV. Design Strategy for the Land Information System

The organizational politics and lack of computer experience within the Land Acquisition Program forced several tough choices regarding the design and implementation strategy for the Land Information System. I made a significant decision in accepting the contract to build this Land Information System. I believe that an information system will help the Land Acquisition Program, despite the organizational factors that complicate the implementation of this system. In recognition of these implementation problems, I have made four choices regarding the design of the system. I will outline these decisions briefly, and then go on to explain how these decisions will allow implementation of the system to proceed from the most basic parcel tracking system into a full fledged decision support system.

First, I decided to introduce simple prototype systems initially, to engage the users in the process of refining the system design specifications. This "prototyping strategy" involves the users trying out successively refined versions of the system to help them to understand and convey their requirements of the system. The feedback from the users includes comments on both the information they need and the style of interaction that they prefer, to determine where improvements can be made in the design. The prototype system will focus on the parcel tracking system, and resource reporting functions for all parcels owned or optioned.

Second, I decided to design the data storage component of the system using formal systems analysis techniques to determine the data table structure and relationships. A database application could be developed for the Land Acquisition Program using the simple menu driven database development tools provided with the chosen database management system. However, this approach would not guarantee that the integrity of the data would be maintained over time. Choosing to use a formal systems analysis approach to designing the system represents a significant compromise of

time and simplicity in order to insure that the system is stable, maintainable and expandable.

Third, I chose to implement the system in a series of stages rather than as a fully developed decision support system. There are numerous reasons for this decision; some pragmatic and some strategic. I call this strategy "incremental implementation."

Fourth, I had to decide how to design and implement the decision modelling component of the land information system, given the organizational barriers that are likely to inhibit the implementation effort. The objective is to institutionalize a more systematic method for evaluating parcels on the basis of their natural resource and spatial attributes. In order to improve the process by which these decisions are made, and to illuminate the preferences that drive these decisions, I have decided that the preference modelling component of this decision model will be designed by a group process involving all the interested parties in the Land Acquisition Program. This approach will also improve acceptability of the model and the chances of successfully implementing this decision support feature in the Land Information System. Chapter VII. presents an explanation of the process of joint model building and how this process might be used by DFWELE to assist decision making regarding land acquisition.

Prototype System Development

The literature on the design of information systems, and decision support systems in particular, stresses the importance of creating a prototype system and testing this with users before committing to a particular design (Henderson and Shilling 1985, Rubin 1986, Sol 1987, Shneiderman 1987).

The introduction of a prototype system early in the design phase is a good way to engage the users in a very concrete way which can help them to clarify their requirements for the system. By providing a prototype

system with many of the interactive characteristics of the proposed system, the users should be much better able to redefine their needs and make specific suggestions for improvements. This is particularly important for users with little or no computer experience, for they will not have any context for describing their needs unless they actually test out a system. In fact, one recommended technique involves having the user interact with the prototype system and "think aloud" about what they are trying to do as a means of communicating the user's insights, strategies, or sources of confusion to the designer to enable the designer to improve the interface and integration of system functions (Shneiderman, 1987).

The prototype phase precedes full development of the data storage system, so that the interface characteristics can be evaluated and refined without constantly modifying the database structure. There may be several iterations of this process needed before the system is sufficiently well specified to warrant designing the full system. Seeking clarification of user needs early, through a prototype system, preserves the flexibility to accommodate significant changes in the system without risking a costly overhaul of the system when it is nearly completed (Shneiderman, 1987).

The practice of using prototype systems to refine the design specification has been strongly advocated and amplified for designing information systems for public agencies. In contrast, large scale private sector MIS systems are often designed according to the principles of Systems Development Life Cycle (SDLC). This traditional approach to designing corporate information systems requires the users to "sign off" on a system design specification too early, before the users have had sufficient opportunity to determine whether the system will in fact meet their needs.

This SDLC strategy is not appropriate for designing information systems for public agencies. An alternative strategy, put forth by Rubin (1986), is called Iterative System Development Cycle (ISDC). The main feature of this strategy, and that which distinguishes it from SDLC, is that the prototyping cycle is on-going and viewed as characteristic of the dynamic

purpose and function of the system. Much as with commercial software packages, the version you buy today will inevitably be further refined and an updated version will appear in a month. This is the principle of ISDC; experience gained through using the system is used to *iteratively* refine the system in an on-going process of system redesign (Rubin 1986). This technique takes account of the fact that the information processing needs of public agencies tend to be less well structured and more subject to change with changing administrations than are private sector systems.

Though these techniques appear to place too much emphasis on the window dressing without enough consideration of the underlying database structure and analytic procedures, users are generally unaware of components of the system that are transparent to them (such as database structure), but they judge the utility of the system by the quality of the interface (Zwart, 1985).

While endlessly evolving system is not an ideal goal, the iterative system development cycle is a realistic approach to the design of an information system for novice computer users. Careful system analysis should also be a priority, so that a sound database structure is developed from the start. In this case, the use of system prototypes and planned, iterative refinements to the information system is consistent with the idea that the more advanced system capabilities will grow with the users' expertise. Such a development plan will offer several benefits in the designing of the Land Information System for DFWELE.

One of the principal benefits of using prototypes of the system to refine the system specifications is the close relationship that this requires between the designer and the prospective users of the system. This is an important factor in the DFWELE case. The more that the users within the Division of Fish and Wildlife perceive that this system is being designed with their needs and purposes in mind, the less suspicious they are likely to be about the system being the Commissioner's system, and the greater the chance that they will accept the system.

The high level of user involvement in the system design will also work to insure that the "human factors" are dealt with well. By this I mean that the subtle points of how processing options are described or named, and how operations are sequenced on a menu, can be worked out with the prospective users of the system. This will help to assure that the people who will have to use the system will be happy with the mechanics of using the system. This process of working through the design issues will in fact be a good first learning experience for the staff of the Land Acquisition Program. Overall, the only negative factor related to the use of prototype system development is that the system will take somewhat longer to develop and will require more of the designer's time to interact with each of the prospective users as they explore each new version of the prototype system.

Systems Analysis

A critical factor to insuring that the system will remain useful and trusted over time is to design controls such that only the right data go into the system and that the integrity of those data is maintained. These are the traditional concerns of the data processing department of any large organization. They have however, been of less concern to the designers of microcomputer systems. This is not because maintaining data integrity is not a problem with microcomputer applications; it is. Rather, concern for the reliability of the data has been less with microcomputer applications because, 1.) these microcomputer systems have often been built by so called end-users who do not have the data processing training or experience on which to draw, and 2.) microcomputers are too new for the problem of data updating strategies to have caused big problems with data integrity. Therefore, the designers of these systems either do not realize the trouble that they are buying, or they do not understand the techniques used to insure the integrity of these systems. Because these systems tend to serve a smaller set of users, often serving only the designer, the problems that were encountered were reasonably limited in scope (Rivard and Huff 1984).

The Land Information System for DFWELE is intended to serve many users over an extended lifespan. During this time it is anticipated that many new features will be added to the system. Both of these factors argue for a more rigorous analysis of the information needs, the data required to support those needs, and a system design which will preserve the integrity of those data.

The information needs I have described earlier in this thesis. The data to support those information needs has been determined through a careful analysis of the existing manual systems that are to be replaced. For example, the data required to shepherd a parcel through the acquisition process was gleaned from ledger sheets used to track the parcels manually, and from the flow charts of the timing requirements of this process as outlined in Figure 2. on page 28.

The most important consideration when designing an information system that will be stable through time, is the analysis of the relationships among the various data. This analysis is the tricky part of system design, but the most critical for assuring that the integrity of the data is maintained as new data are entered and old data are edited and updated. The techniques for doing the analysis vary, but for relational database systems, the goal is to achieve "normal form." This is a complex theory, and there are different degrees of normal form. It will suffice to offer a simple example of how this analysis of the data and use of normal form provides protection of the integrity of the data in the system.

Suppose that DFWELE is negotiating with Mr. Sam Jones of Old Town, to purchase three separate parcels of land that once formed the Jones farm. Initially, the department was interested in only the two wooded upland parcels, and when the discussions got serious, the initial parcel information form was sent to the Administrative Assistant for recording. Mr. Jones's name and address were entered into the system for each of the parcels, along with the address of each of the parcels, and other data. Later, Mr. Jones moved off the land, to another community. Now Mr. Jones has offered the department his last remaining parcel of land, and a

negotiation has begun over the purchase of that land. Again, the information form was filled out, but this form lists the owner of the parcel as Mr. Jones of Newtown. The address and telephone number are different for this property owner than for the first two parcels. The computer will readily accept the new information without question. If this were the end of the story, the new parcel and the two previously acquired parcels would appear to have belonged to two different Mr. Jones. On the other hand, the Administrative Assistant may well remember that this is the same Mr. Jones who owned a parcel at 123 Country Road, or the Right of Way Agent may have so indicated. In this case, the Administrative Assistant calls up the information for the 123 Country Road property owned by Mr. Jones of Old Town, and proceeds to enter the change of address. The problem is that there were two parcels in the system owned by Mr. Jones showing the Old Town address. The correction made by the Administrative Assistant has affected only one of those records. In this way the integrity of the data has been compromised, because it was not possible to make the necessary change and have it reflected systematically throughout the data. While the search strategy the Administrative Assistant used to locate other parcels owned by Mr. Jones might be faulted in this case, the problem is characteristic of database updating procedures used by inexperienced or inattentive operators. In fact, in some cases it would be impossible to know if all the relevant records had been updated. The answer to this problem is to keep separate lists of property owners and parcels with appropriate references to the relevant data in the other file. Then when an address change is made in the property owners list, the new corrected address will always be matched with any of the properties owned by that person, and it will be clear which address to change since it will be for the one owner who lived at the old address.

Designing a database in normal form requires that these types of contingencies be anticipated and analyzed. Finally, appropriate measures must be taken in structuring the database to provide for the integrity of the data through time.

Incremental Implementation

An information system is built of many parts; there are components that allow for input of new data, components that create reports from data stored in the system, and of course the database tables themselves. A decision model is an additional component that is layered on top of these other pieces. Each of these pieces must be designed individually. The design of each piece must proceed with consideration for the integration of the whole system, but each piece must be designed and tested individually. Because of the limited interdependence of the various components of the information system it is possible to consider implementing the system in phases, rather than all at once.

It is wise to test out the most basic functions of the system in actual operation, to ensure that the parts work well with real data and under the real pressures and constraints of the office setting. Giving users an opportunity to use the system for important yet basic needs will provide the essential initial experiences of success with the system and will give the users confidence in the system (Bollens and Drummond 1986). Sophisticated features such as decision models are more likely to compromise the success of the implementation of an information system if they are difficult to understand and to master; or because of organizational resistance to changes in the decision making structure (Markus 1984).

The incremental implementation design strategy for the DFWELE Land Information System was proposed as a way to introduce the new system in phases, minimizing the shock of the new technology, and deferring the more controversial aspects of the system. The objective was to meet the most critical needs first, and later to add additional features to expand the capabilities of the system, resulting in the final stages in a fully operational decision support system.

The first stage of this system design entails automating the parcel tracking system to provide greater efficiency to the operation of the Land Acquisition Program. This is perceived to be the most critical need of

the program because of the increasing pace of acquisitions, and the inability of the existing manual systems to manage the information. Another important function of the LIS is the production of summary reports on the resources protected by DFWELE. To provide this capability, the parcel tracking system will also involve the collection of resource data on parcels, once they reach the option stage of the acquisition process.

The use of this initial system will help to build experience in handling information in the form needed to support further system development later. The implementation of this parcel tracking system will not address the organizational issues which are blocking the implementation of a decision support system, but will provide some tangible benefits to the program. These are discussed more fully in Chapter V.

The second step in the system design will be to develop an automated inventory system for managing data on the resource characteristics of land already protected by the Department. To provide a complete picture of the characteristics of the DFWELE lands, the addition of data on the existing inventory of DFWELE lands is critical. This is a logical second step because the data gathered on parcels being acquired by DFWELE should be retained and added to the data on previously acquired DFWELE lands, once the acquisition process is complete. These resource data are also the essential foundation for the possible development of a facilities management system for the Division. The potential future uses of the Land Information System are outlined in Chapter VI.

The third major feature to be designed is a decision model for evaluating the desirability of a parcel, or group of parcels, for acquisition. This model will be designed in a group process of joint model building. This decision model is envisioned as a set of standardized methods for assessing the value of a parcel of land based on its natural resource attributes. The Department considers many different types of natural resources in selecting land for conservation, including: cold water streams, riverbanks, wetlands, and mature softwood stands, to

name just a few. There is a class of models which provide a means of reducing individual measures of each of several attributes into a single score. These are appropriately called **multi-attribute models**, and there are significant methodological and logical difficulties associated with using these models (Smith and Theberge 1987). Nonetheless, this class of models appears to be the most promising for providing assistance to the decision making process regarding land acquisition. Important resource attributes have been identified through an interview process with the land acquisition staff and include measures of resource characteristics and spatial location. These attributes are being collected to provide the resource reporting capability, but these data are being collected in a form that will likely be of use in developing a multi-attribute decision model. Some of the analytic problems associated with quantifying the spatial attributes of parcels are discussed in Chapter V. The process of joint model building and its applicability in the DFWELE case are described in Chapter VII.

Despite the benefits of this incremental implementation strategy, there is a potential problem. Many researchers report that in the public sector, the need for DSS capabilities drives the development of the information system, and that the DSS needs shape the structure of the database (Henderson and Shilling 1985, Rubin 1986). If the DSS development is delayed until the design of the information system is finished and implemented, there may not be the flexibility to optimize the design of the DSS. To counter this possibility, a significant effort has been made to identify all the information needs of the Land Acquisition Program, but the process of joint model building may result in new criteria being identified.

V. Parcel Tracking & Reporting System for DFWELE

A parcel tracking and reporting system was chosen as the first step in designing and implementing a Land Information System for DFWELE. This first phase of system development and implementation includes a tracking system for facilitating the complex legal process of taking title to land once the decision has been made to acquire a specific parcel, and also includes two different types of reporting capabilities. Reports on the status of "tips" on parcels of land that have been referred to the Land Acquisition Program are included in this phase, as are reports on the natural resources and spatial context of parcels optioned or acquired by the Department. This first stage of system development provides three services: 1.) tracking parcels through the acquisition process, 2.) reporting on action taken relative to tips received from citizens, and 3.) summary reports on the natural resources and spatial context of parcels acquired by the program.

These are fairly structured tasks that provide a good starting point for the automation of the Land Acquisition Program. The system will be introduced using a prototype of the system which has only the input and output functions operating. Once the specifications of this parcel tracking system are determined through interaction with all the users, an operational parcel tracking system will be implemented. As the staff go through the process of adapting to their new work patterns using computers, both the staff and the analyst can learn from this first increment of information system. New data needs may be determined, or the system of reports that are developed may need to be changed. This first stage of system implementation will serve as the shakedown cruise for the system. The time required to perform routine tasks will be monitored to detect whether there are inefficiencies in entering or retrieving information which can be corrected.

Although a parcel tracking system may at first appear to be similar to many transaction-based information systems, there are some significant features particular to the DFWELE organization, and to open space planning

in general, which complicate the design and implementation of this system. I do not intend to specifically draw a comparison between the transaction-based systems typical of a corporate MIS and the parcel tracking and reporting system for DFWELE, but I will highlight the factors which make the DFWELE system different.

In respect to meeting the three different functions the system will serve in this first phase of design and implementation, three issues warrant special analysis:

1.) data accuracy and currency;

2.) changes in the information flows which support the decision making in the Land Acquisition Program; and

3.) the magnitude of the improvement in the program after implementation of the parcel tracking system.

In this chapter I will explain the significance of these issues, and the reasoning behind the decisions that I made in regarding these issues.

Data Accuracy and Currency

As discussed earlier, in order to automate a data management system, the data must be standardized and collected, and entered into the automated system. In this case, information may be hard to get in a timely and accurate form from the District Managers and Right of Way Agents. Two factors inhibit the ability to collect accurate and timely data. First, the field agents may feel that the detailed forms (filled out at the point of securing option on a parcel, Appendix B.) require too much time and effort to complete.

The information on stream frontage and length of internal roads is difficult to accurately quantify. However, because a map of the property must be drafted at the same time as the form is completed, the agent who drafts the map should be quite able to measure the frontage and road length using a scale. On the other hand, for the Administrative Assistant in Boston to take these measurements for each parcel that is being

acquired would be impractical. Information on the local zoning affecting the parcel, is clearly impossible for the Boston staff to research; but it is a factor that the agent should have already considered when determining a fair market price for the property based on comparable sales. Nonetheless, the perception that these forms are difficult or time consuming, may cause agents to delay submission of the reports, compromising the timeliness and comprehensiveness of the information.

One difficulty involved in obtaining information from the five District offices of the Division of Fish and Wildlife is that these five offices are far flung across the Commonwealth. The geographic dispersion alone complicates the data acquisition problem. Reports that don't get into the mail on time, that are "forgotten," or withheld a week because of few parcels to report on; these factors will affect the accuracy of the information in the parcel tracking system because the absolute currency of the information will be in doubt. There is no simple answer to this problem. Perhaps the only solution is for the Chief of Realty and the Administrative Assistant to keep open and frequent communications between the Boston office and the District offices, and keep sending the message that these reports are important and useful to the Land Acquisition Program.

The most difficult information to obtain in an accurate and meaningful form are the data on the spatial context of the parcel being investigated. Several measures of spatial context are requested, and the purpose for collecting this information may not be immediately apparent to the field agents, especially in the absence of a decision support model.

Information such as the "distance to the nearest non-adjacent protected open space" can be of use without a formal decision support system. This data can be used to sort the records of parcels with current options on the basis of proximity to other protected open space. This would provide a single dimension indicator of "potential" for forming linkages between this parcel and other protected open space. A measure such as this might be of significant interest to either the Chief of Realty or the Director

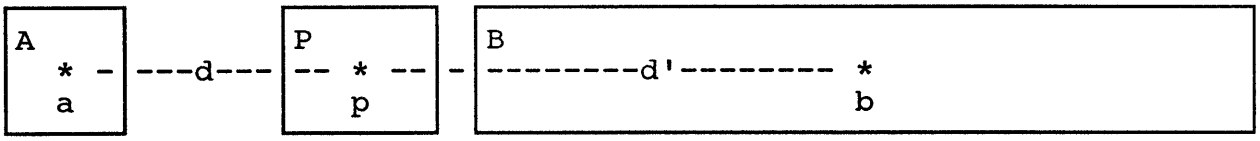
of Research and Planning when considering where to direct the efforts of the field agents. This is a benefit that could be realized even in the absence of a decision model.

A problem arises if this type of spatial information is to be entered into the system for each parcel as if it were static data that did not change. The context in which the Land Acquisition Program operates is one of explosive real estate development. To counter this pace of development, the open space acquisition effort has accelerated, fueled by the recent $500 million capital outlay budget of 1987. Acquisitions are constantly being made, by other EOEA agencies as well as DFWELE, causing the information on the "nearest non-adjacent protected open space" to become out of date and inaccurate in a matter of months. This is particularly true in areas of concentrated acquisition activity.

There is an alternative solution to this problem of data currency. Rather than entering a specific value for this datum, the proximity to protected open space could be calculated as needed. For example, the measure of proximity between parcels might be defined as the distance between the center of the parcel in question and the center of the nearest protected parcel. This calculation could be performed using the Land Information System, provided that: 1.) a record existed in the LIS for every parcel of protected open space in the Commonwealth, and 2.) that geographic coordinates of the parcel were recorded for each parcel of protected open space. To determine the nearest parcel of open space, the system would have to calculate the distance to every other protected parcel, and then evaluate the distances to determine the least distance, and finally match the least value to the name of the parcel and report the name of the "nearest non-adjacent protected open space." At present, there is no comprehensive list of open space parcels in the Commonwealth, with or without the coordinates of even the center of the parcel. The utility of this approach would depend on the currency (and accuracy) of the list of open space parcel centers.

The computational method for determining the nearest non-adjacent parcel of open space is also limited by a simple geometric problem. The issue is that this method computes the wrong spatial measure. The LIS could compute the distance between centers of parcels, but the measure that is desired is the distance between the parcel boundaries (see Figure 6.). As a result, it is possible to get a misleading or "wrong answer" from the system by using this algorithm. For instance, the large parcel, B, which extends to within a small distance of the edge of the parcel in question, P, is actually the "nearest non-adjacent protected open space." However, the computational method of determining the nearest parcel would identify the smaller parcel, A, as the nearest, because the distance, d, between the center point, a, of parcel A, and the center point, p, of parcel P, is less than the distance, d', between the center point, b, of parcel B, and the center point, p, of the parcel P in question.

Figure 6.



The answer obtained using this algorithm is misleading in this case because it does not inform us that parcel B is the nearest non-adjacent parcel to parcel P; but it is not a wrong answer. We simply have not posed the question in a form which reflects the meaning that we intended.

The algorithmic method of determining the nearest non-adjacent parcel could be improved by measuring the distance between the parcel boundaries. This is not an approach that the LIS can handle, however, because the LIS has no information about the location of the parcel boundaries due to the complexities of managing and analyzing this type of data. Computations of this type are possible using a geographic information system (GIS), once the boundary data for all open space parcels has been entered into the system. The most common method of entering this type of information from a map into a GIS is a process known as digitizing.

Because this data on the spatial context of a parcel is subject to becoming obsolete very rapidly, I have decided that this data on the nearest non-adjacent protected open space will not be added to the inventory data when the parcel is finally acquired. Instead, the spatial data on the parcel will consist of the geographic coordinates of the center of the parcel, and the list of adjacent parcels of protected open space as of the date of purchase. This data will be sufficient to give an adequate description of the immediate surrounds of the protected parcel, and will in time be supplemented by data and analyses available in the EOEA geographic information system.

This question is fundamentally one of how much information to request from the field agents, and how much information gathering can be justified for the parcel tracking and reporting system. While the spatial information is not essential to the process of taking title to a parcel, the information can be of substantial benefit to the Land Acquisition Program. Ultimately, the "distance to the nearest non-adjacent protected open space" is likely to be a criterion in a multi-attribute decision model when this feature is added to the system. I made the decision to include this type of data request on the resource information form, even in this first stage of development of the parcel tracking and reporting system, in consideration of the broader information needs of the Land Acquisition Program, and the likelihood of ultimately implementing the decision support model within the DFWELE Land Information System.

Significance of Changes in Information Flows

The resistance of the District Managers and Right of Way Agents to sharing information on parcels may be a problem. This resistance is likely to be more acute for the resource and spatial information than for the process tracking data, though both types of data are requested on the same from, filled out at the point of securing the option to purchase from the landowner (see Figure 5. on page 48 for details).

The impression that these forms request information that is not necessary or which will not be used, may cause the agents to resist

complying with this request. The data on the spatial context of the parcel (eg. length of corridor created by this acquisition), which the agents have not previously gathered as part of their normal investigation of properties, might not be provided if the agents don't understand or agree with the uses of these data. They may be less careful in researching the data, or they might simply omit responses to those suspect data items, thus compromising the accuracy and adequacy of the data submitted.

Managing this resistance will require a great deal of reassurance from both the system designer and the Director of Planning, to indicate that the purpose for collecting these data is not to judge the performance of individuals. The purpose is rather to enable resource specific reports to be produced which can be used in public meetings and at conferences to publicize the good work of the Land Acquisition Program. An additional benefit of these reports will be the ability to lobby more effectively for continued funding of open space acquisitions.

Another important way to indicate that the purpose of the system is to improve the functioning of the system rather than to drastically alter the way the program functions, is to work closely with the prospective users in the Division of Fish and Wildlife during the prototype phase of system development. This will lend credence to the assertion that the needs of the Division are a central concern in the design of the Land Information System.

Magnitude of the Improvement in the Land Acquisition Program

On the positive side, the changed pattern of information flows will mean that the Chief of Realty will have more accurate and up to date information, both on the status of parcels in any stage of negotiation, and those already in the acquisition pipeline. It should improve the Chief's sense of professionalism to be able to answer any question about the progress of a parcel within a moments notice.

The parcel tracking system will be used to enhance the communication between the Realty office in Boston and each of the district offices. Status reports will be sent out to the Right of Way Agents to keep them apprised of the progress of parcels they secured options on. This will help the Right of Way Agents to understand the total process of acquisition better, and will enable them to answer the questions of the willing seller as they wait for the bureaucracy to grind out a check and close the sale.
This will enhance the Right of Way Agent's feeling of professional responsibility, and provide them with the necessary information to be accountable to the landowners with whom they have negotiated a sale.

Reports can also be used to close the open-ended life cycle of a citizen's "tip" about land. Currently, the tip that turns out to not be of interest to the district just dies at that point without anyone necessarily recording the receipt of the tip, the reason the parcel was not of interest, or whether the tip was referred to another agency. With the parcel tracking system keeping track of tip information, the answers to each of these questions will be kept in the system. However, a new question arises; what happened to that tip that the district was interested in, but which never showed up as an optioned property? The Realty office in Boston can head off these problems by periodically sending back to the districts reports of all outstanding tips. The Right of Way Agents could then update these reports by simply checking off whether the parcel had been visited, whether it was no longer of interest and why, and whether the tip had been referred. This ability to close the loop on tips will make the Chief of Realty and the Commissioner both a lot happier, as neither of them will be on the spot in quite the way they are presently. Because the Land Acquisition Program relies in part on the good faith cooperation of citizen environmentalists to identify lands worthy of acquisition, it is very important to be able to respond to that constituency.

With a parcel tracking system in place, the Chief will also have detailed resource information about a parcel as soon as there is an option to purchase the property. The breadth of this information makes it very

likely that the Chief can justify the acquisition of most any parcel on the Commissioner's own terms. Conversely, if a parcel of dubious value got to the point of being optioned, having the detailed resource information would be the only way of identifying that this was a not a high priority parcel for acquisition.

The combination of the tracking information; which includes such items as the purchase price of the property, the appraised value, and the name of the owner; along with the detailed resource information about the parcel; allows for the possibility of using this system for auditing the Land Acquisition Program. Given the magnitude of the current funding of this program, this is a real benefit from the taxpayers' perspective. The system would furnish all the financial information necessary for a traditional audit, but the resource data would allow for another type of assessment of the value of the acquired lands.

The exact time savings that will be realized with the implementation of the Land Information System is hard to predict. In fact, at least initially, it will probably take longer for the Administrative Assistant to enter the tracking data on the system than it currently does for the manual tracking system. The amount of data that is being managed is increasing, and the interaction with the system is likely to be slow at first. I do not anticipate that there will be appreciable time savings realized in the data entry task compared to the manual system of logging information. The time savings will be realized in report generation. Reports on the activity of the program, by region, by account, or by time period will be vastly easier and quicker to produce. It will also be possible to quickly create reports which were impractical without the Land Information System. Without an automated system it simply was not feasible to cross reference all the resource data of interest for each parcel, but the LIS will handle this task with ease.

VI. The Future Growth of the Land Information System

My hope is that the Land Information System of the Department of Fisheries, Wildlife and Environmental Law Enforcement will have a long and useful life of service to the Land Acquisition Program. The system may endure through many changes in the Land Acquisition Program, and the demands on the system are likely to change. The degree to which I have anticipated these changes and planned for them is one measure of the adequacy and quality of the system design. There are some changes that cannot be foreseen, and I have worked to design the system in a stable way such that these unforseen changes can be made without having to discard or redesign the system. How does this parcel tracking and reporting system relate to the future needs of the Land Acquisition Program of DFWELE?

In the first case, the parcel tracking system provides three useful functions. The ability to track individual parcels through the long complex procedures involved in taking title to the land is an important function that will benefit the program. It will now be possible to insure that parcels do not languish at some step halfway through the process because of some inadvertent oversight. The ability to immediately answer citizen's inquiries about the land that they referred to the department for possible acquisition, will be a relief to the Chief of Realty and the Director of Research alike. The summary reports on the resources protected through acquisition of land will be an important public relations improvement which will serve the Commissioner's interests and will help the Chief of Realty assess the effectiveness of the Land Acquisition Program.

These immediate benefits will motivate the collection of essential data, and will begin the process of automating the land records within DFWELE. Any additional features or capability that might be added to the LIS will rely on this basic database of information about the land. In this respect, the parcel tracking and reporting system provides a solid foundation for the future expansion of the Land Information System.

There are several foreseeable changes in the future of the Land Information System. First, the implementation of decision support functions is a priority. Second, the EOEA geographic information system (GIS) is expected to be operational within one year. Concurrent with the availability of the GIS, a Local Area Network (LAN) will be installed, linking the two machines running the DFWELE LIS, and providing on-line access to the EOEA GIS. Within two to five years, all the district offices will have microcomputers which will be linked via modem to the Boston offices of DFWELE.

Planning for each of these developments is a complicated task. The implications of these developments for the initial design of the LIS are a bit speculative; nonetheless, there are some issues and opportunities which will need to be considered.

Linking the DFW District Offices to the LIS via Modem

Once the district offices are linked to the information system in Boston, it will be possible and expedient for the Right of Way Agents to enter the data directly into the system. This will be a major change in the job responsibilities for these agents, and they may view it as an unpleasant burden. After all, the Right of Way Agents will not be the ones who use this information, and since they do not receive the benefit from this task, they may not be as careful as the Administrative Assistant at entering the information accurately or promptly. The Administrative Assistant currently provides a central check on the frequency of data updates and the plausibility of the data coming from each of the five district offices. In the case of long lapses between updates from any office, or the submission of implausible data, the Administrative Assistant can contact the agents in the field and head off a problem in the making. This important check on the system would be forgone in the interests of efficiency if the Right of Way Agents enter data into the system directly. I would recommend this change only if the system is working well initially and reports are coming in to the Administrative Assistant regularly and with good accuracy.

On the other hand, to automatically keep tabs on the submission of reports by the field agents, the system could log the date of each update. This would allow the Administrative Assistant to check the dates reports were received by the system from any district. The plausibility of the data entry for certain items could be assured by including data entry rules which would prevent the entry of certain types of erroneous data such as misspelled town names, or numerical data that should be text.

Linking the LIS to the EOEA GIS

Adapting the system to take advantage of interaction with the EOEA GIS through a local area network is a simpler task. There are two questions to be answered: first, what uses could the system make of the GIS, and what is required of each system to insure that the databases are compatible?

The Land Information System could make use of the analytic and graphic capabilities of the GIS in a number of ways. It is beyond the scope of this thesis to elaborate on all the possible benefits of linking these two systems, however, I will give two examples of how such capability might be used.

The EOEA GIS will have a comprehensive geographic data layer depicting all protected on open space for the Commonwealth. The open space parcels are identified in the GIS by a 5-digit ID code. By including this code in the DFWELE LIS, the LIS will have the capability of linking the resource data for each parcel with the geographic depiction of the parcel in the GIS. This common ID code is a fundamental requirement for linking the data in these two systems.

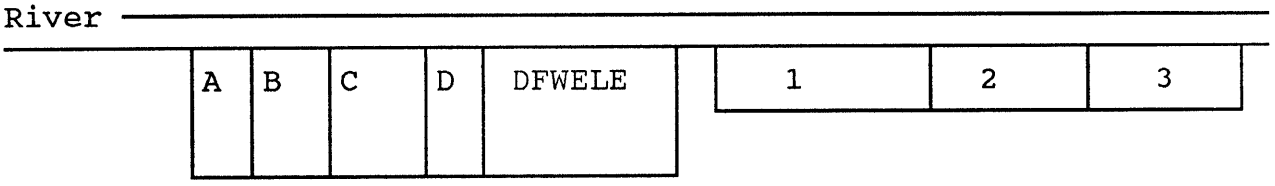
The most basic function that the GIS could provide as a result of this common ID code is the production of maps of DFWELE lands reflecting some of the parcel specific data stored in the LIS. This link will allow the creation of thematic maps of the DFWELE land holdings showing, for

example, which areas have rare species present, or those areas which provide public access to streams and rivers.

The GIS could also provide a powerful analytic framework in which to explore the implications of various acquisition options. The optioned parcels could be added to the geographic database by digitizing the parcel boundaries from the map provided by the Right of Way Agents. It would then be possible to examine the parcel relative to other protected open space in the area, and relative to the variety of natural resources that the Land Acquisition Program is striving to protect.

It would be possible for example to measure the degree to which a parcel or set of parcels extended a river protection corridor. The length of riverfront contained within the boundary of a set of contiguous parcels could be calculated by the GIS. The GIS would give the desired answer to this query (except in exceptional cases), but this might not be a sufficient analysis by itself. Even if decisions were made exclusively on the basis of an objective to maximize protected riverfront, this analysis of multiple options might give a sub-optimal answer. Consider the simple case depicted below.

Figure 7.



Let us suppose that the Department already owns the parcel marked "DFWELE," and that there are current and valid options to purchase any of the parcels: A, B, C, D, 1, 2, and 3. Assume that the Department also wants to link new parcels to those already owned by the Department. The

GIS would report that to maximize the amount of riverfront protected by a set of contiguous parcels, with the parcel marked DFWELE included, the best set of parcels is comprised of A, B, C, and D. The set 1, 2, and 3 is not considered because a road runs between the DFWELE parcel and parcel 1. The fixed constraint that the set must include the existing DFWELE parcel gives us a result that is sub-optimal on two grounds; first, there is an alternative option available (1, 2, 3) which will protect more riverfront; and second, the alternative option will likely be less expensive because of its smaller total area. Clearly, there are multiple characteristics of interest in selecting lands for acquisition. The real benefit of the GIS is that many such analyses may be performed, and the results can be visually confirmed, or rejected as inconsistent with other criteria for measuring the value of a parcel or set of parcels. Or the analysis may be refined on the basis of learning about the boundary effects (the results of the analysis given extreme input values) of the analysis as it was originally stated.

Implementation of Decision Support Features in the LIS

The eventual development of decision support features is a high priority of mine. I believe that even the process of trying to build the multi-attribute model of land preference could stimulate a more comprehensive consideration of the goals of the Land Acquisition Program. The use of the model in decision making could then put this more comprehensive set of considerations into practice.

I have made sure that in the implementation of the parcel tracking and reporting system, much of the data that will initially be collected to provide summaries of the resources protected by the Land Acquisition Program, will be in a form that will be useful for a decision model. However, these few data on resources and spatial location of the parcels do not necessarily constitute a complete set of data sufficient to fuel a decision model. More importantly, the most significant factor impeding the development of the decision support system is the organizational infighting for control of the program. Chapter VII outlines a process for

developing a decision support model within the Land Information System, despite the conflict within the organization.

The type of decision support model that I have described, a multi-attribute model of parcel desirability, may not in itself be sufficient to provide useful decision support. Partly, this is a problem with the Land Acquisition Policy of DFWELE, which is not specific about how parcels are to be judged against these policy objectives. While there are number of different qualities or types of ecological "value" mentioned in the policy statement, it is never stated whether the objective is to purchase parcels which have the very best of a single resource type, or parcels which are relatively "good" across most or all the resource types. This is a question of how to make tradeoff decisions across different resources and a factor which clearly affects the way in which the preference structure model is built.

Either type of preference structure could be built into a model for screening parcels relative to the objectives of the Land Acquisition Program, but what are those objectives? If the intention is to purchase the best parcels of each type-- wetlands, rare species habitat, game habitat; it would be simple to select those parcels that had the highest value score for one of these resource characteristics. If, however, the objective is to purchase the parcels which are the best across all the different dimensions, then the model becomes a little more complex. This preference structure could be modelled by using a linear weighted sum method to aggregate across criteria. This method presents some significant methodological difficulty, however, because it is necessary to express each of the resource measures on a ratio scale with a common or unitless scale. The difficulties of constructing a mathematically, and logically valid model of this type are well known, and yet the applications of this modelling technique have frequently ignored these constraints (Elliott 1981, Smith and Theberge 1987).

As noted earlier, if the preference for parcels is affected by the spatial distribution of the optioned parcels relative to other protected

open space, then the measures of adjacency or connectivity present a problem in themselves. It is very difficult to capture in an algorithm the particular type of spatial analysis that one can apply visually by analyzing a map of a region. The problem is that visual inspection is not a scaleable technique. That is as the number of options increases, it is not possible to analyze each option individually. The automated analysis is faster, more comprehensive, and more uniform in applying the analysis. The difficulty lies in specifying the type of analysis that is to be applied. Some of these analyses may only be possible with a GIS system, not with a Land Information System as explained earlier. But that does not make the problem of specifying the analysis any easier, it just makes the task of validating the analysis easier.

The problem of combining measures of resource characteristics and spatial characteristics in a single model of parcel "value," is immense. The question of whether one gets the correct analysis of options is significant. Nonetheless, the experience of working through a systematic consideration of the preference tradeoffs that are involved in making decisions about acquiring land is an important step toward improving the basis on which these decisions are made. The best way to insure that the decision makers understand the nature of the analysis and believe in the results of that analysis, is to enlist their assistance in formulating the model. This is the primary benefit of using the techniques of joint model building and exploratory analyses of the effects of different environmental policy choices. Chapter VII discusses such a process and how it might be used for implementing the DFWELE Land acquisition policy.

The development of the decision support models will be the most significant and challenging growth path for the Land Information System. Implementing this model will involve dealing with the political power dynamics of the organization, articulating complex preference structures regarding the desirability of land for conservation, and the technological and methodological problems associated with implementing these preference structures in an algorithmic decision model. To successfully implement this decision support component of the LIS will require skill at managing

a group process of collaborative model building, and some considerable expertise in the methodology of multi-attribute model building.

How Generalizable is the DFWELE LIS to Other Uses?

I have mentioned that the LIS could be adapted for use as a facilities management tool which the District Managers could use for making management decisions on Wildlife Management Areas. This use of the system would quite probably require the addition of more detailed resource information for each area, and the creation of new models geared toward resource management, within the LIS. These uses could be accommodated with the LIS, but within the constraints that affect the system in general.

It may be that the types of analyses that the District Managers will want to perform can not be supported by the LIS alone, but will require the greater spatial analytic power of a GIS. Even if this is the case, the LIS would be the appropriate platform from which to access the GIS for these special analyses.

With a new group of system users, it will be important to insure that the integrity of data in the system is maintained, and to prevent this new use of the system from interfering with the primary purposes that are served by the system. Consequently, the new information needs and data requirements should be systematically analyzed and implemented using the principles of designing in normal form.

Is the LIS *generally* useful for planning or managing other organizations' open space acquisition program? The answer is maybe. The general structure and considerations about what data are needed and how to handle changing conditions which cause the data to need frequent updating, will be common across land acquisition programs anywhere. The specifics of the parcel tracking system as it is designed for DFWELE, will not be transportable to any other agency, even within Massachusetts EOEA. The reason is that the required steps for taking title to land, and the sequence of events in that process are unique to DFWELE. However, the

structure of this parcel tracking component is general enough so that it would be possible to simply change the names of the steps and the timing parameters (related to public notice), and the system could provide the process tracking function for a different process. This is the case within EOEA agencies. A relatively simple switching of the acquisition process steps would adapt the parcel tracking and reporting features to serve any of the EOEA agencies. The preference modelling component of the system would not be transportable. This type of model would have to be reconstructed anew for any other organization.

VII. The Potential for Development of Decision Support

What are the goals for Decision Support?

The objective of this effort to implement decision support features in the DFWELE Land Information System is not to attempt to support all the decisions that must be made in operating and managing the Land Acquisition Program. Neither is the goal to *replace* human judgement in the decision making about land purchases. The goal is rather to develop some models that assess the "value" of land to DFWELE for conservation purposes. Models of this type depend in part on the subjective evaluations of people who have an understanding of what makes land "valuable" for ecosystem protection or wildlife management. As such the input of these specialists is critically needed if these types of models are to be credible and appropriate for use by decision makers.

This goal is linked to, and at least in the short term constrained by, the capabilities and structure of the parcel tracking and reporting system described in Chapter V. There may be important measures of parcel value that require information that is not currently being collected for the LIS, or the preferred analysis of spatial characteristics may require the use of GIS in addition to the LIS. Both of these limitations may be overcome with adjustments to the LIS as described in chapter VI. The natural resource data and information about the spatial context of the optioned parcels can be used as the essential foundation for the development of decision support features.

The pace of land acquisitions is accelerating. Soon there will be many more options to purchase land than can be acquired with a finite amount of funds. The Land Acquisition Program would benefit from having a system which would apply a series of standardized evaluations of the resources and spatial characteristics of each parcel, and produce a list or a rank ordering of the parcels for each type of analysis. Such models can be used to broaden the types of evaluations that can be performed, beyond the limited number of factors that have traditionally been possible to assess when making acquisition choices. For example, it would be possible to

highlight the parcels which excel on one measured resource characteristic, as well as those parcels which have a wide variety of resources but no one of which is individually outstanding. These analyses would perform a variety of types of screening of parcels, and allow the program staff to focus on just a fraction of the available options. With more time for reviewing these options, the DFWELE staff will be able to review these fewer options in more detail and make better decisions. The availability of resource and spatial information in the LIS makes possible several types of analyses of parcel value.

Another type of decision analysis that would benefit the Land Acquisition Program is a comparison of the resource characteristics of the lands acquired over the past year, with those acquired earlier, and with those currently under option. One possible scenario would be to determine, by querying the LIS, what the "average acre" of land looks like: it has 0.02 miles of riverfront, 0.1 acres of wetland, 0.7 acres of forested upland, and 0.2 acres of open field, for example. The average acre characteristics could then be calculated for parcels acquired during any particular time period. This type of analysis would provide the information base on which to anchor a discussion of whether the program was succeeding in meeting its goals for acquiring specific types of resources. The result of this type of analysis might be a refocussing of the program in a particular region to emphasize efforts to acquire a particular type of resource. At the extreme, this retrospective analysis might be used to make decisions about regional allocation of specific funds based on the suite of resources present in a region compared to those already protected in that region. It would be quite possible to build this type of analysis on top of the parcel tracking and reporting-LIS as it is currently designed.

These are the specific types of decision aides which could feasibly be designed and implemented, using the parcel tracking-LIS as the foundation. They are types of analyses that are not currently possible without the LIS, but which would assist decision makers in making more effective

decisions about how to make strategic progress protecting land resources with the Land Acquisition Program.

Joint model building for decision support

The implementation of the parcel tracking-LIS for the Land Acquisition Program at DFWELE provides an excellent opportunity to develop some decision support models. However, designing effective decision models will require extensive input from the DFWELE staff. Input is needed in order that the models use the most appropriate or important determinants of land value, and that the choice structuring is relevant to the DFWELE decision makers. In light of the need for input from many DFWELE staff, a process of joint model building is the most effective way to coordinate the input from a variety of experts within the Department. Despite the considerable investment of time and effort that this consensual process involves, it offers the brightest prospect of combining the judgement and perspective of each of the participants so that their input compliments rather than conflicts with the input of the other participating experts. This process presumes that there are important common interests or perceptions of what is valuable in land, or at least that there is latitude for satisfying different interests simultaneously. This effort could substantially improve the determination of land value by standardizing and rationalizing the analysis that is applied to these lands. This would provide the Right of Way Agents with a significantly better understanding of the measures of parcel value that are applied when deciding whether to exercise an option.

One such process of joint model building, termed Adaptive Environmental Assessment (AEA), is outlined by Hollings (1978). This approach "depends on a small group of people that interacts with a wider set of experts during a series of short-term intensive workshops" (Hollings 1978). The focus of the workshops is the development of a quantitative model can serve to orient the discussion and analysis of the impacts of policy implementation. The process of building a model forces hard thinking about what data are essential, what the important interactions may be, and

what the decision alternatives are. The focus is on building a model which specifically addresses the management goals and objectives. As a result, the assessment is both dynamic in its exploration of the impacts of various management options, and grounded by the objectives of the agency.

The basic process begins by convening a small group of people including some of the specialists required for the technical aspects of the assessment, a few of the important decision makers, and a computer specialist or methodologist. This first session is pivotal as it establishes what the management objectives are, what the general parameters of the problem are, and culminates in the development of an initial model. After this preliminary meeting, the first workshop involving the full panel of specialists is called. This group of specialists may include: scientists, economists, managers, policy makers, and one or two computer analysts. The workshop session begins again at the beginning, but with the experienced core group members assisting, to identify the impact categories, the key information needs, policy objectives, possible alternatives, time horizon and spatial effects. The workshops are followed by an extended period of "consolidation" during which time the core group works on building and implementing the model, or performing additional research if needed to proceed with the modelling.

This series of four or five workshops, each lasting two or three days, is held over an extended time period (up to a year). During the middle stages of this process, the attention turns from building the model to exploring the policy or project impacts, using the model to illustrate which are the important impacts, and highlighting ways to avoid or mitigate those impacts. The participation of the managers and policy makers is very important at this stage. The later workshops concentrate on communicating the results of the assessment and the recommendations of the group to the policy makers and the community (Hollings 1978).

There are several benefits of this approach to environmental policy assessment. It exposes the gaps in the existing information, allowing for

future information gathering to be more focussed; it is a dynamic approach that explicitly considers the interactions among components of the problem; it focusses on management objectives while analyzing a range of alternative policies, it address the uncertainty of the predicted impacts, and performs sensitivity analyses. The *process* of model building and the resultant policy analysis directly involves the important staff, managers, and decision makers in the exploration of the impacts of a project or policy, and alternatives to that project.

How could joint model building be used by DFWELE?

If a process of joint model building is going to succeed at DFWELE, the purpose of the models and the objectives of the process must be expressed clearly and persuasively to the participants in the process. Without a significant commitment of time and effort by all the specialists, the process can not succeed. However, there is currently a great deal of uncertainty and discord over what determinants of land value are actually being used by the Land Acquisition Program staff. The Commissioner is concerned that the Right of Way Agents may not be considering a broad enough set of land characteristics when evaluating parcels. The Right of Way Agents are concerned that everyone in Boston wants to tell them how to do their job, and even then the message which comes through is not clear. The objective of the joint model building process is to rationalize that evaluation process with the input of the specialists who best know the circumstances and constraints affecting the evaluation of land. There is enough discomfort over the existing procedures, that the DFWELE staff may be highly motivated to find a new way of making acquisition decisions, provided they have reason to believe that the new method is likely to be better.

The implementation of the land acquisition policy would be the focus of the joint model building. The most pressing need of the Land Acquisition Program, once a parcel tracking system is in place, is to develop a model for measuring or assessing the desirability of parcels of land for

acquisition. There are a number of specialists within the department who should be included in the model building process to provide the variety of expertise and perspective needed for this type of assessment.

The specialists should include all those who participated in the Commissioner's working group on land acquisition policy, plus others. At a minimum I would suggest the following individuals should be included:

Director of Fish and Wildlife
Chief of Realty
Realty Administrative Assistant
District Managers (5)
Representative of the DFW Board
Director, Rare & Endangered Program
Fisheries Biologist
Wildlife Biologist
Computer Consultant
Deputy Commissioner
Director of Planning
Legal Counsel
Right of Way Agents (7)
Director Riverways Program

This group would encompass the range of expertise from within the department that should be involved in developing these models. Included are policy makers, program managers, technical specialists, and at least one person who understands the methodology. Both the Commissioner's Office and the Division are represented, and in numbers that should insure a good balance to the viewpoints or perspectives on how such a choice model should be structured, and what the determinants of land value are.

There are several types of questions that they must address in developing assessment models of land value. Are the right resource data being collected at the point of securing the option. Are there irrelevant data being collected in this process? What other data might be better indicators of land value? The answers to these questions will determine the need to modify the parcel tracking-LIS. It may be possible to considerably shorten the information form if many data are being collected that are not relevant to the assessment of land value. Or, it may be determined that the form needs to be filled out earlier in the acquisition

process in order to provide more timely information to effectively assist in decision making. For example, if there were significantly more options becoming available than the program could acquire, then requiring the Right of Way Agents to submit information earlier in the negotiations with the landowner would allow the Chief of Realty to assess the "desirability" of the parcel, and this information could be used to advise the Right of Way Agent. The advise might be either to negotiate aggressively for a deal, or the assessment might indicate that the parcel was of interest only if a bargain purchase price could be obtained.

Other important questions will arise in the process of designing the models. Is it important to purchase the best examples of each of several types of resources, or is it preferable to purchase lands that have diverse types of resources, but of only average quality. What are the relationships between different types of resources that provide synergistic benefits? What measures of adjacency or proximity make sense to measure. How important are these spatial and connectivity measures compared to the resource characteristics? These are difficult questions both from a perspective of specifying the priorities of the program, and because of methodological problems associated with the measurement of these resource inter-relationships and spatial characteristics.

The question of program priorities is raised pointedly by the following two contrasting opportunities: Parcel A.; these 5 acres on Cape Cod are the only remaining breeding habitat of the endangered Red-Bellied turtle, and include a small pond which will have to be placed off-limits to all visitors during the spring and summer season when the turtle is breeding and its young are vulnerable, there is little other wildlife value to this land-- price is $2.5 million; or for the same price, a 1000 acre tract in the Berkshires that has a cold water trout stream, several beaver colonies, mature hardwood uplands that are known bear habitat, and the parcel includes one of several sites where a Peregrine falcon has historically nested although no falcon has successfully nested there in 20 years. Assume that both properties are only eligible for acquisition under the account for protection of Rare and Endangered habitat, but the

budget will not allow both purchases. One important question in this case is, if the intent is to protect endangered species, are all the other resource attributes of any consequence? How does the size of an area affect the ability of that resource to support endangered species over time; will a 5 acre preserve be enough protection for the turtle population? Should the degree of rarity be taken into account, if so how does one assess degree of rarity? Should qualitative attributes be used at all? What are appropriate techniques for amalgamating qualitative and quantitative measures?

These are not questions for an analyst to try to guess at, the professional advise of experts is needed, as well as the subjective evaluations of the other decision makers. These questions must be addressed by the relevant experts, but the answers must also account for the management objectives of the decision makers. The analyst can provide counsel on the technical issues of appropriate modelling methodologies, and should be able to understand the issues of concern to the agency specialists and implement their conceptualization of the problem in a valid model. Exploring the use of these models of land value with some extreme cases such as the previous example, will provide the type of sensitivity analysis that will be necessary to insure that the model is really credible. These issues need to be discussed in the resource specific terms of a few stylized examples in order to deduce the important data and their inter-relationships as applied to evaluating land value. Moreover, this process must initially be worked out without regard to the political overtones of any specific real case, where the owner of the parcel is known, and the source of the tip and the proponent of the acquisition are known. These factors would cloud the model building process. An alternative approach that might be more believable than this stylized example would involve a discussion of how some of the older DFWELE properties would be evaluated using a model or models of land value. This method would allow the Right of Way Agents and District Managers to bring up issues particular to these specific lands that might genuinely affect the acquisition choice but which would not be incorporated in a stylized example.

Can this process of joint model building work at DFWELE?

I have discussed in earlier chapters how these tensions within the department led me to defer implementation of decision support features in the Land Information System. i believe that the barriers to successful implementation of the decision support features lie more at the level of the Commissioner and the Fish and Wildlife Board, rather than with the staff.

The struggle between the Commissioner and the Board of Fish and Wildlife over control of the Land Acquisition Program has been bitter and has affected the morale of the staff in both the Commissioner's office and in the Division of Fish and Wildlife. There are historical as well as genuine philosophical reasons for the difference of perspective on which types of lands the department should be buying. Nonetheless, the political problems between the Board and the Commissioner are more related to personal and symbolic issues of control, rather than to gaping differences over which lands are worth buying. The issue is style as much as substance, and the issue of the Commissioner's personal style and involvement in the details of land acquisition is a much bigger, more controversial issue than the issue of how to make more effective decisions in the Land Acquisition Program.

The traditional values of the District Managers and the Right of Way Agents notwithstanding, the staff are caught between their sense of loyalty to their superiors and their desire to continue to be as effective as possible in buying high quality lands for conservation. The professionalism of the land acquisition staff is evident in their efforts to keep the Land Acquisition Program operating effectively, in spite of political influences. There is reason to believe that they can and will work together cooperatively to improve the program, particularly if they can be sheltered from the political storm. Their ability to communicate and collaborate was demonstrated during the Land Acquisition Policy working group meetings held in the summer of 1987. These were not wide-open, easy-going brainstorming sessions, but a spirit of cooperation and

working for the mutual interest was evident in the group's efforts to develop the land acquisition policy. If the land acquisition staff, working with other specialists within the Department, can initiate a series of workshops to discuss what are the priorities for acquisition, as they did in the Commissioner's working group on land acquisition policy, then the staff also have the ability to design and develop their own decision support tools.

A group similar to the Commissioner's working group on land acquisition policy could collaborate to produce a set of models for assessing the value or "desirability" of land parcels to the Land Acquisition Program of the Department. Several conditions or factors would determine the likelihood of success of this group's efforts. First, the support for this project will have to come from both the Commissioner and the Fish and Wildlife Board. Without the support of both the Commissioner and the Board, the process would be perceived as just another partisan exercise. Second, the participants must make time available for this project. Each workshop will require one or two full day sessions, with probably two or three sessions required before the models are sufficiently well developed, validated, and demonstrated to the decision makers. Three, it would be very motivating to hold these workshops away from the normal workplace. The atmosphere of a working retreat would make this a more special, less onerous exercise. Fourth, and most importantly, the utility of these models must be demonstrated to the Commissioner and the Fish and Wildlife Board in order that they have confidence in the models and sufficient understanding of how the models perform evaluations of land.

Despite the complexity of accurately capturing any particular preference structure in a multi-attribute model, this process of collaborative model building would provide a forum for discussing the system of preference tradeoffs that have to be made with every acquisition decision. These decisions and the underlying dynamics of choosing one parcel over another, would be discussed in terms of resource tradeoffs, without the complication of the political history of any specific real world parcel. The discipline of building a model to assess the value of

land acquisitions would focus the professional energy of these specialists on the important determinants of habitat value, rather than on the partisan positions that are characteristic of their roles in the bureaucracy.

The use of these types of models could help to minimize the polarized atmosphere that exists in the department. In this context, it is likely that the points of agreement could be accentuated, and the magnitude and significance of the disagreements could be more accurately explored. The process of working through the joint model building could shift the focus back to making the best use of the resources at hand and to maximize the effectiveness of the land acquisitions. Because there will need to be several such models developed, the participants need not become deadlocked over the one right model for assessing land value. In fact, it may be appropriate to develop different models for each different account. These models would be used to determine desireable parcels according to the criteria established for that specific account, but with consideration of the interactive effects of linking parcels acquired under different accounts. The exploration of the synergistic benefits of acquiring combinations of parcels over time would be a significant step in improving the effectiveness of the decision making process.

The communication of the rationale behind the models will help the Commissioner and the Board of Fish and Wildlife to understand and trust the there is a middle ground where the interests of both parties, and the constituencies they serve, can be met. It may also help to remove the scrutiny of the program by the Commissioner and the Board, if they are convinced that their interests are being served in a rational and systematic manner.

Even if the models developed by the group turn out to be overly simplistic, and not as useful in daily decision making as is hoped, the dialogue initiated by this joint model building should leave an impact on all the staff who are involved with the Land Acquisition Program. The

subsequent decisions made by the participants in the process are apt to reflect the broader set of concerns than they did before the workshops.

Joint model building can be used develop some decision models which will help the Land Acquisition Program of DFWELE make choices among many options on parcels of land. This technique can also be used to develop a model for analyzing the priorities of the program in a changing real estate market. The implementation of these decision support features is a logical and important next step for the wider use of the Land Information System.

VIII. Conclusions

Will the decision makers in the Land Acquisition Program of DFWELE actually make more effective decisions once they have an information system? Will an information system help DFWELE streamline its acquisition process so that land is acquired more rapidly? Can decision support models developed using an innovative, collaborative model building process provide wise counsel to the decision makers, and influence their decisions? Will the Land Acquisition Program operate more strategically to acquire land that serves multiple purposes; preserving wildlife habitat, while protecting water supplies and connecting other protected lands? Unfortunately, it may not be possible to prove this one way or the other.

Is the implementation of the Land Information System likely to help the Land Acquisition Program in some way? Almost surely it will. Once the staff have found their own ways of working the system into their daily routine, the system will provide a variety of services which were not available before; instantaneous access to information about the status of a parcel or a tip, reporting on resources protected by the program, a better way of rationalizing the bureaucratic process of acquiring land. The staff will take pride in being able to report on the status of the program of a parcel at a moments notice. The program will be capable of handling a higher volume of acquisition activity. These are all important benefits that will be realized through the information system.

But will *better* decisions be made about acquiring land? Certainly the opportunity will be there, especially once the decision support features are developed. The key ingredient to *better* decision making is *people* who are dedicated to making better decisions. These people include the Right of Way Agents, for they control the supply of land that is actually available to buy, by virtue of the options they secure from landowners. These people include the Commissioner and the Fish and Wildlife Board members, who have the power to splinter the Land Acquisition Program into disconnected parts, unable to coordinate or cooperate to maximize the

benefits of lands acquired, much less to establish corridors of connected conservation lands. These people include all the other land acquisition staff who can assert their professionalism and work for acquisition of lands that serve a variety of interests.

It is not enough to just provide a better tool for planning open space acquisitions, the people must know how to use it and find a use for it. Still, it is not trivial to build a better tool for open space planning. This takes a great deal of study of the task that the tool should perform, and the setting in which the tool will be used.

The effort to design and implement an information system for open space planning, while still in its early stages, has taught me several lessons. Some of the theories of design and implementation of information systems for public agencies seem to be accurate and useful in the DFWELE case. The principles of the interaction theory of information system resistance, systems analysis, iterative systems development cycle, prototyping, and incremental implementation have proven helpful in conceptualizing the problems and strategies that affect the design and implementation of the DFWELE Land Information System. The theory and prescriptions have been helpful to me so far, and the situations of agencies and personnel described in the literature are similar to those I encountered at DFWELE. However, the literature did not provide all the answers to the difficult decisions that arose during the design of the LIS for DFWELE. To design a land information system so that it will be stable over time and can be successfully implemented, requires a complete organizational analysis, a careful study of the goals and purposes of the information system, and a self-conscious examination of the designer's role and motivation for designing the system.

The hard work has to be done just reasoning about the implications of each choice that has to be made. Choices about what really matters in *this specific case.* While some of the general principles of information system design are transportable to any such problem, the particulars of the individual case will determine what data goes into the system, what

information must come out of the system, and how much help the users of the system will require to extract that information from the system. These concerns go back to the question of the purpose that the system is to fill. This must be clearly thought out, consistent with the organizational setting, and squarely addressed by the design and implementation of the system.

The implementation of the Land Information System for DFWELE will be very interesting. The implementation process will determine whether the system is in fact used effectively and creatively in practice. There are many barriers to the full acceptance of the system. It will be a challenge to successfully portray the purpose of the system to the staff in the Division of Fish and Wildlife. It will be a challenge to keep the purpose of the system from unfairly serving one faction's interests over another's. I will be personally challenged to initiate and manage a collaborative, consensual process of designing a decision support system.

All the pieces are in place. The task has been well studied. Now the proof is in the implementation.

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THE LAND ACQUISITION MISSION

OF THE

DEPARTMENT OF FISHERIES, WILDLIFE AND

ENVIRONMENTAL LAW ENFORCEMENT

AUGUST 3, 1987

The Following individuals have worked cooperatively through a committee process to prepare the attached policy statement dated August 3, 1987, to assist the Department of Fisheries, Wildlife and Environmental Law Enforcement in its land protection efforts. We believe that this document expresses the philosophical and policy guidelines on which the land acquisition program should be based. This document will be submitted to the Fisheries and Wildlife Board and to the Commissioner for their review and comment.

Gwilym Jones	Robert Austin
Richard Cronin	Anthony Rodriquez
Lewis Schlotterbect	Daane Crook
Carl Prescott	Judith Wagner
William Minor	Steve Johnson
Henry Woolsey	Michelle Provost

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I. DFWELE'S Stewardship Responsibility

The Department of Fisheries, Wildlife, and Environmental Law Enforcement (DFWELE) is charged with stewardship responsibility over the wildlife and native wild plant resources of the Commonwealth for the benefit and enjoyment of the people of Massachusetts. This stewardship duty emanates from the state constitution and those sections of the General Laws of Massachusetts which establish and articulate DFWELE's statutory mandate.

A. Constitutional Origin of DFWELE's Stewardship Responsibility

Article 97 of the Amendments to the Constitution of the Commonwealth of Massachusetts guarantees that:

> The people shall have the right to clean air and water, freedom from excessive and unnecessary noise, and the natural, scenic, historic, and esthetic qualities of their environment; and the protection of the people in their right to the conservation, development and utilization of the agricultural, mineral, forest, water, air and other natural resources is hereby declared to be a public purpose.

As a result of this constitutional mandate, DFWELE is charged by law with the duty to carry out its statutory responsibilities in such a manner that the people's right to the natural and esthetic qualities of the environment is protected for their benefit and enjoyment.

B. Statutory Mandate of DFWELE

The Department of Fisheries, Wildlife and Environmental Law Enforcement is statutorily responsible under Chapters 21, 21a, 130, and 131 of the General Laws for protecting and enhancing ecosystems which support a rich diversity of healthy fisheries, wildlife, and flora in the Commonwealth, as well as for providing open space and access for outdoor recreation. This statutory mandate requires the Department to, among other duties:

1) Provide an early warning mechanism to assure the preservation and enhancement of the state's natural ecosystems from adverse environmental impacts, including habitat destruction by physical alteration or chemical and/or bacterial contamination.

2) Plan and direct the state's wildlife and fisheries management programs based on ongoing resource analysis and environmental monitoring.

3) Develop and implement environmental assessment and mitigation measures to safeguard the state's ecosystem support structures upon which all wildlife, fisheries and threatened species are dependent.

4. Provide real protections to the Commonwealth's wildlife and fisheries through enforcement of the state's hunting and commerical and recreational fishing, hazardous waste, and recreational vehicle regulations.

5. Work cooperatively with the other state environmental agencies, environmental advocacy groups and the agency's constituents (outdoorsmen/women, environmentalists, conservationists, hunters, fishermen/women, recreationalists) to achieve broader conservation goals and progressive ecosystem management.

6. Provide ready access to the state's publicly controlled water bodies and coastal areas for the recreational benefit of the state's residents.

Thus, DFWELE is the primary environmental protection agency of the Commonwealth charged by the state legislature with the duty to promote the well-being of the Commonwealth's wildlife and native wild plant resources and the habitat within which they exist.

II. Land Acquisition Authority

The Department and its component Divisions and Boards have the authority to acquire lands and interests therein in order to carry out this constitutional and statutory mandate. For example, under Section 6 and 7 of Chapter 131 of the General Laws, the Division of Fisheries and Wildlife has the authority to acquire public fishing grounds, fishery and wildlife management areas, and wildlife sanctuaries, while the

Division of Marine Fisheries has the authority under Section 17 of Chapter 130 to acquire lands necessary for the protection and improvement of the marine resources of the Commonwealth.

Consistent with the Department's constitutional and statutory mandate, DFWELE's primary focus in land acquisition is holistic ecosystem protection. As a result, the Department will concentrate its acquisition efforts on significant fisheries and wild floral and faunal habitats, with special effort to locate habitat important to as wide a diversity and as large a quantity of fish, flora, and fauna as possible (consistent with recognized wildlife management practices), whether they be game, nongame, or endangered species. It is the Department's firm belief that only holistic ecosystem protection, which emphasizes the importance of the whole ecosystem and the interdependence of all its parts, can adequately safeguard the wild plant and wildlife resources of this state for the present and the future benefit of residents in all areas of the Commonwealth.

III. Priorities for Land Acquisition

The Department seeks to protect and perpetuate the natural diversity of plant and animal species that exist in the Commonwealth through an aggressive land acquisition program thoughout the state that preserves a variety of natural ecosystems. Certain types of land have been found to support a great abundance and diversity of wildlife and native wild plants. Other lands may be found to be essential for the provision of public access to Commonwealth lands and waters for recreational activities that are supported by the Department. These

lands will be given special attention in the selection and prioritization of acquisition areas, particularly if found to be fragile, threatened, or in danger of imminent alteration.

A. Rare and Endangered Species Habitat

Massachusetts has approximately 130 species of native animals and 250 species of native plants determined by the Division of Fisheries and Wildlife to be rare and endangered, and these numbers are growing. In addition, fifteen natural community types have been determined to have particular ecological significance in maintaining the state's biological diversity. The Division's Natural Heritage and Endangered Species Program has given these threatened species and exemplary natural communities top priority for census, research, and management efforts. Through extensive inventories conducted over the past seven years, the Division's Natural Heritage Program has compiled data-bases which reference more than 4,000 occurrences of rare and endangered species and natural communities in the state. From this information, a list has been derived of more than 250 key habitat sites in which these communities and the rarest plant and animal species now live. These sites, which represent a very significant proportion of the natural biological diversity indigenous to the Commonwealth, are particulary vital to the continued survival of Massachusetts', 380 rare and endangered species. The Department is committed to the protection of these species and shall extend every effort to protect the habitat necessary for their survival.

B. Major Rivers and Streams

Rivers and streams provide excellent habitat for diverse species of fish, wildlife and wild plants. They are also critical for water supply, and their banks and floodplains provide natural corridors linking open spaces together. Since some species of wildlife cannot exist within limited habitat confines, these river and floodplain corridors are essential to enable these species to reach necessary habitat types. Streambanks and lands adjacent to rivers also act as a natural filter by screening out pollutants such as road salts. The recreational benefits of natural green corridors for canoeing, hiking, fishing and other nonintrusive recreational activities that are supported by the Department are obvious. For these reasons, the Department is committed to the acquisition of land adjacent to rivers and streams throughout the Commonwealth with the intent of establishing riparian corridors that connect areas of valuable wildlife habitat.

C. Wetlands

Inland and coastal wetlands and marshes represent the most prolific and diverse wildlife and wild plant habitat in the Commonwealth. Inland wetlands also serve as natural storage areas for water and act as recharge areas for groundwater supplies. Coastal wetlands and marshes act as nurseries and provide nutrients upon which most of the marine fishery food chain depends. Although several regulatory and land restriction programs exist to protect wetlands, the Department will continue to place wetlands in a priority status and protect such important habitat.

D. Adjacent Lands

The Department through its Division of Fisheries and Wildlife currently owns approximately 54,000 acres of wildlife management areas and sanctuaries scattered throughout the Commonwealth. In order to permit better management and protection of the wildlife resources on these lands, DFWELE will seek to acquire parcels both adjacent to and within the boundaries of existing wildlife management areas and sanctuaries. In addition, the Department will acquire properties adjacent to conservation lands under federal, state, municipal, or private non-profit ownership if such lands are adequately protected from development.

E. Public Access Areas

The Department is authorized and directed by statute to identify, acquire, and develop boat and canoe launching areas, paths, and trails for recreational pursuits that which least impinge on the natural charac-teristics of the land. In accordance with this mandate, 121 such boat and canoe launching areas have been constructed on the coast and on State-owned Great Ponds, other ponds, and major rivers. DFWELE also provides funds annually for the maintenance of trail systems throughout the state. while continuing to provide for public access to the state's inland and coastal waterbodies, the Department will take caution to include in its selection process to ensure consideration as to the appropriate size and the least environmentally intrusive siting, ensuring that such access areas will not jeopardize the ecological viability or alter the aesthetic qualities of their surroundings.

F. Major Acquisitions

In keeping with its mission of holistic ecosystem protection, the Department will seek to acquire large contiguous tracts of undeveloped land which provide diverse cover and habitat for multiple species of wildlife and native wild plants. Such acquisitions may include large single purchases or multiple acquisitions to provide large contiguous land holdings.

IV. Acquisition Program Policies

A. Recreation

The Department's primary mission in the acquisition of property throughout the Commonwealth is the preservation and protection of habitat for wildlife and native wild plants. In keeping with this mandate, public recreation is only allowed upon such lands in a manner and to the extent that such recreation does not jeopardize wildlife and native wild plant species or the habitat upon which they depend. Recreational activities supported by the Department on properties other than wildlife sanctuaries and rare and endangered species habitat include fishing, hiking, boating, canoeing, hunting, nature-walking, cross-country skiing, photography and bird observation. Hunting is not permitted on wildlife sanctuaries and special restrictions on recreational activities may be imposed to protect rare, threatened and endangered species and their habitat. Due to its adverse impact upon natural ecosystems and an inherent conflict with the recreational activities referenced above, the Department discourage the use of motorized land vehicles on properties under its jurisdiction.

B. Networking With Federal, State, Municipal Agencies

The legislature has vested in DFWELE stewardship responsibility for the wildlife and native wild plant resources of the Commonwealth, and authorized the Department to acquire those lands necessary to carry out this duty. Thus, DFWELE is the state agency primarily responsible for acquiring the types of lands listed above. In certain instances, other federal, state, and municipal agencies may also have an interest in protecting and preserving similar habitat. The Department is interested in cooperating with such agencies and coordinating such acquisition activities to make maximum use of fiscal and staff resources. The Department will keep other agencies and municipalities apprised of its acquisition priorities and areas under active consideration. The Department will also entertain joint aquisition projects with federal, state and municipal agencies on properties containing significant wildlife and wild plant habitat.

C. Networking With Private Conservation Organizations

The Department has historically worked very closely with non-profit land protection organizations such as The Nature Conservancy, The Trustees of Reservations, the Massachusetts Audubon Society and the Berkshire Natural Resources Council. It is the Department's intent to continue this close working relationship as well as to develop and utilize a network of regional and local land trusts, conservation commissions, and watershed associations to assist in the identification and acquisition of significant wildlife and wild plant habitat.

D. Fund Expenditure

The Department recognizes that escalating land prices and inflation continually erode the purchasing power of the funds available to the Department for acquisition. The Department will purchase property as expeditiously as possible throughout the state while maintaining its record of acquiring high quality wildlife and native wild plant habitat at the lowest reasonable price. The Department will make every attempt to streamline the acquisition procedure and appropriately staff the acquisition program to minimize unnecessary delays in the acquisition process.

E. Fund Disbursement

As the steward for the state's wildlife and native wild plant resources for the benefit of residents across the Commonwealth, the Department recognizes the need to acquire wildlife and native wild plant habitat in each of the five wildlife districts. It is the intent of the Department to identify and acquire the habitat needed for as wide a diversity and as large a quantity of game and non-game wildlife and wild plants as is possible within each wildlife district in a manner that maximizes state-wide protection of these precious natural resources.

F. Fee, Less Than Fee Interest

It is the policy of the Department to acquire property in fee wherever possible in order to maximize the protection that accrues through outright ownership. In some instances, however, it may not be possible or even necessary to purchase all of the property rights to a parcel of land.

In such cases "less than fee" alternatives such as conservation or preservation restrictions or easements, access easements, or rights-of-way will be pursued. Since the Department's primary interest is land protection, every attempt will be made to acquire whatever rights are necessary to adequately protect the land in question.

G. Periodic Policy, Priority Review

The Department is cognizant of the dynamics of the acquisition process and the need for periodic review and updating of its policies and priorities. Accordingly, the Department and its Divisions and Boards will review such policies and priorities on or before each July 1st and make such amendments or adjustments as are necessary.

RWA/pl
ADFWELE

DEPARTMENT OF FISHERIES & WILDLIFE
LAND TIP - SHORT FORM

R.O.W AGENT: DATE OF REPORT:

SOURCE OF TIP: DATE TIP RECEIVED:

SOURCE'S ADDRESS: SOURCE PHONE:

OWNER INFORMATION

OWNER'S NAME: OWNER'S TELEPHONE:

OWNER'S ADDRESS:

PARCEL INFORMATION

TOWN WHERE PARCEL IS LOCATED:

USGS QUADRANGLE:

SPECIAL FEATURES:

TRACKING INFORMATION

MAP CHECK? (YES OR NO): DATE:

WINDSHIELD SURVEY? (YES OR NO): DATE:

IS THE PARCEL OF INTEREST TO THE DISTRICT?:

WHY?:

DFWELE REALTY PROGRAM
POTENTIAL OPEN SPACE ACQUISITION

DFWELE DISTRICT: DATE OF REPORT:

R.O.W. AGENT:

PARCEL OWNER: ASKING PRICE:

OWNER'S ADDRESS: DFW OFFER:

OWNER'S TELEPHONE:

PURCHASE OR RESTRICTION?:
EMINENT DOMAIN?:

ANTICIPATED MANAGEMENT TYPE:

COMMENTS:

PARCEL LOCATION:

TOWN: ACRES: USGS QUAD NAME:

NEAREST STREET TO PARCEL: ZONING:

DEVELOPMENT PRESSURE (LOW, MODERATE, HIGH):

HYDROLOGIC DATA:

COLD WATER STREAM FRONTAGE (LINEAR FEET) AND NAME:

RIVER FRONTAGE (LINEAR FEET) AND NAME:

ANADROMOUS FISH RUN? (YES/HISTORIC/NO):

100 YR. FLOODPLAIN ACRES:

COASTAL FRONTAGE:

PONDS OR LAKE FRONTAGE AND NAME:

COMMENTS:

SIGNIFICANT NATURAL LANDFORMS OR FEATURES (ESKER, ERRATIC BOULDER, VIEWS, ETC):

RESOURCE INFORMATION:

TOTAL HARDWOOD/MIXED HARDWOOD ACRES:

TOTAL SOFTWOOD ACRES:

TOTAL FRESHWATER WETLAND ACRES:

TOTAL COASTAL WETLAND ACRES:

TOTAL OPEN ACRES:

ACCESS AND IMPROVEMENTS:

LENGTH OF FRONTAGE OF PUBLIC ROADS:

LENGTH OF INTERNAL ROADS (PASSABLE BY AUTO):

TOTAL TRAIL LENGTH ON SITE:

MAINTAINED BY WHOM?

NUMBER OF BUILDINGS:

CONDITION:

CURRENT OR ANTICIPATED USE OF BUILDINGS:

OTHER IMPROVEMENTS (I.E. BRIDGES, DAMS, POND/STREAM ACCESS:

HABITAT DATA:

HABITAT GOOD FOR WHICH SPECIES (INCLUDING NON-GAME):

UNUSUAL OR SIGNIFICANT SPECIES ON SITE (BEAVER FLOWAGE, HERON ROOKERY, OTHER):

COMMENTS:

ADJACENT TO PROTECTED OPEN SPACE?:

NAME, OWNER & ACREAGE OF ADJACENT PARCEL(S):

TOTAL PROTECTED RIVER FRONTAGE IN THIS COMPOSITE TRACT:

TOTAL PROTECTED CWS FRONTAGE IN THIS COMPOSITE TRACT:

TOTAL TRAIL MILEAGE IN THIS COMPOSITE TRACT:

PART OF PROPOSED CORRIDOR? (EITHER RIVER OR UPLAND CORRIDOR):

NAME OF CORRIDOR:

NAME, OWNER & ACREAGE OF ADJACENT CORRIDOR PARCEL(S):

LENGTH OF CORRIDOR FORMED BY ACQUISITION OF THIS PARCEL (RUNNING LENGTH OF CONNECTED PARCELS):

TOTAL PROTECTED RIVER FRONTAGE IN THIS CORRIDOR:

TOTAL PROTECTED CWS FRONTAGE IN THIS CORRIDOR:

TOTAL TRAIL MILEAGE IN THIS CORRIDOR:

MOST IMPORTANT CORRIDOR PARCELS TO ACQUIRE TO COMPLEMENT THIS ACQUISITION (NAMES AND ADDRESSES OF OWNERS):

DISTANCE TO NEAREST NON-ADJACENT PROTECTED OPEN SPACE;

STRAIGHT LINE:
NAME, OWNER & ACREAGE OF NEAREST PARCEL:

ALONG RIVER CORRIDOR:
NAME, OWNER & ACREAGE OF NEAREST PARCEL:

ALONG OTHER CORRIDOR:
NAME, OWNER & ACREAGE OF NEAREST PARCEL: