Historical Patterns of Land Protection in North-Central Massachusetts: The emergence of a greenway

Alisa Diane Golodetz

A Division Three Project
submitted in partial fulfillment of the requirements
for the degree of Bachelor of Arts
School of Natural Science
Hampshire College
Amherst, Massachusetts
February 1993

Committee:
Larry Winship, Associate Professor, Hampshire College
Brian Schultz, Assistant Professor, Hampshire College
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this magnum opus is dedicated to

my parents

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ABSTRACT

In north-central Massachusetts, the patterns of protected lands suggest a possible circular greenway, or conservation corridor. The patterns of ownership, acquisition history, and landscape of the protected lands illustrate how greenways are mosaics of land-uses and landscapes. Exploration of these patterns reveals how the mosaic of protected lands developed, why creation of a greenway is useful, and what conflicts arise in creating a interconnected system.

Protected lands were defined as "protected from development in perpetuity." For each protected area, the acquisition date, means, group, and purpose were determined. Boundaries of the protected lands were collected on United States Geologic Survey topographic maps and digitized into a Geographic Information System. Spatial distribution and relationship data were collected from the topographic and digitized maps.

The patterns of acquisition purposes reveal that the protected lands include a diversity of purposes which are not evenly distributed. Integrating the lands into a greenway would provide a structure in which land purposes could be more equally represented and effectively distributed for the benefit of the protected lands and the local community. Acquisition history shows that land protection ideas, means, and purposes developed over time in response to concurrent social, economic, and political conditions indicating that land protection activities have not been random and will continue to evolve with changing circumstances.

Spatial patterns illustrate that, by area, most of the protected lands are connected although many individual parcels remain isolated. This discrepancy suggests that goals for the greenway need to be established to help guide future acquisitions. Towns are within close proximity of the greenway and roads of different types contact the majority of parcels. While the greenway is accessible to humans, thereby fulfilling social functions, human activities and road interruptions pose threats to the ecological integrity and connectivity of the greenway. The patterns explored in this study provide necessary background and important baseline information on which future greenway studies can be built to create a coordinated greenway plan.

I. INTRODUCTION

Land protection, in its most general sense, involves allowing certain land-uses and prohibiting others. The function humans have assigned to a land area reveals to what degree each component of that area is being protected. While a housing development serves residential interests and an industrial park serves commercial interests, land protection for conservation is concerned with the natural environment[1]. Protected natural areas can function as parks, nature reserves, or corridors for human and wildlife movement, as in a greenway. The greenway, a spatially connected system of protected areas, is an increasingly common way to improve the conservation value of protected land. However, beyond the designation "greenway," the purposes of these conservation systems are variable. The goals for greenways depend on the unique aggregation of ownership, history, and landscape which make up the greenway.

Planning and design of a greenway necessitates exploring the patterns of ownership, history, and landscape for the whole greenway as well as for each constituent land area. To create the pattern of a greenway, the patterns of land protection which formed it must be understood. Owners of protected areas determine the activities permitted on their land, thereby revealing the goals and values assigned to that land. Purposes must be seen in a historical context, which includes when, how, and where land was acquired as well as the

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1 "Natural environment" is used here to describe the non-human components of this planet. Certainly, humans are an important, and often influential, part of the systems of life on Earth. However, it is necessary to be able to distinguish between what is human and what is everything else. "Natural environment," and other such terms, will be used throughout this document to identify this latter category, however rough a distinction it may be.

concurrent social, political, and economic climate. The physical, ecological, and human aspects of the landscape in which protected areas exist indicates what types of land will comprise the greenway and how the lands relate to cultural features and each other. Understanding the ownership, historical context, and landscape of protected lands enables land protection advocates to consider the goals for and functions of a potential greenway.

In north-central Massachusetts, currently protected lands form the framework of a possible greenway. Many parcels of land which are owned by a variety of groups, were protected at different times, and occur across a variable landscape lie in a circle around Orange and Athol, Massachusetts (Figure 1). If connected, these lands could form a continuous area of protected lands called the North Quabbin Greenway. While the development of the framework was accidental, it is possible to make the completion of it more purposeful by considering the ownership, historical, and landscape patterns of the protected lands. The results of the patterns can indicate why and how the protected lands should be connected into a greenway. However, the meaning and origins of "protected lands" and "greenways" must be understood for discussion of their patterns to be useful.

Protected Lands Defined

For the purposes of this project, protected land was assumed to mean "undeveloped, natural areas protected in perpetuity from development." However, it became clear that this definition barely scratches the surface of a complex idea. In general, land protection is a current action with a future vision, which is based more on land-uses than landscapes.

In theory, land protection will insure the continuation of certain types of land-uses. Whether land is protected for timber management, watershed

protection, wildlife management, habitat and species preservation, recreation, research, or agriculture, organizations protect land-uses which they regarded as threatened in some way. Legal documents, such as deeds which transfer development rights on private land to a conservation group, and political actions, such as state legislatures appropriating funds for the purchase of land for protection, can indefinitely establish on a land area certain land-uses while prohibiting others uses.

Land which is protected may be unaltered by human activity or may have an intensive land-use history. Resources, such as timber and wild game, may be extracted from the land, or endangered plants and animals may be preserved. Management may allow a range of recreational activities, such as off-road vehicle travel, motorboats, and snowmobiles, which could alter the soils, plants, animals, and aesthetics of an area. Alternatively, regulations may limit activities to less damaging pedestrian activities, such as hiking, canoeing, and skiing. Use of the land may involve alteration of the landscape for agricultural production or water collection, or it may involve restoring the land's ecosystem to some previous state (e.g. meadows or old growth). The legal documents and political actions which protect a land area may easily be overturned by subsequent legal or political means in the near future or may remain in place for many generations.

Within all of this variation remains the common idea that certain land-uses are being protected into the future. While a protected land area can be regarded as a unique and independent unit, it is also a part of the entire landscape in which it is located. Greenways attempt to aggregate variable and separate areas across a landscape into one system. Thus, as an integrated method of land protection, greenways offer a holistic approach to protecting land-uses throughout an area.

Greenways Defined

Just as the characteristics of individual protected lands vary, so do interconnected protected corridors. By definition, the only common characteristics among greenways is that they are linear natural or open areas. Recreation paths through urban areas, long-distance hiking trails, and rural, interconnected nature reserves are all examples of greenways (Smith 1993). It is difficult to discuss greenways generally because the design of each greenway depends on the conditions of the specific site as well as the values behind the specific purpose. Therefore, it is not possible to describe the "ideal" greenway.

Nonetheless, there are some aspects of linear conservation design which are applicable to every greenway. Width and connectivity are two of the most important aspects of a greenway's structure (Smith 1993). A greenway should be wide enough to serve its purpose whether to provide a vegetated corridor for human and/or wildlife movement or to preserve biodiversity. The optimum width will also depend on what type of movement for which particular species is desired. The less a greenway is interrupted by roads or other similar barriers, the easier it is for people, wildlife, and water to flow along the corridor. Other design considerations include the landscape context in which the greenway exists (e.g. is a forested greenway surrounded by more forests or agricultural fields?) and the degree to which portions of the greenway have been modified or degraded by human activity (e.g. are native species being crowded out by exotic ones?) (Smith 1993).

Consideration of the width and connectivity of a greenway helps determine which functions a greenway can fulfill. While the design and goals of each greenway are different, there are some functions which are possible in

every greenway. Humans can use the resources of a greenway whether they are recreating, harvesting timber, or managing and collecting a clean water supply. Greenways can provide a variety of environmental benefits from preserving biodiversity, limiting urban sprawl, counteracting global warming, or generating clean water and air. Linear conservation areas can also offer humans spiritual renewal and escape from the pressures, crowding, and pollutants of modern life (Smith 1993). Finally, greenways can serve plants and animals by providing habitat. The human use, environmental benefits, spiritual value, and plant and animal habitat functions of greenways address both ecological and social concerns (Smith 1993).

However, the co-existence of ecological and social concerns is not unique to greenways. Every way in which humans relate to the land involves the ecological and social realms. Human land-use can thus be seen as a mosaic of different uses. In the same way, every greenway is also a mosaic of uses, which reflect different ownership, historical, and landscape patterns. It is unlikely that any greenway is homogeneous. More realistically, a greenway includes a variety of lands such as privately and publicly owned land, recreation sites, protected riparian corridors, abandoned agricultural areas, pristine areas, forested ridges, and valley fields (Smith 1993). Thus, greenways inherently function as mosaics because they include many different land-uses, both current and historical. Because there are so many types of land and land-uses, the concepts of greenways and land protection must be flexible and dynamic in order to evolve with changing circumstances. Greenways and land protection are not recent ideas; they are both components of the conservation movement and have developed over time within the context of this movement.

History of the Conservation Movement

Conservation in the United States began as a popular movement in the late 1800s. Many people, including J.J. Audubon, H.D. Thoreau, and G.P. Marsh, had been developing and publishing their observations of the degenerating natural world and their ideas about what should be done since the early 1800s (Nash 1982). Nonetheless, in the 1870s and 1880s, most ranchers, lumbermen, and miners in the western United States were oriented towards obtaining wealth through exploitation of the natural world. At the same time, the federal government was aggressively encouraging settlement and development of the newly acquired western lands (Frome 1962).

As a result of land disposal, in 1890, the western frontier was officially closed. This event "carried immense symbolic meaning, for it suggested...that the process of exploiting inexhaustible resources was coming to an end. Natural resources were no longer substantially unclaimed; they had been mostly appropriated" (Koppes 1988). Concurrently, the buffalo and passenger pigeon were nearly extinct; the rising population and standards of living increased the demand for resources; the eastern forests had been largely logged over; there were water rights battles in the west, and new science and technology were allowing humans to control the environment even further (Stupski 1988). The evidence of the widespread exploitation of the natural world catalyzed many individuals and organizations to develop conservation ideals and agendas.

In 1875, the American Forestry Association was founded to encourage the government to advocate forest preservation as well as use. Ten years later, the federal government's Division of Forestry was created and began to set aside land in National Forest Reserves. These Reserves were established to protect timber and water supplies as well as to supply the nation with timber

products (Frome 1962). In this same time period, Yellowstone, the first National Park, and the Adirondack Forest Preserve, one of the earliest state-owned forest reserves, were established (Nash 1982).

The twentieth century began with the presidency of Teddy Roosevelt, an ardent conservationist. Roosevelt, along with his Chief Forester, Gifford Pinchot, advocated that natural resources must be protected and well managed for the benefit of the whole nation (Worster 1977). They transformed the original Division of Forestry into the United States Forest Service and the Forest Reserves into the National Forests (Frome 1962). Roosevelt and Pinchot were at the center of the Progressive Conservation Movement in which conservation was defined as the "planned and efficient management and development of natural resources according to scientific principles" (Stupski 1988).

In opposition to the Progressive Conservation Movement, John Muir was concurrently advocating natural resource preservation. Although his assertion that the rights of nature and humans were equal was not commonly accepted, many shared his zeal for defending nature against economic and consumptive views of the natural world (Koppes 1988). The establishment of the National Park Service in 1916 (Frome 1962), granted preservation of nature an official place in public lands policy. However, the National Park Service did not satisfy many preservationists. Although the National Parks protected wonderful natural areas, they were also being marketed as tourist attractions (Koppes 1988).

Conservation efforts slowed during the capitalist-oriented 1920s, but President Franklin Roosevelt gave new life to the conservation movement in the 1930s. The Great Depression had dislodged the public's confidence in the private sector, so strong government action was welcomed. Following John Wellsley Powell's lead, many government leaders advocated planning for the efficient use and equitable distribution of the country's natural resources. Land

was to be assessed and categorized according to its optimum function. Additionally, federal funds poured into many hydro-electric dam projects, which boosted the economy. However, these dams also allowed humans to retain control over nature (Koppes 1988), indicating that natural resources were still popularly viewed as commodities for human consumption.

At the same time, Aldo Leopold was questioning the utilitarian view of nature embodied in the dam projects. Instead, he offered a perspective of the natural world, which was based on ethics and scientific principles, especially ecological ones (Worster 1977). In his 1933 essay, "The Conservation Ethic," he suggested that humans "'inherit the earth, but within the limits of the soil and the plant succession we also rebuild the earth.'" As the ultimate goal for civilization, he proposed a "'universal symbiosis with land, economic and esthetic, public and private'" (Meine 1988). However, his ideas did not become popular until the 1960s and 1970s when preservation resurfaced as a philosophy of the conservation movement (Koppes 1988).

After World War Two, Americans' interest in outdoor recreation increased. In the 1960s and 1970s, federal funds assisted in the expansion of both the national and local public land systems. At the same time, federal legislation raised environmental standards, especially for water and air (Cordell et al. 1989). Environmental and conservation efforts met resistance in the 1980s, but decreasing landfill space, polluted air and water, loss of open space, wildlife habitat fragmentation, as well as increasing global warming have inspired renewed interest in and action for protection of natural resources.

The impetus for protecting lands has changed over time. Nonetheless, government and private organizations have always protected land in an attempt to sustain an aspect of the natural world which they perceived as threatened. Land protection has also always reflected prevailing social, political, and

economic attitudes. In the beginning of the conservation movement, the concern centered around forest and water resources. Later, energy resources, outdoor recreation areas, open space, and wildlife habitat became the focal points of conservation. The changing tide of public and private attitudes also affected greenway development.

The idea of greenways originated in the 1860s with Fredrick Law Olmstead. He developed a number of urban park designs in which vegetated pathways linked many small parks together. His designs, which focused on scenic and human movement needs, addressed the concerns of that era. Olmstead did not call his plans "greenways," but his naming of a series of open spaces encircling Boston as the "Emerald Necklace" evokes similar connotations. In the first part of the twentieth century, other planners followed Olmstead's lead and carried on his visions. As part of the New Deal in the 1930s, three new towns, Greenhills, Ohio, Greendale, Wisconsin, and Greenbelt, Maryland, which were encompassed by greenways, were designed and built (Smith 1993).

While greenways had largely been used in urban areas since the mid-1800s, in 1921, Benton MacKaye suggested the development of the Appalachian Trail, a 3,379 kilometer hiking trail from Maine to Georgia. Although still focused on human movement, the Appalachian Trail was the first rural greenway. In the 1960s, planers, recognizing that greenways could fulfill ecological as well as social functions, developed techniques to identify areas of particular natural resource value. These techniques incorporated ecological concepts into the developing greenway idea. More recently, an increased concern for open space and interest in outdoor recreation have resulted in the growth and popularity of greenways (Smith 1993).

North Quabbin Greenway

The protected lands in north-central Massachusetts serve as an example of the increasing interest in greenways as conservation tools. Historically, most of the lands were protected independently from each other and somehow ended up forming the framework of a circle around Orange and Athol, Massachusetts. Currently, Keith Ross of the Mount Grace Land Conservation Trust is taking advantage of the circle pattern of protected lands to develop a greenway. He is coordinating efforts to link the protected lands together by protecting more lands. His vision for this greenway, called the North Quabbin Greenway, goes beyond north-central Massachusetts, however; the greenway could link up with other conservation systems to the north and west (Ross, personal communication).

North-central Massachusetts presents its own set of characteristics which influence the design of the North Quabbin Greenway. The area has a history of intensive agricultural use, but is now mostly forested. The current population tends to be centralized in scattered towns, but is diffused throughout the area. The area includes ridges, valleys, rivers, and lakes. Quabbin Reservoir, a large human-constructed lake, extends south of the greenway (Figure 2). The Metacomet-Monadnock Trail, a long-distance hiking trail which starts in Connecticut and goes through Massachusetts to southwest New Hampshire, passes through the northwest corner of the greenway area.

Owners of the protected lands in the area include the United States Army Corps of Engineers, four state agencies, one town conservation commission, and six different private organizations. Uses of these lands include timber management, water supply protection, wildlife management, and nature preservation. The lands are protected in a variety of manners and to varying

degrees. If a greenway's ultimate function is to be a mosaic of different land-uses and landscapes, then this greenway meets that description.

The North Quabbin Greenway can potentially serve many functions. Already, a large amount of land forms the framework of the system, and there is the possibility of even more land being included. In such a large area, many wildlife species can be protected and a variety of land-uses can co-exist, each in its own space. The large amount of forests and waterways suggests that timber and water could be central to the greenway's functions in providing basic necessities, a healthy environment, recreational and aesthetic pleasure for humans, and plant and animal habitat.

The North Quabbin Greenway could also balance local and regional needs. Currently much of the timber and virtually all of the water (in the Quabbin Reservoir) are consumed outside the area. However, the local economy could benefit from the greenway if resource extraction provided local jobs or if recreationists supported tourist-related businesses. Finally, the North Quabbin Greenway can be part of a regional New England system of greenways, thereby increasing the potential of each greenway as well as benefiting the region as a whole. However, the extent to which any function can be realized relies on more than just the unique characteristics of north-central Massachusetts. Equally as important are the local patterns of ownership, history, and landscape.

Objectives

Emergence of the framework for the North Quabbin Greenway has, thus far, been accidental. It is possible that further efforts to complete the greenway could be similarly unplanned; acquisitions could be made without consideration of the goals and functions of the individual protected lands much less the whole

greenway. However, it is also possible to complete the greenway in a more purposeful manner by examining the following questions:

1. What has been the result of apparently random acts of land protection? What is the mosaic with which greenway planners have to work?
2. What is the purpose in completing this, or any other, greenway? Why not continue to randomly protect land without considering any system or plan?
3. How can conflicts between opposing functions be resolved? How will the resolutions of conflicts affect the function of the greenway as a system?

In asking questions of both a theoretical and a practical nature, contextual as well as specific information useful in considering the greenway's future will be revealed. Furthermore, these questions are applicable to all greenways, and the way in which they are addressed here will demonstrate how posing these kinds of questions can contribute to the planning of any greenway.

In this study, three variables, landowner, time, and space, were used to examine the patterns of acquisition purpose, acquisition history, spatial distribution, and spatial relationships. Each pattern provided information relevant to answering the questions above. The pattern of acquisition purpose reveals the goals and values of each landowner as well as how the lands are managed, how much area is devoted to different functions, and to what degree the lands are protected. Historical patterns show how each land area represents a different era of land protection which includes a unique set of goals, methods, and groups as well as a particular economic, political, and social climate. Spatial distribution illustrates the size and shape of the protected lands individually and as a potential greenway. The relationships of protected lands to cultural features, such as towns and roads, and to each other

helps in determining how accessible the greenway is to humans, how severely roads interfere with the continuity of the greenway as a corridor, and to what degree all of the land areas are or are not connected.

By examining patterns, it is also possible to address how information can be applied to the future greenway in establishing goals, implementing management techniques, and determining the types of land to be acquired to complete the system. Although these concerns involve understanding the history and landscape of the area, they ultimately rely on the goals and values behind each protected component. To explore these goals and values, it is necessary to know who the owners of protected land are in this area and what functions their lands serve.

II. THE OWNERS OF PROTECTED LANDS

A brief introduction to each group owning protected land in north-central Massachusetts will reveal three types of information: the goals and values of each landowner and the function of their lands, the great variation in how and to what degree lands of different types are protected, and the local historical context in which these lands were protected. To facilitate the description of each landowner, the groups have been divided into four categories according to the primary function of their land (Table 1): 1) resource control, 2) resource extraction, 3) resource use (not necessarily extractive), and 4) resource preservation. As will become evident, these four categories are loose associations of groups and do not definitively characterize any group or their land-uses.

Methods of Protection

There are two ways in which a private organization or government agency protects land in north-central Massachusetts. The first is ownership in fee of the title to the land. Owned land may be protected in various ways. State-owned land is protected simply by being part of the public domain that will remain in state ownership until a two-thirds vote by the legislature allows it to be sold (Steinmetz, personal communication). Such a legislative action would most likely require a significant change in circumstances from those in which the land was acquired. Therefore, as long as social, political, and economic conditions remain relatively constant, state lands are likely to remain in the public domain. Private organizations protect the land they own because the

organizations are designed to act as stewards of the lands they acquire beyond the lifetime of the previous owner. Often, there will be a legal agreement between the landowner and the organization detailing how the organization is to care for the land.

The second option in protecting lands is to acquire the development rights to the land in the form of a restriction while the ownership of the title to the land remains with the current, and any subsequent, owner (Commonwealth of Massachusetts 1992). Three types of restrictions are used in north-central Massachusetts. The conservation restriction, the agricultural preservation restriction, and the watershed preservation restriction are all similar in their structure, but they differ in the conditions which they protect, the activities which they prohibit, and the agency in which they are authorized (Commonwealth of Massachusetts 1992). Restrictions are legal agreements (Commonwealth of Massachusetts 1991a) and may be held by any approved organization or appropriate state agency. They exist in perpetuity until a public hearing is held and the proper government authorities approve the removal of the restriction (Commonwealth of Massachusetts 1992). The different ways in which government agencies and private organizations have used ownership of land titles and restrictions to protect land will become evident in the following sections.

Resource Control

The United States Army Corps of Engineers owns land in two flood control projects in north-central Massachusetts. The Corps is the only federal agency owning land in the area. Flood control mechanisms, such as dams, were built to regulate flood waters, which will inundate the land areas, if necessary. Because of the dams and the potential flooding, the land appears

developed and, occasionally, altered. However, because the threat of floods will always exist and always disallow any other kind of development on the land, the flood control project lands can be regarded as protected. Furthermore, rather then protecting nature from humans, these flood control lands are used to protect humans from nature. The water resources are not being extracted or used; they are being controlled. Management activities include timber harvesting, wildlife management, and recreation (Department of the Army 1981).

Resource Extraction

The Massachusetts Department of Environmental Management was formed in 1904 as the State Forestry Department in response to citizen pressure for the "people of the state...to own and manage some portion of the timber lands" (Hick 1927). A reforestation act authorized the Department to purchase, reforest, and sell back to the original owner cut-over lots. The lots which were not resold became the framework for the state forest system, which began to take shape in 1914 when the legislature "saw the need of large forest areas under State ownership" (Hick 1927). In 1914 and 1921, the legislature authorized the purchase of land which was to be reclaimed for timber production and watershed protection. All the land acquired between 1904 and 1935 (when the 1921 Act terminated) was purchased for no more than five dollars an acre (Hick 1927).

Today the state forest lands managed by the Department of Environmental Management, exist to produce timber, protect watersheds, provide recreation, and address other conservation needs of the state (Commonwealth of Massachusetts 1991b). However, timber extraction is the primary purpose of these lands. Currently, timber is not being harvested on the

state forest lands in north-central Massachusetts to the extent possible, because the markets for the available stock are limited. Management zones regulate where and to what extent various activities can occur. Some areas are intensively used and impacted while others are, to a large extent, left undisturbed (Rivers, personal communication).

The New England Forestry Foundation, founded in 1944, is a private organization which protects and manages small, private forests. Continuous and complete forest management for small private forests is a service which the Foundation believes the government should not and private forestry consultants could not offer. In addition to managing forests, the Foundation is also interested in "the preservation of woodlands for posterity;" they currently own all of their land in fee. Each of the Foundation's forests is managed individually so that, although forest management, including timber extraction, is the priority of all the lands, limited recreation and wildlife management occurs on some properties. The New England Forestry Foundation is the only group owning protected land in north-central Massachusetts which has a clear regional agenda; they own and manage forests throughout New England (Applegate 1982).

The Metropolitan District Commission, a state agency, owns the land and waters of Quabbin Reservoir and the nearby Ware River Watershed. The Reservoir was constructed to supply metropolitan Boston with a reliable source of clean water. Two dams were built on the Swift River and a 95 square kilometer lake flooded the river valley, drowning four towns (Kimball n.d.). Although the dam construction altered the area irreversibly and is a form of development, Quabbin Reservoir land is protected because it is owned by the state, and because Boston's need for water is not likely to diminish or disappear. The land constituting the Ware River Watershed serves as a catch

basin for supplementary flow into the Reservoir (Drawbridge, personal communication). Considering that the Ware River Watershed lands perform a secondary role in management of Boston's water supply and are not highly developed, the future of the Ware River Watershed may be less secure.

The purpose of the Quabbin and the Ware lands is to generate a clean water source which can be extracted and sent to Boston and its surrounding communities. Therefore, the Metropolitan District Commission manages the forests, the few open areas, and the wildlife on their lands to maximize the clean water supply (Spencer and Drawbridge, personal communication). Although recreational activities were not originally allowed at Quabbin Reservoir, hiking, fishing, bicycling, and picnicking are now permitted, in a limited manner (Friends of the Quabbin n.d.). In contrast, most recreational activities are permitted on the Ware River Watershed lands (Drawbridge, personal communication). The Metropolitan District Commission owns the majority of their land in fee, but a few watershed preservation restrictions have been acquired. These restrictions are designed to "protect the water supply or potential water supply of the commonwealth" and do not allow building construction, earth excavation, and other activities "detrimental" to the watershed (Commonwealth of Massachusetts 1991a).

Another state agency, the Department of Food and Agriculture, owns only agricultural preservation restrictions in north-central Massachusetts. These restrictions protect "land or water areas predominantly in their agricultural, farming, or forest use," and prohibit non-agricultural construction, earth excavation which degrades the agricultural potential of the land, and other such activities (Commonwealth of Massachusetts 1982). Responsibility for managing and maintaining agricultural activities, which are extractive both in creating fields and in cultivating and harvesting crops, lies with each landowner.

Resource Use

There is only one town which protects land in north-central Massachusetts. The Athol Conservation Commission was formed in 1965 to oversee the "development and protection of natural resources...in Athol." The Commission is authorized to "acquire, improve, protect, limit future use of, or otherwise properly conserve open space" (Wirth 1986). The Commission originally held conservation restrictions, but all of the town land is currently owned in fee (Greene, personal communication). Conservation restrictions retain "land or water areas predominantly in their natural, scenic, or open condition or in agricultural, farming, or forest use" and often permit public recreational use of the lands. Forbidden activities include most types of construction, waste or soil disposal, vegetation destruction, earth excavation, and water pollution (Commonwealth of Massachusetts 1991a).

Like state land, town land is protected because it is public domain, and town regulations probably allow for the lands to be sold under certain circumstances. In addition to protecting natural resources, the Athol Conservation lands also provide many recreational opportunities; few activities are prohibited. Timber harvesting has occurred in some areas, but management activities are primarily devoted to providing recreational access (Greene, personal communication), suggesting that the resources of the town lands are primarily used and rarely extracted.

The mandate for the state's Division of Fisheries and Wildlife requires the agency to acquire land for preserving and protecting habitats and their species but also to provide recreation (Minior, personal communication). The primary recreational activities are hunting, trapping, and fishing, the extraction of the very resources the agency is protecting. However, because the extractions are

not systematic or carried out by the agency, describing the function of the Division's lands as resource use, rather then resource extraction, appears more accurate. The Division engages in few management activities (Steinmetz, personal communication), so most of their lands are not impacted, beyond the activities of hunters and other recreationists. The Division owns lands in fee as well as owning many conservation restrictions.

The original lands of Harvard Forest, a research and teaching institute of Harvard University, are an excellent example of how a private organization becomes the steward for another person's land. In the early 1900s, James Brooks owned many hectares of woodland in Petersham, which he had carefully assembled and managed over the years. Although he originally wanted The Trustees of Reservations to buy his land, Harvard University ended up as the recipient (The Trustees of Public Reservations 1907). One of Harvard's faculty members, R.T. Fisher, had been looking for a site where the University could locate its new Division of Forestry, and where he could demonstrate his ideas about "profitable and practical utilization of wood crop" (Anonymous 1907). In becoming part of a well-established institution, Harvard University, Harvard Forest lands are protected to the extent that the University remains in existence, that current conditions remain relatively constant (i.e. that forestry does not become obsolete and the University sells the lands to raise capital), and that past and present members of the University continue to value the Forest (Foster, personal communication).

Today, the purpose of Harvard Forest lands remains scientific research and other educational endeavors (Foster, personal communication). Timber is harvested off the lands, usually for scientific reasons, and scientific experiments are carried out in the forests. However, only a few areas of Harvard Forest are used intensively; most are left alone in their current state. Pedestrian

recreational activities are allowed on most of the Harvard Forest properties, all of which are owned in fee and some of which also have conservation restrictions on them (Woolsey, personal communication).

Resource Preservation

The Swift River Valley Trust is a private organization currently consisting of a representative from Harvard Forest, The Trustees of Reservations, and the Massachusetts Audubon Society. All three groups own a significant amount of land in the Swift River Valley in Petersham. In the 1960s, a private landowner in Petersham was interested in having more of the valley protected. He proposed creation of this new land trust, which would involve all the protected landowners in the valley (Woolsey, personal communication). Since its organization in 1967, the landowners involved in the Trust have changed, but, presumably, the purpose has remained the same. The Trust was created to promote "research and public education in...natural history" (Fiske et al. 1967). While research and education are the purposes of the Trust, the purpose of the one parcel the Trust owns seems more preservation than research oriented.

The Trustees of Reservations is the oldest land trust in the world. Founded in 1891, The Trustees were established to acquire lands which, in the words of the founder, "possess uncommon beauty and more than usual refreshing power...just as the Public Library holds books and the Art Museum pictures - for the use and enjoyment of the public." Protecting natural beauty for human enjoyment still guides The Trustees as they seek out lands of "exceptional scenic, historic, and ecological value" to acquire (Hopkins 1992). Most of the Trustees' lands are owned in fee but some are protected with just a conservation restriction (O'Brien, personal communication). The Trustees' properties are managed to maintain or restore a desired ecological condition

and to provide passive recreational access. Each property is managed differently according to the wishes of the grantor and/or the discretion of The Trustees. Some lands are managed to maintain historical landscapes; others are let alone to return to their "original" state. Some of properties are wildlife sanctuaries, but others allow hunting (O'Brien, personal communication).

Soon after The Trustees of Reservations formed, the Massachusetts Audubon Society, another private organization, was founded in 1896 as a bird protection society. The Society's first land acquisition was a sanctuary for bird populations as well as place for humans to observe and learn about birds. Subsequent sanctuaries were acquired and designed to satisfy the public's interest in all forms of nature. Through the 1970s the Society acquired many land areas which served as sanctuaries, but, more importantly, as educational centers. As threats to species habitats and populations increased in the 1980s, ecological concerns became a higher priority than education (Hecker 1986). Research efforts, such as inventorying properties and censusing populations throughout Massachusetts, have become important additions to the Society's activities (Anderson, personal communication). In north-central Massachusetts, all Massachusetts Audubon Society properties, which they own in fee, are currently wildlife sanctuaries. For the most part, the Society's management philosophy for these sanctuaries is minimal interference with the ecology of the lands and allowing, but not encouraging, passive human use. The Society also owns a number of conservation restrictions (Storrow, personal communication).

Mount Grace Land Conservation Trust was incorporated in 1986 as a private organization to protect land in-north-central Massachusetts. The Trust employs a variety of means to protect land including purchase of the title, securing a conservation restriction, or reselling land to other groups for management and protection. Most of the land for which the Trust is responsible

is protected by conservation restrictions, many of which involve active timber management. The few properties owned in fee by the Trust are for preservation purposes and passive recreational activities. Mount Grace Land Conservation Trust is leading the effort to complete the North Quabbin Greenway (Ross, personal communication).

Each of the landowner's goals, management strategies, and lands are unique. Because almost all of the groups have interests in other parts of Massachusetts, if not New England, the patterns of their protection activities in north-central Massachusetts are only a part of each group's larger patterns of activities. The protection activities of each landowner are influenced by national, regional, and statewide factors. However, the landowners in north-central Massachusetts also respond to unique local conditions in their protection activities.

III. STUDY AREA DESCRIPTION

The study area, located in the north-central part of Massachusetts, straddles the border of Franklin and Worcester Counties, extends into a small area of Hampshire County, and includes portions of 22 towns (Figures 3a and 3b). Arbitrarily, six contiguous United States Geologic Survey (U.S.G.S.) topographic maps (1:25,000) define the boundaries of the study area on three sides while the Massachusetts-New Hampshire state line is the northern boundary.

The area covers 151,700 hectares from the Connecticut River Valley (60 m a.s.l.) across the Pelham Hills to the undulating highlands of central Massachusetts (493 m a.s.l. on Mount Grace) (Figure 2). Only a small portion of the fault-formed Connecticut River Valley, bordered by the Pelham Hills and filled with deep surficial deposits of sedimentary and igneous rock, occurs in the study area. The central highlands, formed from granite schist and gneiss, are characterized by rugged topography with southward trending valleys (Motts and O'Brien 1981). The deep, loamy and sandy soils which predominate were formed in glacial till, but there are also pockets of glacial outwash and lacustrine and alluvial sediments (United States Department of Agriculture 1989). Temperatures average 4°C, rainfall 107.5 cm, and snowfall 135 cm. The frost-free season in the highlands is about 166 days and is slightly longer in the Connecticut River Valley (Black and Brisner 1952, United States Department of Agriculture 1967).

When European settlers arrived in this region as early as 1633, the landscape was almost completely forested (United States Department of

Agriculture 1967). By the first half of the nineteenth century, much of the land had been cleared for agriculture. Subsequently, through the late nineteenth century, most farms were abandoned as better farmlands in the west were discovered and made accessible. Forests dominated by white pine (*Pinus strobus*) reclaimed the old fields and were logged over by 1910 for box and barrel manufacturing (Black and Brisner 1952). Once new technologies rendered the pine containers obsolete, this industry was also abandoned (Raup 1966). Currently, the area remains largely rural and is 70 to 80 percent forested (Dickson and McAfee 1988). The forests form part of the transition hardwoods-white pine-hemlock vegetation zone (Irland 1982).

The population of the 10 towns that are completely within the study area is 32,965; the population of all 22 towns is 124,038 (United States Department of Commerce 1991). Township population densities range from 13.7 persons per square mile (New Salem) to 875.0 persons per square mile (Gardner). The mean population density is between 97 and 138 persons per square mile (Hornar 1991) but is unevenly distributed. Towns and cities with populations between 7,312 and 35,228 and population densities between 100 and 875 persons per square mile lie in the center or around the edges of the study area (Figure 1). Towns with a population less than 7,000 and population densities under 100 persons per square mile occupy most of the central part of the study area. Route 2, a two to four lane state highway which links eastern and western Massachusetts, bisects the study area (Figure 2).

An economic profile of the study area reveals that jobs and decent wages are scarce, but poverty is not severe. Education and manufacturing sectors, located largely outside the study area, employ the largest number of people in the Athol/Orange Labor Market Region. Unemployment rates in this region are 5.6 percent higher than the national average and 4.9 percent higher than the

state average (Franklin County Commission 1991). Furthermore, the average per capita income is $13,860, considerably lower than the state average of $17,224. However, while 7.4 percent of the people in the study area are living below the poverty line, this value is 1.5 percent less than the state average (United States Department of Commerce 1992).

The set of conditions unique to north-central Massachusetts contributed to the mosaic of lands currently protected there. However, as stated earlier, this mosaic is a result of patterns of ownership (acquisition purposes) and history (acquisition history) as well as landscape (spatial distribution and relationships). While background information has introduced the owners and the landscape, detailed investigation of each pattern as well as of the interrelationships between the patterns is necessary if questions concerning the function of the North Quabbin Greenway are to be approached.

IV. METHODS

The majority of land parcels that could be considered protected from development in perpetuity were examined. To be protected in perpetuity from development meant that legal, political, or other institutional means were established to indefinitely maintain the land-use activities and ecological characteristics of a land area existent at the time of protection. These means include ownership of the title to the land or of a restriction on the land by a government agency or private organization. Several land parcels which appeared to be protected, but did not satisfactorily fit the working definition of "protected lands," were not examined (see Appendix B).

Protected Land Boundaries

Boundaries of all the protected lands were located on U.S.G.S. topographic maps. Except for the lands in Petersham, for which boundaries were taken from the newly revised town tax map, maps of individual land parcels were transferred to the U.S.G.S. base maps using a Zoom Transfer Scope (Cambridge Instruments). Occasionally, boundaries were approximated when the owner could not provide a copy of the necessary map.

The mapped boundaries were entered into a Geographic Information System (G.I.S.) in a vector format using the digitizing program ROOTS™ (Corson-Rickert 1992). Polygon areas were calculated and then the vector files were transposed into raster format with a grid cell size of 45 meters for display in the IDRISI program (Eastman 1992). The large size of the maps necessitated deletion of every fourth cell for printing purposes.

The area values calculated by ROOTS™ were used as much as possible; however, unavailable boundary information and digitizing errors required some use of area values provided by the land owners. Areas were collected for each parcel of land (an area of land geographically independent from the landowner's other land areas) and for each lot (portions of each parcel which were acquired at different times).

Acquisition Purposes

The most recent and important reason, for which each land owner is protecting their land, was considered the purpose for all of a landowner's parcels. Clearly, this generalization does not take into account a group's multiple goals, changes over time, and subtle differences among the purposes of their various parcels. However, such intricacies were too complex to consider here.

Acquisition History

For each lot, information was collected on the year and means of acquisition, price, former owner, land-use history, and motivations behind the disposal and the acquisition of the land (see Appendix C for copies of all data sheets). Some lots passed from the ownership and protection of one group to another. Others were originally protected by a restriction and were later acquired in fee. In both cases, the current owner, acquisition information, and protection status were used in analysis. There were four public works projects, each of which acquired numerous individual lots within a few years. Therefore, each parcel of the projects is represented as having one acquisition per decade.

Spatial Distribution

G.I.S. was used to determine five factors: the size of the study area, the largest and smallest independent and contiguous parcels, the size distribution of the parcels, and the area of the protected lands combined. The remaining measurements and calculations were made from the topographic maps. The length of the greenway was measured at the innermost possible circle, at the outermost possible circle, and at a circle midway between these two extremes (Figure 4). From the inner and outer circumferences of the greenway, the area and width of the landscape occupied by protected lands were calculated.

The width of the current shape of the greenway was calculated by intersecting the middle loop of the greenway every 3.8 kilometers with a perpendicular line coming from the center of the study area. At each intersection, the distance along this center line which ran through the closest uninterrupted area of protected land was measured.

Determinations of amounts of land needed to complete the greenway were made by choosing unprotected areas along the middle circle to be protected (Figure 4). The distance across these gaps from the edges of neighboring protected areas were measured and multiplied by several possible widths to produce area figures. Both the shortest distance between two protected areas and the presence of desirable features to protect, such as waterways and long distance hiking trails, were considered in choosing gaps.

Spatial Relationships

Spatial relationships among protected land parcels were examined on the topographic maps. Parcel distance from population centers was measured as the shortest distance between the center of human activity in a town and the closest boundary of the protected parcel. The center of human activity was

determined subjectively based on the junction of major roads and personal information. For each parcel, distance was measured to both a small town (population less than 7,000) and a large town (population greater than 7,000).

Roads were placed into three categories: unimproved, light-duty, and highways, as suggested on the topographic maps. Foot or jeep trails were not considered. The number of times a road followed a parcel's edge, came to a dead end within a parcel, or bisected a parcel was counted for each road type.

For each parcel, the number of adjacent protected parcels was counted. Parcels which were separated by only a road were still considered to be abutters, but those which were separated by an unprotected water body were not.

V. RESULTS

Acquisition Purposes

Most of the study area is protected for water (30,187 hectares), timber (12,619 hectares), and wildlife interests (4,509 hectares) (Figure 5). Land for flood control covers 2,510 hectares, and land for preservation involves 2,267 hectares. Land for research, multiple-uses, and agriculture ranges from 1,165 to 624 to 159 hectares, respectively. When landowners are identified with just one protection purpose, more than one group shares a common purpose only in the cases of timber and preservation (Table 1).

The land protection purposes arranged on a spatial scale illustrate that the land for water protection is only found in the southwest and southeast corners of the study area (Quabbin Reservoir and Ware River Watershed, respectively) (Figure 6). These lands consist of two large, contiguous areas, with smaller parcels scattered around the periphery of the larger areas. Timber lands are mostly located in the northwest corner of the study area where they appear to show a nearly contiguous area. Other smaller timber lands are distributed throughout the study area.

Lands for wildlife and preservation are located throughout the study area in small to medium-sized parcels although wildlife lands predominate on the eastern side of the area. Lands which are limited to a particular area include flood control lands (the northeast corner of the study area), multiple-use lands (the town of Athol), lands for research (the town of Petersham), and lands for agricultural preservation (the southeast corner of the study area).

Acquisition History

Year of Acquisition - In the study area, 512 lots of land totaling 56,528 hectares were acquired for protection between 1908 and mid-1992. Of this total, the majority of lands (231 lots covering 41,236 hectares) were protected between 1920 and 1949 (Figures 7 and 8). The least land was protected during the first two decades of the century; an average of 729 hectares were acquired each decade (Figure 7). This amount increased dramatically to 8,305 hectares in the 1920s and peaked at 25,288 hectares in the 1930s. Total land protected decreased to 7,645 hectares in the 1940s and, over the remaining five decades, an average of 2,621 hectares were protected each decade. Of these last five decades, the most amount of land was acquired in 1950 (3,179 hectares) and the least amount in 1960 (2,059 hectares). In 1990, 2,492 hectares have already been protected in the first 2.5 years of the decade; this trend, if continued, would result in a total of 9,968 additional hectares being protected by the end of the decade. The cumulative area, summarizing this land protection history, shows the slow rate of acquisition in the beginning of the century, the sudden surge in activity in the mid-century, and the slow but steady pace since 1950 (Figure 7).

When considered together, the average size and the total number of lots acquired each decade (Figure 8) illustrates in more detail how the land was acquired in three distinct periods: 1900-1919, 1920-1949, and 1950-1992. The average area of acquired lots increased from 22 hectares in 1910, 66 hectares in 1920, 271 hectares in 1930, and peaks at 736 hectares in 1940. The average size of lots acquired in the last five decades are similar in value to the 1920 figure and are within a small range of each other (45 to 92 hectares). In contrast, the number of lots acquired each decade rises from 5 in 1900 to 36 in 1910 and peaks earlier at 126 lots in 1920. The numbers then drop to 12 in

1940 but rise again to an average of 44 lots for each of the last five decades. Finally, the relationship between the two variables shows that the size of the lots is small relative to the number of acquisitions, except in the 1900s and 1940s when the reverse is true.

Ownership categories - Ownership of protected lands, when grouped into four categories, federal, state, and town governments and private organizations, shows considerable variability in acquisition patterns (Figure 9). Both the federal and town governments acquired land in a limited number of decades. The federal government protected land only in the 1940s, and the town government acquired 526 of their 594 hectares in the 1960s but has since acquired an average of 23 hectares per decade. In contrast, both the state government agencies and the private organizations have acquired land in every decade of the century. The state was most active in the 1920s, 1930s, and 1940s, and private organizations were most active in the first one and the last three decades of the century. Nonetheless, the state has acquired much more land per decade (a mean of 4,935 hectares within a range of 6 to 25,205 hectares) than the private groups have (a mean of 352 hectares within a range of 24 to 898 hectares), except in the 1900s when the reverse is true.

Individual Landowners - The federal and town governments, represented by the Army Corps of Engineers and the Athol Conservation Commission, respectively, have limited periods of acquisition activity. Their cumulative protected area both show a sudden rise in acquisition in one decade and then little or no increase thereafter (Figure 10a).

The four state government agencies show a greater diversity in acquisition activity over time (Figure 10b). The Department of Environmental Management has been active since the beginning of the 1900s. The cumulative area line for this organization is similar to the cumulative area line

for all protected lands (Figure 7); the increase in protected land is slight in the first two decades, dramatically greater over the next three decades, and slower but steady throughout the last five decades. The Metropolitan District Commission first acquired a large amount of land in the 1930s and 1940s and did not acquire any more land until the last two decades. During the last twelve years, the Commission has protected 803 hectares. The Division of Fisheries and Wildlife did not begin protecting land until the 1960s, but their acquisition activity has increased at a fairly steady rate through the following four decades. The greatest increase was in the 1970s and the smallest increases were in the 1960s and the first part of the 1990s. The Department of Food and Agriculture is the most recent state agency to protect lands and has, since the beginning of its activity in 1980, acquired 159 hectares.

Of the six private organizations owning protected land in the study area, only Harvard Forest was active in the first half of the century (Figure 10c). The Forest acquired 898 of its 1,157 hectares in the first decade, and increased this amount to 1,133 hectares by the end of the 1930s. Since then, Harvard Forest has acquired only 24 additional hectares. The Massachusetts Audubon Society acquired 20 hectares in the 1940s, tripled its holdings in the 1960s, and has since acquired increasingly large amounts of land. The Trustees of Reservations also began protecting land in the study area in the 1940s, and although their holdings have increased dramatically, the amount acquired per decade has been decreasing since the 1960s. The activity of the New England Forestry Foundation has been limited to the 1950s, 1970s, and 1980s; their largest acquisitions were in the 1950s and 1970s. Mount Grace Land Conservation Trust began protecting land in the 1980s and has so far more than doubled its holdings from 107 hectares in the 1980s to 231 hectares in the

1990s. The Swift River Valley Trust's only acquisition was 13 hectares in the 1960s.

Spatial Distribution of Acquisitions - The spatial distribution of land protection activity over time is shown in four time periods: 1900-1919, 1920-1949, 1950-1979, and 1980-1992 (Figure 11a-11d). In addition, a fifth map shows the lands for which either the acquisition date or the acquisition lot boundaries were not known (Figure 11e). Lands protected between 1900 and 1919 were acquired by only two organizations, the Department of Environmental Management and Harvard Forest, and totaled 1,459 hectares (Table 2). The Harvard Forest lands are the larger areas just to the southwest of the center of the study area in the town of Petersham (Figure 11a). The only Department of Environmental Management acquisition which could be shown is a very small lot on the eastern boundary of the study area.

In the next period, 1920-1949, more Department of Environmental Management lands were acquired, mostly in the northwest corner of the study area (Figure 11b). The Metropolitan District Commission acquired the majority of the lands for the Quabbin Reservoir and Ware River Watersheds in the southwest and southeast corners, respectively. Additionally, the two Army Corps of Engineers flood control projects were established in the northeast corner. Harvard Forest also acquired some more land during this period, and The Trustees of Reservations and the Massachusetts Audubon Society made their first acquisitions in the area. By the end of the period, 42,678 hectares were protected (Table 2).

During the next period, 1950-1979, very small to quite large areas were acquired throughout the study area (Figure 11c). New acquisitions included land to the east of Quabbin Reservoir in the town of Petersham, which The Trustees of Reservations and the Massachusetts Audubon Society acquired

around one of Harvard Forest's original holdings (see Figure 11a). One of the Division of Fisheries and Wildlife's large wildlife management areas is distinguishable adjacent to one of the flood control projects in the northeast corner of the study area, as is the Athol Conservation Commission's large acquisition near the center of the study area. Other new groups protecting land during this time include the New England Forestry Foundation and Swift River Valley Trust. Although parcels were generally small (as compared to the previous period), 50,639 hectares had been acquired by the end of the third period.

Finally, in the last twelve years, most lands have been acquired in the southern half of the study area (Figure 11d). Many of the acquisitions fill in gaps around the Quabbin Reservoir and add onto previously protected lands in the town of Petersham. Mount Grace Land Conservation Trust and the Department of Food and Agriculture were the two new groups during this period, by the end of which 55,798 hectares had been protected. The final map, locates the 721 additional hectares for which the acquisition dates or lot boundaries are unknown (Figure 11e). Most of this land is in the northwest corner of the study area and belongs to the Department of Environmental Management.

Currently, the state government owns the most land in the study area (Figure 12). Three state agencies, the Metropolitan District Commission, the Department of Environmental Management, and the Division of Fisheries and Wildlife, own the three largest amounts of land (Table 2). The federal government also owns two large areas (Figure 12), which ranks them as the fourth largest landowner in the area (Table 2). The Massachusetts Audubon Society, The Trustees of Reservations, and Harvard Forest own the most amount of land of the six private organizations. Nonetheless, all three

government classes of ownership (federal, state, and town) own more land than all of the private organizations combined (Figure 12 and Table 2).

Means of Acquisition - For land to be protected, the title or a restriction must be owned by a protecting group. In the study area, 268 lots totaling 4,793 hectares were purchased, 41 lots (1,981 hectares) were donated, and 9 lots (1,041 hectares) were purchased with donated funds (Figure 13). However, the acquisition means for 195 lots totaling 8,712 hectares remain unknown.

The temporal pattern shows that most of the purchased land was acquired in the first half of the century and most of the donated land was acquired in the second half (Figure 14). More specifically, purchases were highest in the 1920s, 1930s, and 1940s and donations were highest in the 1970s, 1980s, and 1990s. While the cumulative area line of the purchased lots is similar in shape to the cumulative area line for all protected lands (Figure 7), the cumulative area line for donated lands is more reminiscent of many of the cumulative area lines for private organizations (Figure 10c).

Government agencies and private organizations clearly differ in means of protecting land (Figure 15). Government agencies own 98 percent (44,710 hectares) of the purchased land and only 12 percent (83 hectares) of the donated land. Conversely, private organizations own 2 percent (181 hectares) of the purchased land and 88 percent (1,801 hectares) of the donated land.

Restrictions - Protection restrictions are a relatively new means of land protection and, thus far, only 14 of the 171 parcels of protected land are protected by restrictions. The earliest restriction was acquired in 1974, but most have been acquired in 1989 and 1990 (Table 3). All landowners, except the Department of Food and Agriculture, have protected land by owning it in fee (Table 4). Similarly, all but three groups have protected land by holding a protection restriction on the land. Nonetheless, 11,753 hectares of the land is

owned in fee, while only 716 hectares have a protection restriction on them. Only the Mount Grace Land Conservation Trust protects more land by restriction (172 hectares) than in fee (59 hectares). Furthermore, the Metropolitan District Commission and The Trustees of Reservations hold only 57 and 5 hectares in restriction, respectively, but the other landowners hold restrictions for land areas between 148 to 175 hectares.

Population - In order to have a context in which to interpret this acquisition activity over time, population figures for the study area, the two major counties in the area, and the state are represented in Figure 16. While the county and state population curves are nearly identical, they differ from the study area population curve. The study area is the only region where population decreased from 1900 to 1910. Furthermore, while state and county populations grew the least in the 1930s and 1970s, the study area population grew at a faster rate during these two decades than in other periods. The slowest rate of growth in the study area was from 1920 to 1930.

Spatial Distribution

The study area totals 151,700 hectares of which 56,528 hectares, or 37 percent, is protected. The smallest individual parcel is 1.4 hectares and the largest individual parcel is 24,407 hectares. Of contiguous parcels, the smallest area is 61 hectares and the largest area is 27,245 hectares. The size distribution of the parcels shows that most of the parcels (38) are 51 to 100 hectares (Figure 17). To both sides of this middle category, the number of parcels drops of fairly steadily to the smallest and biggest classes, in which there are only 17 and 14 parcels, respectively. The one exception to this pattern is the parcels between 31 and 50 hectares, of which there are only twelve. If this class is excluded, there are as many parcels in the three smallest

classes (total 72) as there are in the three largest classes. As would be expected, the total area of land in each size class increases as the size class increases.

The greenway is 49 kilometers long on the inside, 98 kilometers in the middle, and 135 kilometers on the outside. The area between the inner and outer lengths totals 126,093 hectares and is 13.7 kilometers wide. The area which the protected lands currently occupy is an average of 2,794 meters wide within a range of 53 to 21,000 meters. To complete the greenway, a distance 13,901 meters long must be protected. If a minimum passageway of 50 meters is desired, 7 hectares must be acquired. If a more generous passageway of 1 kilometer or the current average width of the greenway were preferred, 139 or 388 hectares, respectively, must be acquired.

Spatial Relationships

Towns - There are 171 individual parcels in the study area. All of these are less than 8 kilometers from a small town and most (100 parcels) are 1.0 to 3.9 kilometers from a small town (Figure 18). However, if area is considered, there is a clear inverse relationship between the area of protected land and the distance from a small town. Distances from large towns range from 0.7 to 18.6 kilometers, but most parcels (116) are a moderate distance of 5.0 to 12.9 kilometers from a large town. In terms of area, more area of protected land (19,340 hectares) is 2.0 to 9.9 kilometers from a large town than any greater (5,142 hectares) or lesser (227 hectares) distance.

Roads - Roads connect with all but 35 of the parcels (Figure 19). Of the parcels affected by roads, 54 have contact with only 1 road, 29 with 2 roads, 32 with 3 to 5 roads, and 19 with 6 to 100 roads. Therefore 88 percent of the parcels are either roadless or are touched by roads less than six times each.

However, while the number of parcels decreases as the number of road contacts increases, the average size of parcels increases as the number of road contacts increases. Parcels with none or few roads are small (24 to 156 hectares), while parcels with 25 to 38 road contacts are much larger (3,187 hectares). One parcel with 100 road contacts is even larger (24,407 hectares).

Roads connect with parcels in a variety of ways; they bisect, dead-end in, or follow the edge of protected parcels (Figure 20). Unimproved roads touch parcels 228 times; light-duty roads, 214 times; and highways, 144 times. Unimproved roads coming to a dead-end in a parcel is the most common type of connection (137 times). Nearly as frequent are light-duty roads and highways which follow the edge of a parcel. All three road types bisect parcels, unimproved roads follow a parcel's edge 49 times, and light-duty roads dead end in a parcel 41 times. Finally, highways rarely dead end inside a parcel (4 times).

Connections - In the study area, 40 percent of the protected land parcels do not connect with another protected land parcel (Figure 21a). Of the 60 percent which do interconnect, 33 percent have one protected neighbor, 17 percent have two protected neighbors, and 10 percent have more than two protected neighbors. However, this same sixty percent of parcels which are connected amounts to 93.2 percent of the total area of protected lands (Figure 21b).

Summary of Patterns

The collected data were organized into four groups: acquisition purposes, acquisition history, spatial distribution, and spatial relationships. Of the acquisition purposes, water, timber, and wildlife interests are designated to the largest amount of land area (Figure 5). The spatial distribution of all the

purposes shows that some are found throughout the study area while others are limited to certain areas (Figure 6).

Acquisition history shows that, according the the amount of land acquired each decade, the century is divided into three periods: 1900-1919, 1920-1949, and 1950-1992 (Figure 7). During the first period, one state agency and one private organization acquired varying amounts of land in the southeast corner of the study area (Figures 10b, 10c, and 11a). Most land was acquired in the second period (Figure 7) when the federal government, an additional state agency, and two more private organizations began protecting land in the area (Figures 10a-10c). The lands protected during this period tended to be large and were located through the study area (Figure 11b). During the final period, two additional state agencies, a town conservation commission, and two more private organizations acquired land in the study area (Figures 10a-10c). These acquisitions were small and scattered throughout the study area (Figure 11c and 11d). Throughout all of these periods, more land was purchased than was donated (Figure 13).

Spatial patterns show that the greenway is quite large and little land is needed to complete the loop. Most parcels are less than 3.9 kilometers from a small town and 5.0 to 12.9 kilometers from a large town. However, more land area is closer to a both small and large towns than the parcel numbers indicate (Figure 18). Roads contact most of the parcels, but generally less than 5 times (Figure 19). Unimproved roads which dead end in a parcel are the most common type of contact, and highways bisecting a parcel are the least common (Figure 20). Nearly half of the parcels remain isolated from other protected parcels, but, by area, nearly all of the protected land is connected to other protected lands (Figures 21a and 21b).

VI. DISCUSSION

The patterns of acquisition purposes, acquisition history, spatial distribution, and spatial relationships of protected lands in north-central Massachusetts reveal information relevant to the future of the North Quabbin Greenway. Because greenways are mosaics of ownership, history, and landscape, each of these patterns helps to illuminate a certain part of that mosaic. As each of these patterns is explored more fully, the information revealed will help answer the questions: what is the effect of apparently random acts of land protection, what is the purpose in making these protected lands into a greenway, and what are the conflicts which creation of this greenway will raise? From the answers to these questions, ideas for future planning of the North Quabbin Greenway can be suggested.

Acquisition Purposes

Land protection activity by twelve different groups in north-central Massachusetts has resulted in a diversity of land purposes. There are at least eight different purposes, only two of which are shared by more than one group (Table 1). These purposes range from controlling resources for human safety, extracting resources for human consumption, using resources for human pleasure or knowledge, and preserving resources for human enjoyment and ecological integrity. However, within the diversity of purposes, there are also some common uses among the lands. Public recreational access is allowed on almost all the lands whether it be off-road vehicle travel or nature walks. Exceptions include the lands with restrictions, in which case public access is

allowed only at the discretion of the landowner, and the Metropolitan District Commission's lands, on which the types and locations of public activities are limited. In addition, the two flood control projects become inaccessible to humans during floods.

Despite the stated purpose of their lands, all of the landowners are protecting many components of natural ecosystems just by protecting their lands. Plant and animal habitats, parts of watersheds, and scenic areas are just a few of the many resources protected by every landowner. For example, while the Metropolitan District Commission protects land to collect a clean water supply and Harvard Forest owns land for scientific research, both sets of land also provide wildlife habitat, maintain forest cover in most places, and serve as scenic natural areas for passing motorists and venturing recreationists.

Because the purposes of the individual lands are diverse with few common themes, the purposes of the greenway will be diverse as well. Furthermore, the purposes of the individual areas address both ecological and social concerns indicating that, like most greenways, the purposes of North Quabbin Greenway will be ecological as well as social. Four general functions for greenways, which were described earlier, resource use, environmental benefits, spiritual renewal, and plant and animal habitat, include both ecological and social benefits and will apply to the North Quabbin Greenway. Resources are used throughout the area in extractive activities (timber harvesting and water collection) as well as recreational ones (hunting, hiking, boating). Because so much protected land is devoted to timber interests and the majority of the study area is forested, a large amount of forests are protected. Large forested areas benefit the environment by improving air and water quality and by providing wildlife habitat. The proximity of many people to the greenway (Figure 3) as well as the widespread availability of recreational opportunities

suggests that the protected lands have great potential for offering humans escapes from modern urban life. Finally, a few areas, especially those owned by the Massachusetts Audubon Society, provide spaces for plants and animals to exist with minimal human interruption.

However, all of these functions from resource use to plant and animal habitat are already occurring on the protected lands, so why does the greenway need to be formed? Although it is possible to point to many diverse as well as common purposes of the protected lands, protection purposes are far from evenly distributed throughout the study area (Figure 5). Water and timber interests, both extractive, dominate. The other six uses (wildlife, flood control, preservation, research, multiple-use, and agriculture) account for decreasingly smaller areas of land.

Because flood control projects will exist only where they are needed and the availability of agricultural lands in the area is limited, it is understandable that neither flood control nor agricultural purposes are well represented. Multiple-use purposes are currently carried out only by the Athol Conservation Commission (Table 1), which functions only within the town of Athol. However, it is possible for other groups with wider geographic ranges, or other towns in specific locations, to adopt multiple-use purposes. Both research and preservation purposes are both the interests of private organizations (Table 1), which may explain why they are poorly represented. All the government agency lands have resource extraction or use purposes (Table 1), and account for the greatest amount of the protected land (Figure 12). Therefore, as long as preservation and research are the primary interests of only private organizations, they will remain underrepresented.

However, both the Department of Environmental Management and the Division of Fisheries and Wildlife are developing plans to assign preservation

purposes to more of their land. The Department of Environmental Management has started a new program to identify and protect wild areas within the state forest lands system. Currently, no such areas exist in the study area, but part of the Federated Women's Clubs State Forest (adjacent to the Quabbin Reservoir) is being considered (Department of Environmental Management 1992). The Division of Fisheries and Wildlife is developing plans to identify and protect ecologically important areas in order to maintain the biological diversity and ecological integrity of Massachusetts (Crook 1992). Some Division of Fisheries and Wildlife lands outside the study area have already been designated as sanctuaries for rare or endangered species (Steinmetz, personal communication).

From a spatial perspective, three purposes serve as keystones in the greenway by virtue of being large, contiguous areas (Figure 6) from which the rest of the lands seem to build (Figures 11a-11e). Water interests dominate the two large areas in the southwest and southeast corners; flood control dominate the two large areas in the northeast corner; and timber interests dominate the northwest corner (Figure 6). The rest of the purposes appear to be interspersed in between these large areas without claiming such prominent portions of the study area.

Therefore, it seems that one purpose in combining the protected lands into a unified system is to balance the distribution of functions. Creating a greenway would provide the framework in which functions could be balanced by devoting future acquisitions to less represented purposes, for example. Additionally, within the structure of the greenway, landowners can develop agreements about distributing the different purposes so that each purpose has a "decent" amount of space and does not undermine another. Determining how much space each purpose should be allotted as well as how to distribute the

purposes equitably and effectively depends on having well articulated goals for the greenway. Additional information including the ecology of the protected lands, the effect of various land-uses on the local community, and more specific details about the management of each parcel are necessary to develop such goals.

The possibility of coordinating the distribution of purposes is limited by the extent to which each group can be flexible with their purpose and the areas in which they operate. Some groups, the Metropolitan District Commission, the Department of Food and Agriculture, and the Army Corps of Engineers, have a one resource purpose and are limited to acquiring land in certain areas. The Athol Conservation Commission is also limited to a specific area, but not to any one resource. The other groups are not limited to any certain area, and, although they are currently following certain principles, they can be more flexible and variable in the way they protect land. Political or legal amendments to mandates and charters would allow the Department of Environmental Management, the Division of Fisheries and Wildlife, the Trustees of Reservations, the Massachusetts Audubon Society, the Swift River Valley Trust, and the Mount Grace Land Conservation Trust to alter their land protection purposes and methods. The flexibility of these six groups recommends them as important members of any coordination effort.

As with any attempts to coordinate diverse elements of a system, conflicts are inevitable. For the North Quabbin Greenway, the conflicts will center around designating and distributing protection purposes. The multitude of functions and the limited flexibility of some groups challenges the landowners to balance the functions of the greenway. Management conflicts concerning hunting versus passive nature enjoyment, extractive activities versus

recreational ones, and preservation versus public access will also surface as groups attempt to integrate their lands.

To combine the protected lands into a system, the goals for the greenway must be developed. These goals may conflict with the functions of the local community. If the existence of the greenway prevents local urban growth, or if too much of the greenway is being used so as to limit economic possibilities, the local community may not support and may even attempt to prevent the growth and development of the greenway. While the greenway can be designed without consideration of the local community, it will be more successful if it does (Little 1990). The resolution of these conflicts, concerning purposes, management, and goals, depends on the desired goals for the greenway as well as the desire for the landowners to coordinate among themselves and with the local community. The greenway could be a well-balanced and well-distributed system which provides resource extraction and tourist-related jobs and supports controlled urban development. On the other hand, it could remain dominated by a few purposes with uncoordinated functions co-existing with little regard for local economic and development concerns. Or, and this is the most likely scenario, the greenway could be something in between these two extremes, as the desire of many landowners to coordinate and establish goals melds with the realities of what each landowner can and will do.

Summary - The purposes of the North Quabbin Greenway are diverse and include a range of activities which address ecological and social issues through resource use, environmental benefits, spiritual renewal, and plant and animal habitat. However, the purposes are unevenly distributed spatially and in the amount of area to which they are assigned. A greenway offers a structure in which problems posed by the diversity, dual nature, and uneven distribution of the purposes can be discussed. Planning will also generate many conflicts

concerning the diversity of interests and goals. The resolution of these conflicts will have ramifications for the greenway as well as for the local community.

Acquisition History

The patterns of land protection in north-central Massachusetts can be understood within the historical context of evolving policies for, uses of, and attitudes towards the land at the federal, state, and local levels. As Figure 7 shows, the time during which land has been protected in the study area can be divided into three distinct periods, 1900-1919, 1920-1949, and 1950-1992, according to how much land was protected in each decade. Examining when, where, how, and by whom lands were protected in each of the three periods will reveal the importance of the concurrent social, political and economic climate.

1900 to 1919 - Land was first protected in north-central Massachusetts during these two decades although only in small amounts (Figure 7). Considering that the concept of reserving land in the public domain for the public good was relatively new at this time, such a slow start is understandable. On the national level, the conservation movement was just beginning to form in response to concerns about diminishing forest resources. Roosevelt and Pinchot were developing their policies of preserving natural resources for the welfare and efficiency of the nation, and were establishing some of the first Forest Reserves, the original National Forests (Frome 1962). While the government was addressing conservation concerns by actively reserving lands to remain forests, in the private sector, scientific organizations were studying forest processes and encouraging better management and more protection of forests for conservation purposes (Stupski 1988).

On the local level, the two groups acquiring land in north-central Massachusetts during this first period were also interested in managing timber

resources (Figures 10b and 10c). However, just as at the national level, the state's Department of Environmental Management was acquiring small logged-over lots to reforest and sell back to the original owner (Hick 1927). The private Harvard Forest was acquiring forested land for studying and teaching sustainable forest management (Anonymous 1907). Because of the absence of state forest land data, only Harvard Forest land appears on the map (Figure 11a).

Harvard Forest lands have been protected within the fabric of Harvard University since their acquisition. In contrast, many reforestation lots have been retained by the state because some of the original owners did not repurchase their lands (Hick 1927). The availability of these lots and the disinterest in repurchasing them may be related to the concurrent drop in population in the area (Figure 16). The retained lots became the framework for today's state forest program which is now protected by the state's political system. Thus, although the original state forest lands were not acquired for protection, their subsequent incorporation into the political system allows the lands to be perceived as protected today.

In addition to serving different purposes and being protected differently, the Department of Environmental Management and Harvard Forest lands were also acquired differently. Harvard Forest acquired almost all of its land in 1908, which would account for the small number of acquisitions and large size of the lots in the first decade (Figure 8). Additionally, most of the land was donated to the University (Figure 14). In contrast, the Department of Environmental Management acquired its land in many small lots over time. The Department of Environmental Management's increase in activity in the second decade (Figure 10b) corresponds with the actions of the legislature in 1914 appropriating more funds to buy potentially forested land for state ownership (Hick 1927). The

increase in activity also accounts for the many acquisitions of smaller lots in the second decade (Figure 9). Because the state purchased all of its land at this point, purchases dominated the 1910s (Figure 14).

1920-1949 - The largest amounts of land were protected in the next period (Figure 7). In each decade of the middle period, the majority of land protected can be attributed to one group. Considering that the post World War I, Great Depression, and World War II eras all occurred during this period, it seems surprising that such large amounts of land were protected. Specifically, in the 1920s, conservation was suppressed on the national level (Koppes 1988), yet in north-central Massachusetts, much land was protected (Figure 7).

State forest land purchases dominated the 1920s (Figures 10b and 14) and are responsible for the apparent discrepancy between the national conservation climate and the local one. In Massachusetts, the state legislature had been increasing the allocation of funds and authority for state forest land purchases since 1908. Their provision of funds in 1921 for acquiring 100,000 additional forest acres built on this momentum and dramatically increased the size of the state forest system (Hick 1927). It is not clear why Massachusetts was going against the tides of the nation at this point. In the neighboring state of Vermont, the Green Mountain National Forest was being established at the same time (Frome 1962), so perhaps the exception to national trends is regionally rather than locally based.

Nonetheless, the commitment of the Massachusetts legislature to acquiring forests for state ownership implies that the concept of protecting land beyond present needs was gaining popularity and being implemented. Emphasis, especially in New England, remained on timber resources as the establishment of the Green Mountain National Forest and the the White Mountain National Forest (in New Hampshire) suggest (Frome 1962). The

White Mountain National Forest shows an additional parallel with Massachusetts state forests. Both forest systems were developed by aggregating many small lots into one system (Hick 1927 and Frome 1962). The ratio of the area to the number of lots confirms that aggregation remained the Department of Environmental Management's method for acquiring land in the 1920s (Figure 8).

The land acquisition activity of the 1930s is dominated by the Metropolitan District Commission's purchase of land for the construction and protection of the Quabbin Reservoir (Figure 10b). The establishment of this Reservoir broadened the scope of land protection in north-central Massachusetts in three ways. First, watershed protection had been an important impetus in land conservation both in Massachusetts (Hick 1927) and nationally (Frome 1962) as one of the reasons behind protecting forested areas. However, with construction of the Quabbin Reservoir, watershed protection became an independent resource concern in the area.

Secondly, unlike the aggregated state forests, Quabbin Reservoir lands were pre-determined large areas targeted to be protected as a unit and all at once (Figure 11b). Eminent domain laws made acquisition by purchase of the designated lands possible (Figure 14). Finally, the construction of Quabbin Reservoir drowned and thus irreversibly altered a valley in order to fulfill the majority of Boston's water needs, which are not likely to decrease. Therefore, Quabbin Reservoir lands appeared to be better protected farther into the future from the outset than either the Department of Environmental Management or Harvard Forest lands.

Even though Quabbin Reservoir was recorded in the data as one acquisition, there were a large number of acquisitions in the 1930s because the Department of Environmental Management was still purchasing land for state

forests under the legislative act of 1921 (Figure 8). Construction of Quabbin Reservoir in the 1930s is largely a result of the water resource needs of Boston citizens; however, the project was likely aided by effects of the Great Depression such as low real estate prices and available labor forces through the Civilian Conservation Corps. Additionally, hydroelectric dams were very popular during this time (Koppes 1988), and although the dam for Quabbin was not an energy source, the construction of the dam coincides with the national conservation attitudes of the 1930s.

The land providing Quabbin Reservoir's supplementary source of water, the Ware River Watershed, was bought in the 1940s in a manner similar to that of the Reservoir (Figures 10b and 14). However, federal activity dominated this decade (Figure 9). The United States Army Corps of Engineers established its two flood control projects in response to catastrophic weather patterns including the destructive floods of 1936 and 1938 (Army Corps of Engineers n.d.). Like Quabbin Reservoir and Ware River Watershed, these two projects were purchased as pre-determined large areas taken by eminent domain (Figure 14). And like Quabbin Reservoir and Ware River Watershed, the projects established a new permanent use for the land because floods will always be a threat, save drastic climatic changes.

However, these flood control projects were different from Quabbin Reservoir and Ware River Watershed as well as state forests because, rather than protecting nature for human use, the projects were protecting humans from nature. As a result of protecting people, the Army Corps of Engineers' land is protected because the threat of floods negates the possibility of development there. Thus, these flood control lands have become part of the protected land system more as a secondary benefit rather than a primary purpose.

New Directions - During the three decades from 1920 through 1949, two additional government landowners protected land in the area; large purchases through new means were made; and the concept of protecting land into the future was further developed. Also, the newly acquired large areas were scattered around the future greenway loop and offered the opportunity for future acquisitions to build off of them (Figure 11b). Land protection was changing during this middle period, and, at the end of the 1940s, there were promises of even bigger changes.

In the 1940s, the private organizations Massachusetts Audubon Society and The Trustees of Reservations both acquired, through donations, small tracts of land in north-central Massachusetts (Figures 10c and 14). Founded around the idea of preserving natural areas (Hopkins 1992, Hecker 1986), these two organizations differed from the first private organization, Harvard Forest, whose acquisition activity decreased after 1944[2] (Figure 10c) and whose land was acquired primarily for research purposes.

The arrival of Massachusetts Audubon Society and The Trustees of Reservations to the area coincided with a shift in conservation attitudes which was occurring nationwide. Publication of Leopold's essay "The Land Ethic" introduced a new environmental philosophy which challenged economic views of nature with ecologically based, community-oriented conservation ideas (Worster 1977). As Leopold's new ideas became accepted, organizations such as The Trustees of Reservations and the Massachusetts Audubon Society gained momentum in their preservation efforts and began to explore possibilities beyond their Boston area headquarters. Even though these two

[2] Harvard Forest did acquire small amounts of land in the 1960s (Figure 10b), and they also recently (late December 1992) acquired a 30 hectare addition to one of their properties (Foster, personal communication).

organizations were protecting areas for the preservation of the land and its natural inhabitants, human use was still an important factor. However, rather than extracting and consuming the resources of these lands, humans were meant to visit the areas and take away no more than knowledge and enjoyment. Thus, as the middle period came to a close, the activities of private organizations and the concepts of preservation and passive human use were suggesting the shape future patterns of land protection might take.

1950 to 1992 - In the final period of this century land area was acquired at a steady rate, the number of groups owning protected land increased, and new methods for protecting land in perpetuity were developed. The steady rate of acquisition over the five decades (Figure 7) as well as a consistent pattern of many acquisitions of smaller lots in each decade (Figure 8) is curious considering how the social and political climate changed so dramatically from one decade to the next. Historical landmarks of this period include McCarthyism, the Vietnam War, the first celebration of Earth Day, several energy crises, the anti-environment Republican 1980s, and the recent renewed interest in and concern for the environment.

Changes in the availability of land helped to limit the acquisition rate through these years. Not only had four large areas been acquired during the previous period (Figure 11b), but the local population was rising (Figure 16). Therefore, both conservation and residential development were competing for decreasing amounts of space. The rise in numbers of groups protecting land (Figure 10) also helped to keep the acquisition rate steady. With more groups actively involved in land protection, a steady rate of acquisitions can more easily be maintained because acquisitions are not dependent on the resources of just one or two groups. For example, the Department of Environmental Management acquired 2,998 hectares in the 1950s, but their subsequent

acquisitions were much smaller. However, as the Department of Environmental Management's acquisitions decreased, the Division of Fisheries and Wildlife and many private organizations began acquiring land (Figures 10b and 10c).

The increase in groups protecting land during this final period can be regarded as a function of the changing environmental movement. Outdoor recreation was increasing; ecology was becoming an important component of conservation thinking; and natural open spaces were decreasing. As these conditions developed, new conservation groups formed and previous groups increased their protection activities. State agencies concerned with wildlife (Division of Fisheries and Wildlife) and agriculture (Department of Food and Agriculture) as well as private organizations concerned with protecting one river basin in Petersham (Swift River Valley Trust), managing small private forests (New England Forestry Foundation), and protecting land in conservation corridors (Mount Grace Land Conservation Trust) acquired land during this time.

The increase in private organizations contributed to many aspects of the diversity of the protected lands. Private groups began to balance out the strong government presence in the area (Figure 12) and increased the amount of land being protected for preservation and passive human use (note that four of the six private organizations are in the preservation purpose class, Table 1). With more private organizations came an increase in donated land (Figure 14). Although it is not clear which is the cause and which is the effect, private organizations have received most of their land as donations, while government agencies have purchased most of theirs (Figure 15). Donations allowed private organizations, which generally rely on membership contributions, to protect land they otherwise could not afford. Thus, the increase in land donations during this period probably made a small but meaningful contribution to the

steady rate of acquisitions. However, acquisition means data are missing for 195 lots, which could further alter the patterns (Figure 13).

When considering the rate of acquisitions from 1950 to 1992, it is important to remember that, although the acquisition rate currently looks steady, the average amount of land protected per decade from 1950 through 1980 has already been protected in only the first 2.5 years of decade 1990 (Figure 7). By the year 2000, then, the total amount of land protected in the 1990s could be much greater than the amount protected in the previous decades, perhaps signaling the beginning of a new pattern.

One land protection activity which never evolved into a pattern is the acquisitions by town governments; only the town of Athol protected land. Without the activity of other towns for comparison, it is difficult to analyze why the Athol Conservation Commission bought so much land in the 1960s and so little afterwards (Figure 10a). However, it appears that the Commission's large acquisition was opportunistic. The area became less accessible after a bridge washed out, and the hilly, rugged terrain remained too difficult and costly to develop (Greene, personal communication). Perhaps other towns have not protected land because the state and private organizations have protected so much.

Restrictions - As new groups acquired land in north-central Massachusetts during the late 1900s, the idea of land protection continued to evolve, finally becoming the concept that is familiar today. Rather than having to evolve into a system as state forests did, lands could be protected within previously existing structures, such as land trusts, well-established private organizations, and the state government. Furthermore, land was not protected by default, as was the case with the Quabbin Reservoir, Ware River Watershed, and the flood control projects. Land protection became a more conscious and deliberate action.

One effect of the development of the land protection concept was a new method for protecting land, the restriction. Two new groups, the Department of Food and Agriculture and Mount Grace Land Conservation Trust, began to acquire land in the 1980s. Although restrictions had been used at least eight years earlier (Table 3), these two groups began to regularly employ this method in north-central Massachusetts. Because restrictions allow land to be protected even if the owner is unwilling to part with the title, the amount of land that can be protected and, ideally, acquired in fee in the future, increases. Other groups have acquired restrictions, especially the Massachusetts Audubon Society and the Division of Fisheries and Wildlife (Table 4). Additionally, the renewed activity of the Metropolitan District Commission during the last twelve years (Figure 10b) has been, in part, to establish watershed preservation restrictions in the Quabbin Reservoir and Ware River watersheds.

Spatial Distribution of Acquisitions - The distribution of acquisitions in the late 1900s across the landscape show that acquisitions from 1950 through 1979 appear to be random (Figure 11c). In contrast, the acquisitions of the last twelve years show a higher tendency to be connected to previously protected parcels (Figure 11d), suggesting that connecting lands together is locally a recent idea. Nationally, greenways have been implemented for over one hundred years, but have only recently gained popularity (Smith 1993). However, with so much data missing from the chronological series of acquisitions (Figure 11e), it is only possible to guess at the local time frame for the development of the greenway concept.

All the landowners were actively acquiring land from 1950 to 1992, excluding Harvard Forest and the Army Corps of Engineers (Table 2). All active groups, save the New England Forestry Foundation and the Swift River Valley Trust, have acquired land in the last two decades. The Division of Fisheries and

Wildlife, the Department of Environmental Management, the Massachusetts Audubon Society, The Trustees of Reservations, and the Mount Grace Land Conservation Trust have all acquired significant amounts of land recently and are free to acquire land anywhere in the area. In contrast, the Metropolitan District Commission has recently renewed its activity and acquired alot of land, but only in the Quabbin Reservoir and Ware River Watershed areas. Similarly, the few acquisitions which the Athol Conservation Commission has made are restricted to within the town of Athol. Finally, the Department of Food and Agriculture has acquired only a few parcels and must limit its acquisitions to agricultural areas, which are mostly in the southeast corner of the study area. Therefore, it seems that, as with acquisition purposes, the Department of Environmental Management, the Division of Fisheries and Wildlife, the Trustees of Reservations, the Massachusetts Audubon Society, and the Mount Grace Land Conservation Trust emerge as the groups likely to be the most useful in greenway coordination efforts.

Results of the Patterns - The acquisition history of the lands in north-central Massachusetts reveals that these five landowners are currently the most active land protectors. Future acquisitions for completion of the greenway are most likely to be made by these landowners which include state agencies as well as private organizations. State agencies own more land than private organizations do (Figure 12) and have recently been acquiring more land than private groups have (Table 2). Furthermore, government agencies purchase the majority of their lands (Figure 15). Therefore, it seems likely that future land will be protected predominantly by state agency purchases, if current patterns continue. Exploring why people sell or give their land for protection, what kind of land is acquired, and what is the history of uses on the lands will further

illuminate historical patterns, thereby providing information useful for predicting and planning future acquisitions.

The historical patterns of land protection also reveal how the idea and means of land protection grew and developed over time. At first, forests were of primary interest, then water became an important issue, and finally, ecosystems, wildlife, and agriculture were protected. In parallel, land was acquired in small lots with the intention of returning it, was then acquired in large contiguous areas through eminent domain, and finally has been acquired to be protected through ownership and restrictions. With each change, land protection was responding to the current social, economic, and political conditions, indicating that land protection was not random and is likely to continue to evolve into the future. Therefore, land protection groups should recognize that the concept of land protection, the purposes of protection, the active groups, and the means of acquisition are all likely to change. Groups should then be able to respond accordingly.

If the protected lands of north-central Massachusetts were connected together in a greenway, it would be easier for owners of protected land to respond to evolutions in land protection. Changes in the reasons for, means of, active agencies and organizations in, and funds available for land protection would have fewer consequences on one large, diverse, and connected system of protected lands than on many small, individual, and isolated parcels. Furthermore, while forest reserves, human-constructed reservoirs, and bird sanctuaries were appropriate land protection responses to various conditions at certain times in history, greenways are an appropriate response to the social, economic, and political conditions of today. Some results of the current social, political, and economic climate include habitat fragmentation, decreasing open

space, and degrading environmental quality. Linear conservation corridors can help alleviate these problems (Smith 1993).

The patterns of acquisition do not suggest what sorts of conflicts creating a greenway might raise. Throughout this century, each group has managed to acquire land for protection without apparent conflicts. Whether or not each group is satisfied with what they have been able to accomplish is another question. Perhaps the only conflict is the availability of funds. Many groups get their funds from the same source (state agencies applying to the state budget, private groups soliciting from the same groups of people) suggesting that coordination to maximize resources is necessary. Each group protects a certain type of land, in a certain locale, for certain purposes, and in certain ways. While these activities could continue in isolation, coordinating acquisition efforts would maximize time, energy, and financial resources.

Summary- The acquisition history patterns show that the idea and means of land protection developed over time in response to current social, political, and economic conditions. Thus, land protection activity has not been random, a trend which plans for future land protection should recognize. The development of land protection also implies that creating the North Quabbin Greenway could be a useful means of managing future changes and is an appropriate response to current conditions. About half of the landowners are still actively protecting land; coordinating their efforts would be efficient and economical.

Spatial Distribution

The values for the size and shape of the protected lands in the study area suggest that the North Quabbin Greenway can fulfill a variety of functions. Most greenways are either bikeways winding through urban areas, narrow (less than 1 kilometer) strips of open space connecting larger protected areas, or long-

distance hiking trails protected by as little as a 100 meter wide swath on either side. Here in rural Massachusetts, the greenway is about 100 kilometers long and 3 kilometers wide. Currently, 56,528 hectares are protected, but if the whole greenway area (the area between the outer and inner loops, Figure 4) were filled in, 126,093 hectares could be protected. A long, wide, large area means that certain goals, which smaller greenways cannot fulfill, such as long-distance hiking trails or large game habitat, are possible. The size also allows many goals to be carried out concurrently because each goal can have its own area in which to be implemented.

The large size of the greenway eliminates some common concerns in greenway design. Width is one of the most important factors in a greenway, not only to provide a comfortable corridor for human and wildlife passage, but also to minimize edge effects on local species (Smith 1993). Although it is difficult to specify how wide a greenway should be, the wider it is, the better. Generally, if the width can be measured in kilometers, it is wide enough for conservation purposes (Thorne 1993). The North Quabbin Greenway is not only kilometers wide on the average, but is surrounded by a lot of forested non-protected land because the majority of the study area is forested. Even if boundaries of the greenway stop at a certain width, it is likely that forest will extend into and away from the greenway, thus eliminating many edge effects.

Many scientists agree that nature reserves of any kind should be as large as possible in order to best maintain biodiversity (Pickett and Thompson 1978, Diamond 1975, and Wilcove McLellan, and Dobson 1986). However, Simberloff and Gotelli (1982) suggest that many smaller nature reserves are better for biodiversity. In north-central Massachusetts, the individual protected parcels cover a range of sizes (Figure 17) providing the diversity of parcel size which Simberloff and Gotelli suggest is important. Yet, if these parcels are all

connected, which many of them are, the range becomes irrelevant. At the same time, by connecting the parcels together, the large area which the previously mentioned authors recommend can be created. However, as mentioned earlier, the large area would be a mosaic of many different factors some of which, such as hunting and road bisections, might be detrimental to maintaining biodiversity. More theoretical and empirical evidence is needed to determine the size of protected lands which would best serve biodiversity interests in the North Quabbin Greenway area.

In addition to being large, Pickett and Thompson (1978), Diamond (1975), and Wilcove, McLellan, and Dobson (1986) also agree that nature reserves should be circular to minimize edge to interior ratios. The North Quabbin Greenway is not, and is not likely to become, circular because of the large population center in the middle (Figure 1). It will most likely remain a loop, which may not be the optimal shape for the ecology of the lands, but has social benefits. With the greenway in place neither the urban area in the center of the loop nor the urban areas outside the loop will be able to sprawl towards each other. Additionally, because of the distribution of population centers in this region, a loop presents the best way to protect the longest continuous area possible, an advantage to recreationists. Furthermore, the large size, which may or may not best maintain biodiversity, increases the extent to which all the greenway functions, resource extraction, recreation, environmental benefits, and wildlife habitat, can be fulfilled.

Clearly there is no agreement and little scientific evidence concerning whether or not corridors are useful ways to protect species and maintain biodiversity (Simberloff et al. 1992). While it is important to recognize this lack of knowledge when considering ecological potential for the greenway, species maintenance is not the primary concern in creating the North Quabbin

Greenway (Ross, personal communication). Admittedly, it is not clear what the primary concern is, but most of the protected land areas here are hectares large and kilometers wide suggesting that this greenway functions as more than just narrow pathways connecting larger areas. In addition to species maintenance, resource use, recreation, and environmental benefits are also being considered in the design of the greenway and will benefit from the size and shape emerging.

Whether species conservation, resource use, recreation, or environmental benefits, are the main goal of the North Quabbin Greenway, it seems that the widest corridor option should be used to complete the greenway. With this option, only 388 hectares must be acquired to complete the greenway if areas as wide as the average width of the greenway are protected in the gaps chosen in Figure 4. Even if this suggested design is not possible, considering that landowners or unmapped barriers may prevent acquisition of the proposed areas, 388 hectares is one-sixth of what has already been protected this decade. At this rate, the greenway can become minimally connected, if not more fully filled in, at least by the year 2000. Completing connections around the greenway will most quickly protect the biggest and most contiguous area of land possible, a benefit to humans and perhaps to wildlife. Once the greenway is completely connected, acquisition efforts can focus on filing in other gaps. By working with the configuration that the historical patterns of land protection have produced, future acquisition efforts will be maximized.

However, the existing configuration also presents many possible conflicts. Because so much of the area (currently 37 percent) is protected, future use of the greenway must be wisely planned to balance future protection efforts with local economic needs. It is possible that much of the greenway can benefit the local economy if resource-based employment opportunities

increase. It is also possible that, if future studies indicate that the current size and shape of the North Quabbin Greenway is not optimal for species conservation, the ecology of the area could be compromised. Finally, it is necessary with urban areas both inside and outside the greenway that passageways through the greenway exist, thus decreasing the greenway's connectivity. Connecting the protected lands into one system, in which these conflicts can be regarded as concerns of the entire area and not just of the individual parcels, would facilitate coordinated and efficient efforts to solve the problems. However, resolution of these conflicts also requires more information on economic (what does the local economy need? what will be the economic costs and benefits of the greenway?), biological (what is the ecological composition of the greenway? what is the optimal size and shape for protected areas for various species?), and demographic (how often and where do people pass through the greenway?) aspects of the area.

Summary - The pattern of spatial distribution shows that the North Quabbin Greenway will be wide, long, and big enough to support many activities and to fulfill many functions. However, it is not clear whether the greenway is the best shape and size to serve species conservation interests. Nonetheless, other interests, such as resource use, recreation, and environmental quality, can benefit from the long, wide, large greenway emerging. Because so little area is needed to complete the greenway, doing so would be a wise investment of resources. Conflicts which the size and shape of the greenway may create include local economic needs versus large protected areas, species conservation versus the large, looped shape, and connectivity versus the need for transportation across many portions of the greenway.

Spatial Relationships

All of the protected parcels are close to a small town, which seems inevitable given the rural nature of the area and the number of small towns found there (Figure 18). Additionally, more protected area is closer to a small town than farther away. Most of the protected parcels and the protected area are a moderate distance from a large town, which reflects how the large towns are distributed in the middle and around the edges of the protected lands (Figure 1). Even though north-central Massachusetts is rural, the human population is distributed throughout it, and few areas are free from or far from people.

Additionally, only 35 of the protected parcels are roadless; most are contacted by more than one road (Figure 19). The proximity of towns and the number of roads contacting so many parcels indicates that human use of these lands is a significant issue. Although there are no "natural wonders" here to attract large crowds, the North Quabbin Greenway is within three hours of metropolitan areas such a Boston and New York City. The area receives much use from visitors as well as local people. Human impacts on the land from recreation include soil compaction, water pollution, vegetation destruction, and wildlife habitat modification indicating that recreation can compromise the ecology of an area (Cole 1993).

In addition to providing access for humans, roads also interrupt the connectivity of a greenway. Along with width, connectivity is the most important aspect of the structure of a greenway (Smith 1993). The flow of elements such as water, seeds, and wildlife along the greenway usually rely on an uninterrupted path. Roads can present a serious enough barrier to these elements as to significantly reduce the conservation value of the corridor (Thorne 1993).

The most common type of road-parcel contact is when roads follow a parcel's edge (Figure 20). This contact is fairly benign because the road does not necessarily provide access to the parcel and it does not penetrate the parcel. However, should the land on the other side of the road be protected, the new larger area would automatically be bisected. Roads which come to a dead end in a parcel are less common (Figure 20) and both provide access to and penetrate the parcel. However, at least some of the parcel remains whole. The least common type of road contact is the most disruptive, bisecting (Figure 20). Access to the parcel is guaranteed and the parcel may be considered as two smaller ones.

While the type of road contact is significant, it is even more important to consider the type of road at the same time. Unimproved roads are the most common type of roads and highways the least common, which is fortunate considering the greater traffic volume and assumed speeds on highways. The most common way road types contact a parcel is when unimproved roads dead-end inside a parcel, which does not seem to be too disruptive to a greenway. However, Smith (1993) and Thorne (1993) both stress how seriously any road contact can degrade a greenway. Although it is fortunate that the protected lands are interrupted by some of the less problematic roads and in some of the less problematic ways, roads present themselves as an important consideration to the greenway's design and conservation goals.

Another way of assessing connectivity is to examine how much of a greenway is linked together. The previous section showed that little land is needed to complete the loop, and Figure 21b shows that 93 percent of all the protected areas are currently connected to other protected areas. However, 40 percent of the parcels remain isolated (Figure 21a). Although the greenway can become a complete loop in a short amount of time, much more effort is needed

to connect all of the parcels together. Therefore, it is important for planners to determine if the goal is to simply make a continuous loop, connect all protected lands together, or both.

Because the protected lands developed in and around human populations, completion of the greenway is a protection measure. The proximity and accessibility of the greenway to human populations indicates that human activity will come to bear on the use of the greenway itself. However, the preponderance of people and roads also facilitates other kinds of land-uses, such as commercial and residential development, which would preclude those uses being protected in the greenway. If the protected lands are connected together in a system, the landowners will more easily be able to deflect encroaching development.

Additionally, problems which human access poses, such as the amount, type and location of recreation, the opposing needs of recreationists and timber harvesters, and the effects of roads on the ecology of the area, can better be resolved within the structure of a system in which individual landowner concerns and goals come together as common greenway concerns and goals. Furthermore, because the protected lands are currently interrupted by roads, creating a continuous loop could offset some of these interferences. Carefully planned acquisitions could focus on the least bisected areas, thereby achieving as much connectivity between the lands as possible.

Summary - The spatial relationships of the lands to cultural features, such as towns and roads, suggest that human use of these lands is an important concern. Completion of the greenway will further protect the lands against encroaching, contrary land-uses; will create a structure in which to resolve conflicts between opposing human activities and between human activities and the ecology of the area; and will provide the opportunity for future acquisitions to

offset the high degree of road interference. In creating the greenway, conflicts such as road interruption versus road use, human access versus nature preservation, and connecting all parcels versus connecting just a simple loop are likely to surface and must be resolved according to the goals of the greenway.

VII. CONCLUSION

The patterns of land protection in north-central Massachusetts have formed a nearly complete circle of protected lands around the towns of Orange and Athol. With the additional acquisition of approximately 400 strategically located hectares, the loop could become an interconnected system of protected lands, the North Quabbin Greenway. Land protection patterns indicate that this greenway will be a mosaic of owners, purposes, and management activities; acquisition dates and means; social, political, and economic influences; and physical, ecological, and human landscapes. Examination of these patterns reveal information about portions of the mosaic which is relevant to understanding why a greenway is a useful land protection method and to making future decisions about the North Quabbin Greenway.

The patterns of acquisition purposes in north-central Massachusetts show that the functions assigned to protected lands are diverse. Throughout the greenway, resources are controlled for human safety, extracted for human consumption, used for human enjoyment and knowledge, and preserved for human pleasure as well as for wildlife habitat. The different ways in which resources are managed reflects the variety of goals and values embodied in the land protection philosophies and activities of each landowner. However, because some groups own much more land than other groups, the purposes of the protected lands are unevenly distributed throughout the area. Exploring historical patterns of land protection begins to reveal why more land is devoted to some purposes rather than others. Often land protection activity in north-central Massachusetts reflected national conservation attitudes. At all times, the

concept, means, and purposes of land protection were evolving in response to current conditions indicating that land protection activity has not been random. Rather, historical acquisitions have been conscious and deliberate actions influenced by concurrent social, political, and economic conditions at the local, regional, and national levels.

Because there are so many different purposes in the area, it is important that they be able to co-exist without undermining each other. Neither timber harvesting and recreation nor wildlife sanctuaries and agricultural areas are compatible purposes and should be spatially separated or carefully managed. In addition, the purposes of the protected lands should be compatible with the needs of the local community. While recreational opportunities will benefit the community, it is important that the protected lands enhance rather than degrade the economic integrity of the area. The evolutionary nature of land protection should be considered as purposes are distributed and balanced. Future land protection activities must be able to respond to unforeseen changes in land protection owners, means, and reasons. These challenges of distributing and balancing purposes as well as staying responsive to changing conditions suggest the need for a structure in which land protection activities can be coordinated and planning efforts facilitated. As an interconnected system of protected lands, the North Quabbin Greenway provides that structure.

Currently, the North Quabbin Greenway is a large, long, wide, and nearly complete circle of protected lands. The large size allows many types of functions to co-exist throughout the area, especially ones which may require large tracts of land, such as large game habitat and wilderness recreation. However, many parcels remain isolated from other protected parcels even though almost all of the protected area is connected to other protected areas. Because of the area's population distribution, the circle creates the longest,

continuous stretch of protected lands possible. Human activity is inevitable in the greenway because the protected lands are so close to towns and accessible by roads.

Human influence on the lands involves the landowners' management activities as well as recreation on, travel across, and development next to the greenway. Management of human impacts requires balancing social benefits, such as recreation, with social needs, such as transportation, and with ecological integrity, such as clean air and water. While the large size of the greenway may allow for many goals to be achieved, those goals remain to be determined. Finally, future acquisitions could focus on simply completing the loop, expanding already protected areas, connecting all parcels together, or some combination of these three possibilities. Clearly these challenges raised by the exploration of spatial patterns also warrant a coordinated system in which solutions can be discussed.

However, the North Quabbin Greenway is more than just a structure in which conflicts can be resolved. It is a system of protected lands, each of which becomes more strongly protected by being part of the system. As the greenway gains recognition, each component is more likely to remain in the system, and the system as a whole is more likely to enlist popular, political, and economic support. Furthermore, as one system, resources can be shared and used more effectively and efficiently, thereby benefiting all parts. While this system is a greenway by definition, in reality it is an interconnected system of protected lands across a landscape. This latter description is the most important way to consider the protected lands in planning the North Quabbin Greenway.

Every group owning land in the North Quabbin Greenway will not be able to participate in a coordinated effort equally. From the analysis of acquisition purposes and history, it appears that the Department of Environmental

Management, the Division of Fisheries and Wildlife, The Trustees of Reservations, the Massachusetts Audubon Society, and the Mount Grace Land Conservation Trust are currently the most active and flexible land protectors. This group has the most important characteristic which an effective greenway planning effort needs: it consists of both government agencies and private organizations (Little 1990). Also, these groups represent all the land protection eras in north-central Massachusetts as well as different land-uses including resource consumption, resource use, and resource preservation. Although currently much less active in protecting land than the other groups, Harvard Forest has a history of cooperation with The Trustees of Reservations, Massachusetts Audubon Society and Mount Grace Land Conservation Trust on land-use and land protection issues and can provide invaluable research facilities and results. Therefore, Harvard Forest should join the five aforementioned groups in collectively leading the creation of the North Quabbin Greenway Council.

The other six landowners should also be represented on the council and their limited yet unique contributions recognized. The Army Corps of Engineers is not an active land protector, but owns two important pieces of land in the system. The Metropolitan District Commission, the largest landowner, is limited to two watersheds but is currently protecting land in both areas. The Department of Food and Agriculture may protect only agricultural interests and only with restrictions, but they are the only group to address the needs of local farmers. The New England Forestry Foundation protects small private forests which the Department of Environmental Management may overlook. However, the Foundation relies on donated land, so their activity depends on opportunity. The Swift River Valley Trust only owns 13 hectares, and as a trust consisting of

representatives from Harvard Forest, Massachusetts Audubon Society, and The Trustees of Reservations, they are already well represented on the council.

Finally, the Athol Conservation Commission only acquires land in Athol. However, the presence of the Commission of the council as the only town government agency is important. More towns should become involved with the greenway effort, not only to represent local interests, but also to be informed about land protection activities in their town. Little (1990) suggests that a greenway council, should include representatives from "citizen organizations, business corporations, [and] professional and academic associations."

The first responsibility of the North Quabbin Greenway Council council would be to establish the goals for the greenway. Because so much land is already protected and the circle nearly complete, the council must work with the lands and purposes which already exist. In the case of the North Quabbin Greenway, it is not possible to start at the beginning and create the desired greenway; it must be built out of the current mosaic. The purpose and spatial patterns indicate that many goals, both ecological and social, are possible for this greenway. However, timber and water interests, as purposes assigned to the two largest amounts of protected land, must be worked around, and underrepresented purposes, such as preservation, should be allotted more space. The established goals will determine how the greenway is completed and managed. If reintroduction of a large wildlife species, such as the panther or wolf, were a goal, acquisitions would need to expand on what is already protected, and alterations in hunting areas would need to be made. If recreation were a main purpose, acquisitions should focus on including a variety of landscapes, and management should address how to reduce detrimental impacts.

In order to establish goals, an interdisciplinary inventory of the entire area is necessary because greenways are mosaics, land protection is an evolving idea, and the greenway will have a multitude of effects on the local community. The information presented in this study helps to identify what additional information is needed. Ideally, established goals would guide the inventory, which would build off of what has already been collected. For example, if watershed protection were a desired goal of the greenway, planners would already have access through this study to information indicating where areas of primary water importance are located and which groups are concerned with water quality. Further inquiries could be made concerning what the conditions of the watersheds are, what is being done in them, and what needs to be done to them.

An interdisciplinary inventory of this nature would be greatly assisted by further work with G.I.S.. The maps completed in this study provide the base maps showing where the protected lands and town boundaries are. Overlays of vegetation, elevation, water bodies, roads, etc., could indicate how varied the ecosystems of the protected lands are, what is the topography of the protected lands, how many water bodies of varying size and type exist on the protected lands, and how severely roads effect the lands (more precisely than achieved here). From these results, goals can be set and areas targeted for protection.

Once the goals are established, the North Quabbin Greenway must be completed to be a integrated system. It may be decided that the greenway should be a complete circle. However, acquisitions should first focus on filling in the gaps on the western side where the gaps are small but would make huge differences in the amount of continuous land protected (Figure 4). While there is a very large gap in the circle on the eastern side, this gap contains an abandoned railroad corridor which the Department of Environmental

Management owns. Therefore a type of connection already exists there. Additionally, this gap is includes Route Two, which poses serious movement and connectivity barriers. Acquisitions efforts would initially be most effective on the smaller gaps until a plan for acquiring this area and straddling Route Two can be developed. The remaining responsibility of the council is to oversee management of the system, a role which will be much more clear once goals are established.

The North Quabbin Greenway Council will address practical issues of the greenway. However, this study has shown the importance of the council, the justification for the greenway, and the relevance of historical patterns. These results provide a context and an informed background in which practical issues can be addressed. Rather than assuming that greenways are "good," this information has shown that greenways are an efficient and useful system of land protection. Perhaps the most significant way in which greenways are important is in being a part of the mosaic of land-uses across the landscape, just as they are mosaics themselves. As part of the bigger mosaic, greenways perform an invaluable function by protecting resources for use or for preservation from encroaching and contrary land-uses.

FIGURES

PROTECTED LANDS IN NORTH-CENTRAL MASSACHUSETTS

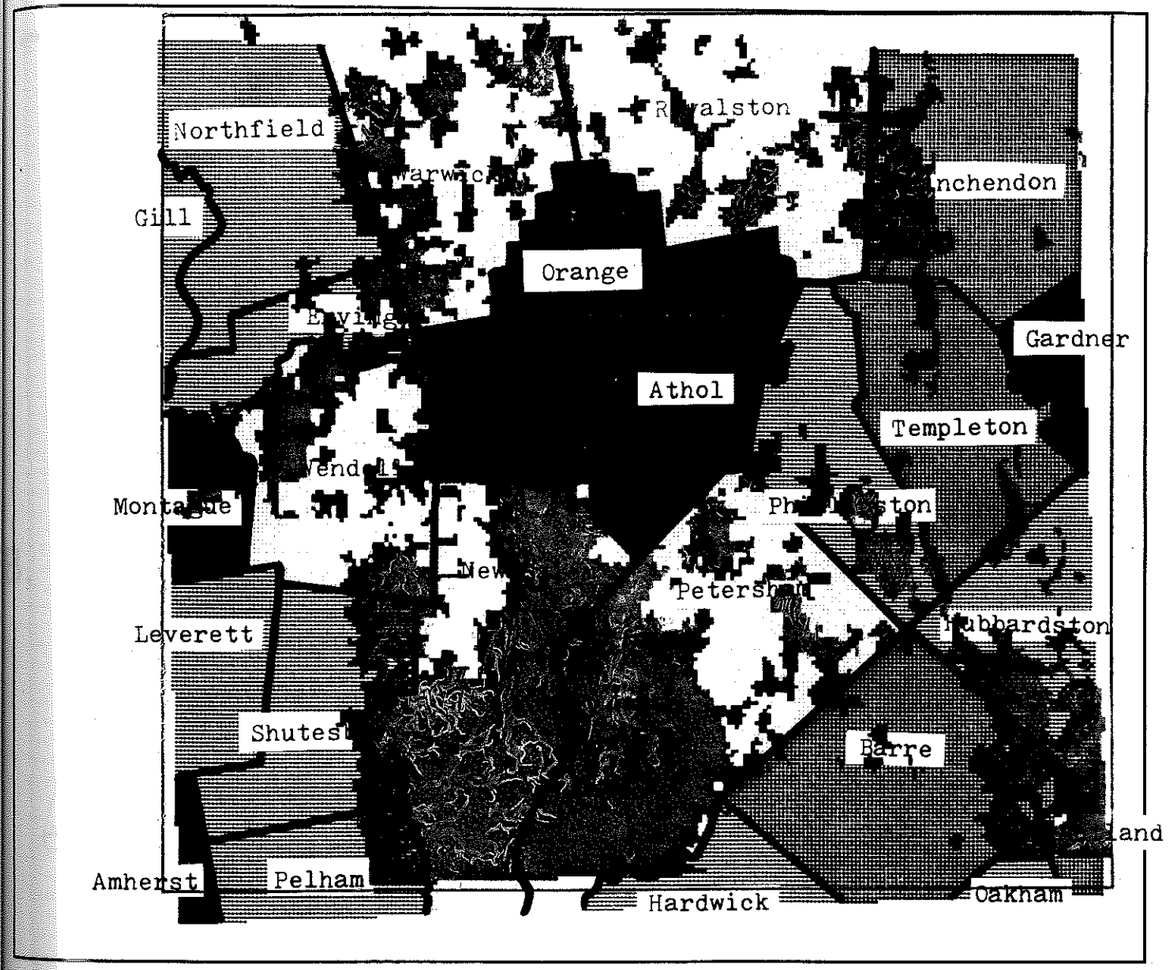
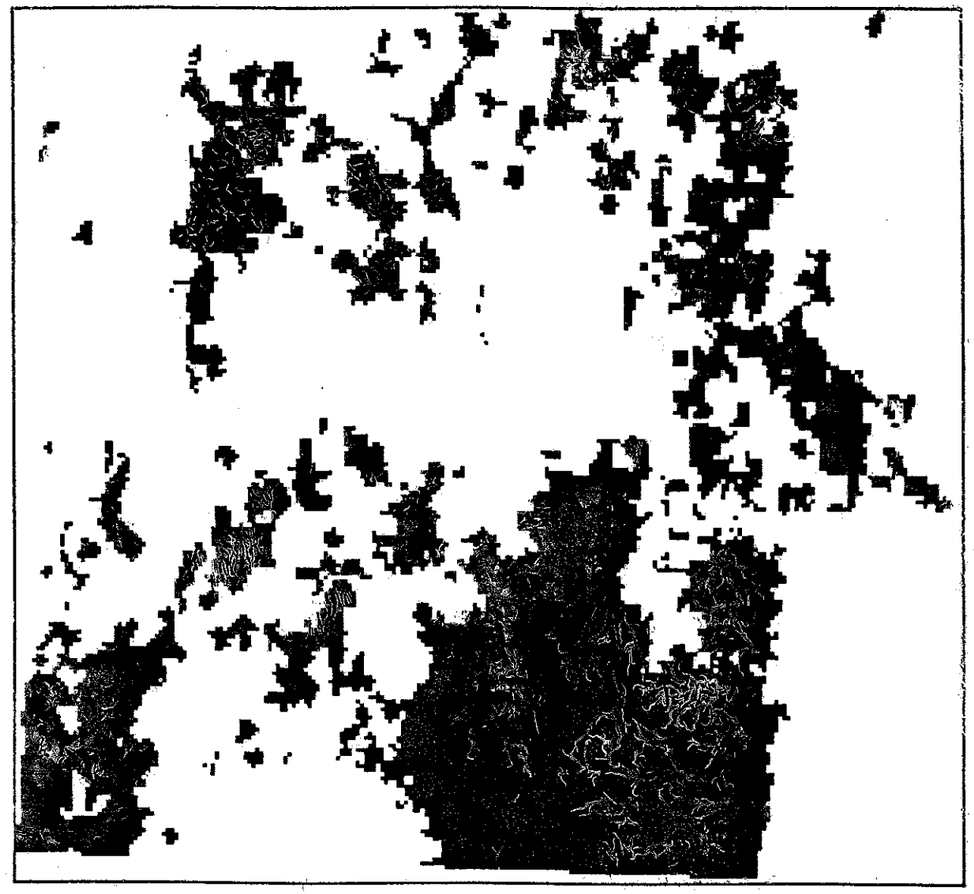


Figure 1. Boundaries of the towns in the study area shown in four population density classes (Hornar 1991).

PROTECTED LANDS IN NORTH-CENTRAL MASSACHUSETTS



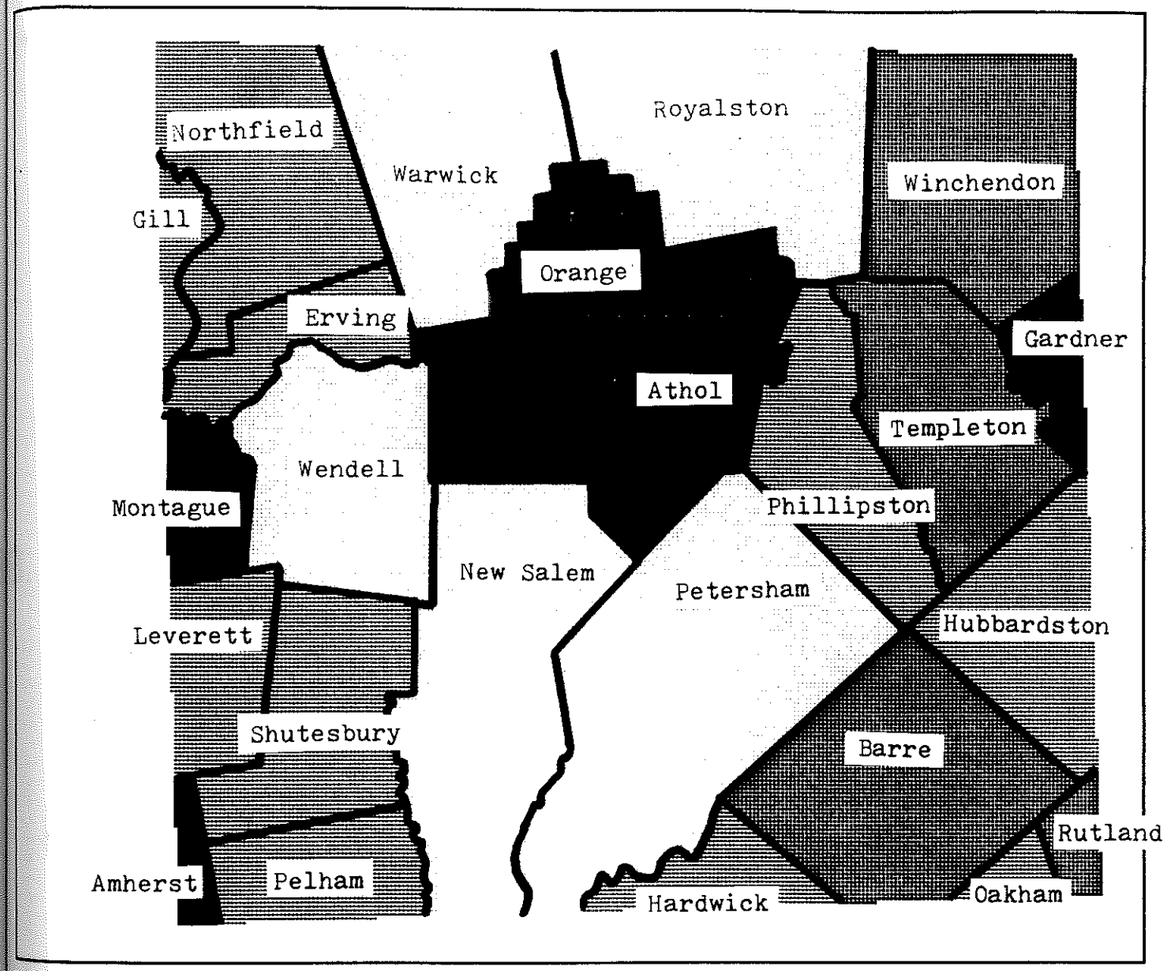


Figure 1. Boundaries of the towns in the study area shown in four population density classes (Hornar 1991).

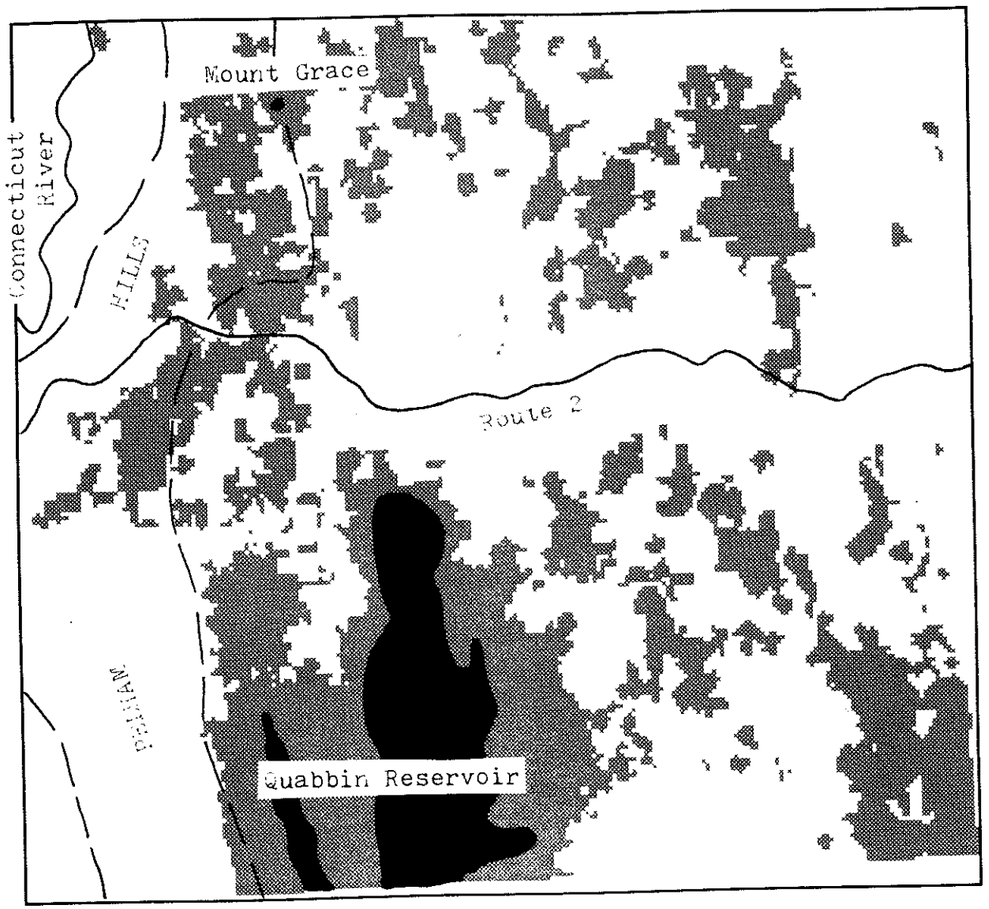


Figure 2. Selected landscape features of the study area relative to the protected lands.

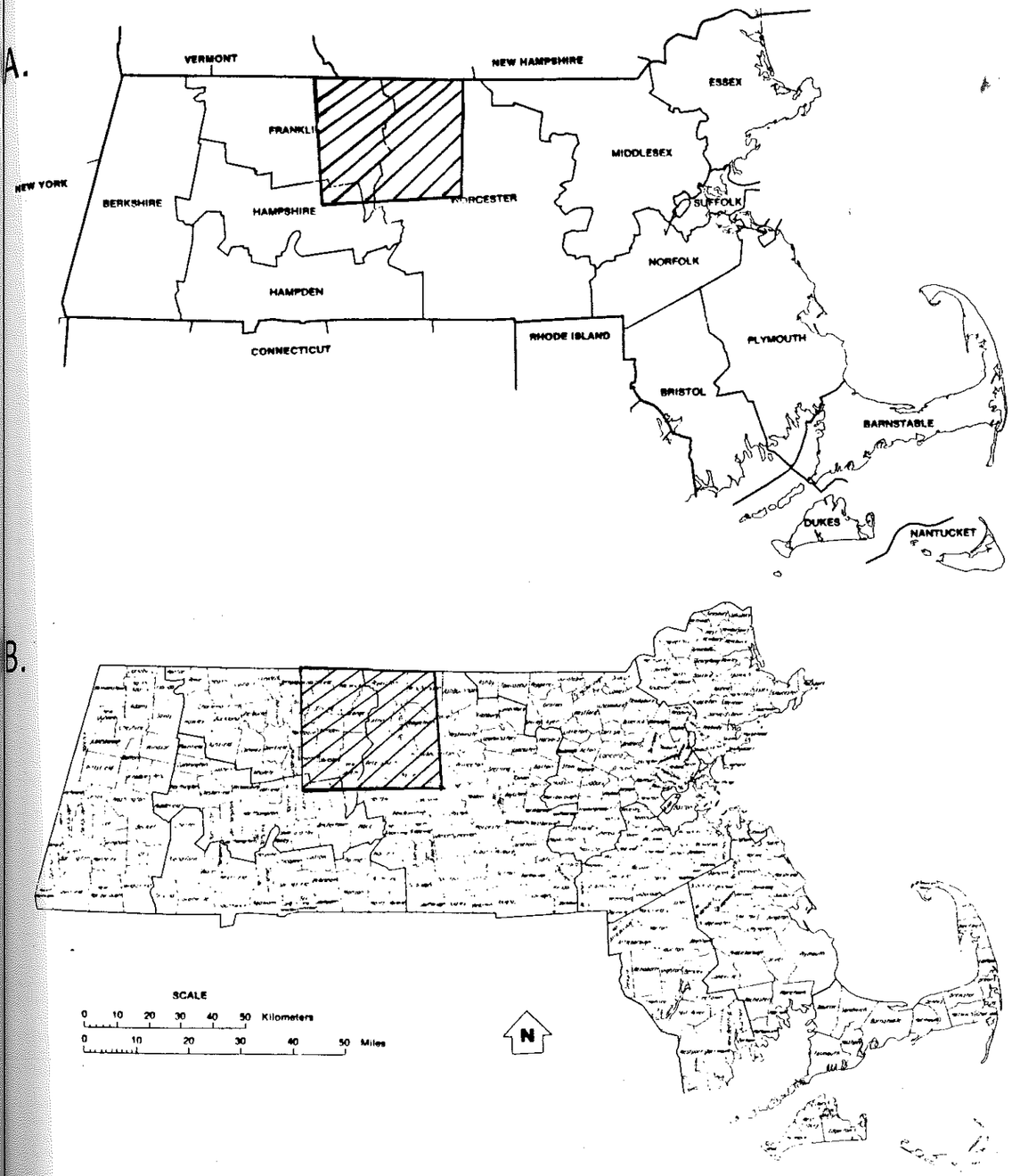


Figure 3. Approximate boundaries of the study area relative to Massachusetts (a) county lines and (b) town lines.

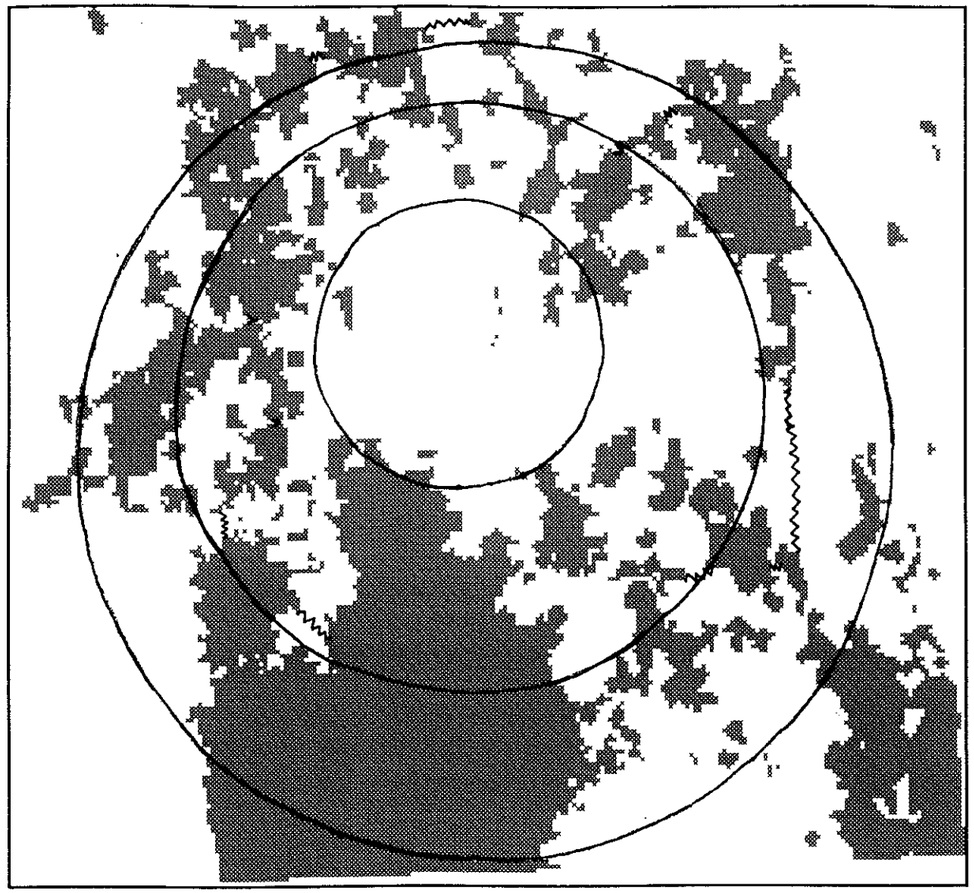


Figure 4. Three possible measures of greenway length and many possible gap closures relative to protected lands.

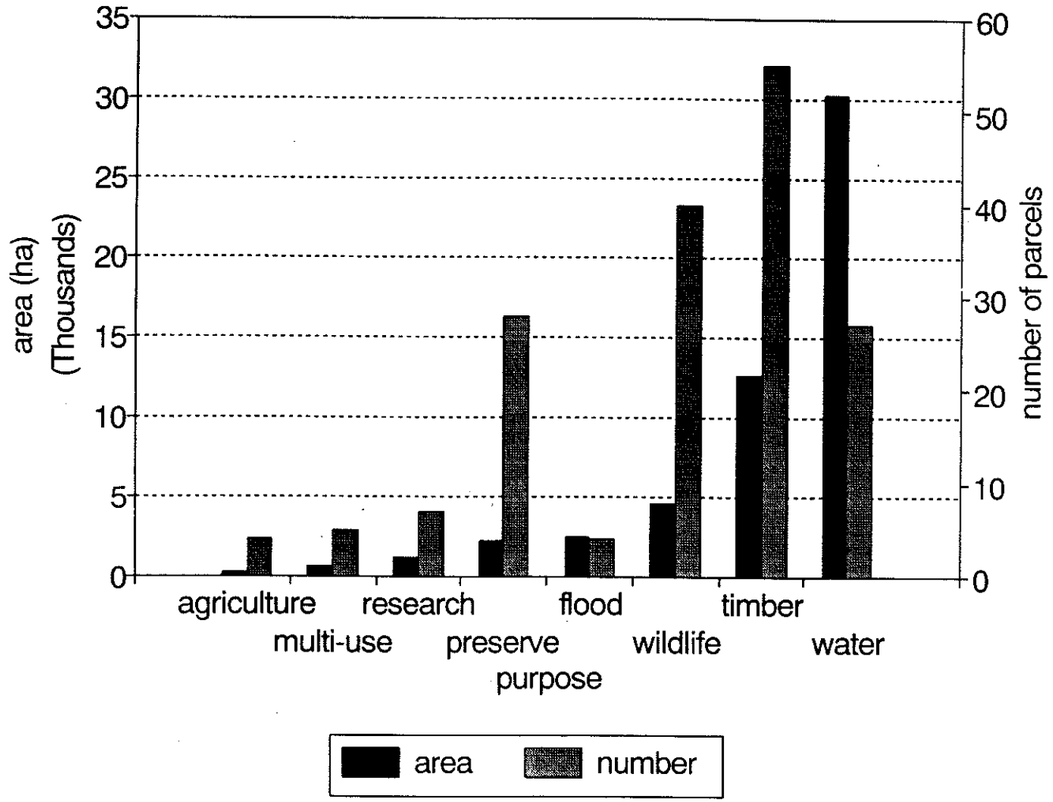


Figure 5. Area and number of parcels protected by current protection purpose.

BOUNDARIES OF TOWNS IN STUDY AREA

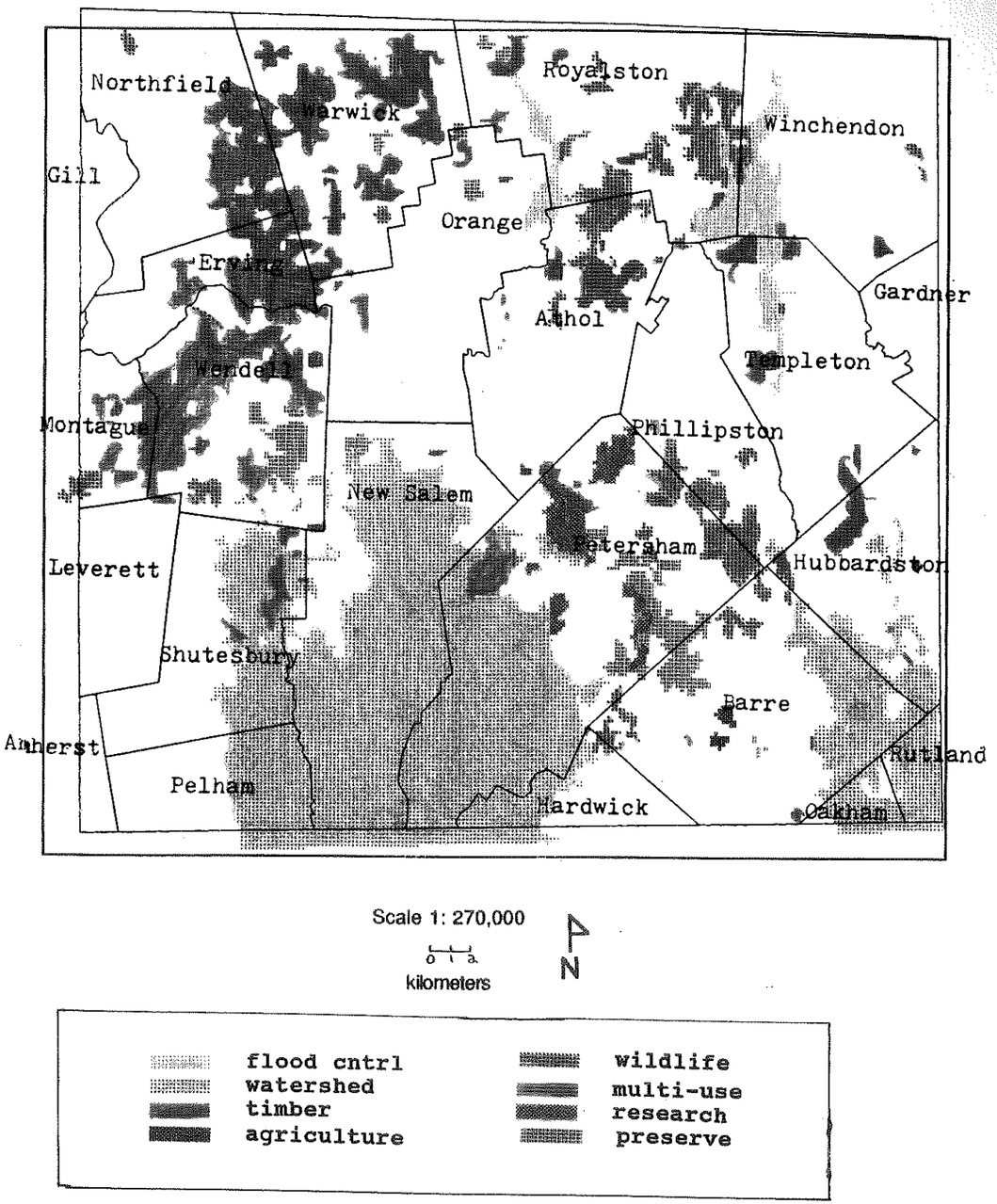
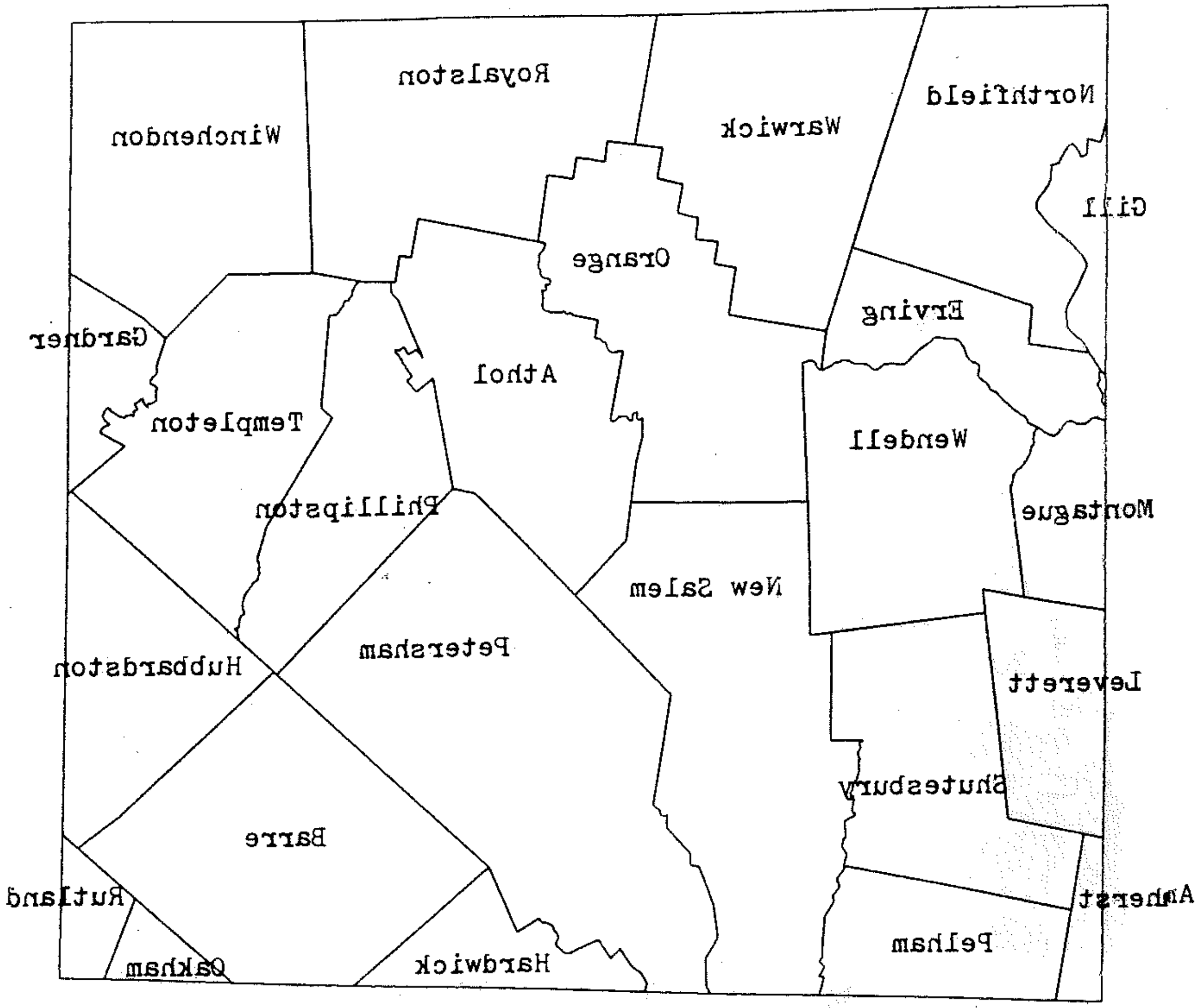


Figure 6. Location of protected lands in the study area shown by acquisition purpose.

BOUNDARIES OF TOWNS IN STUDY AREA



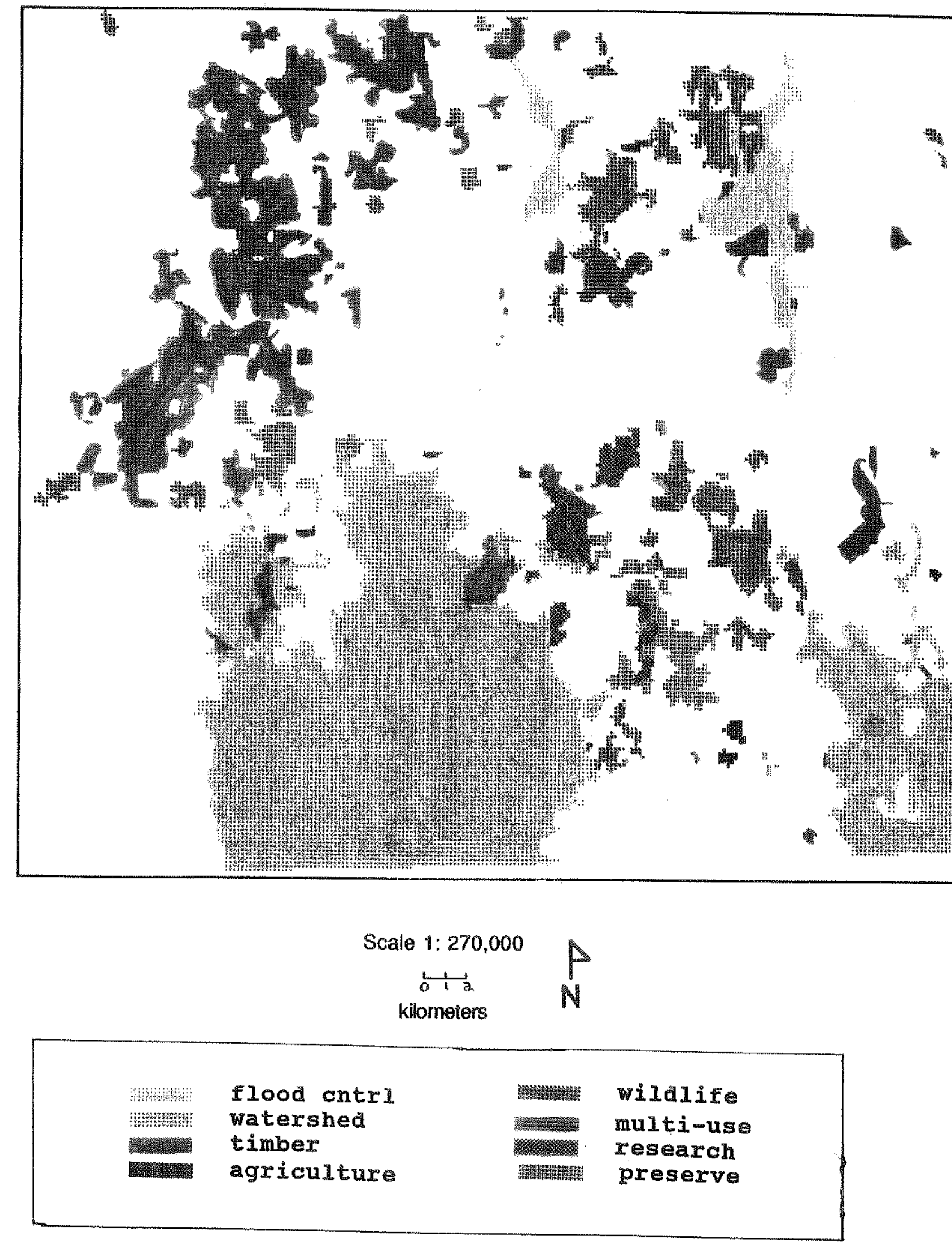


Figure 6. Location of protected lands in the study area shown by acquisition purpose.

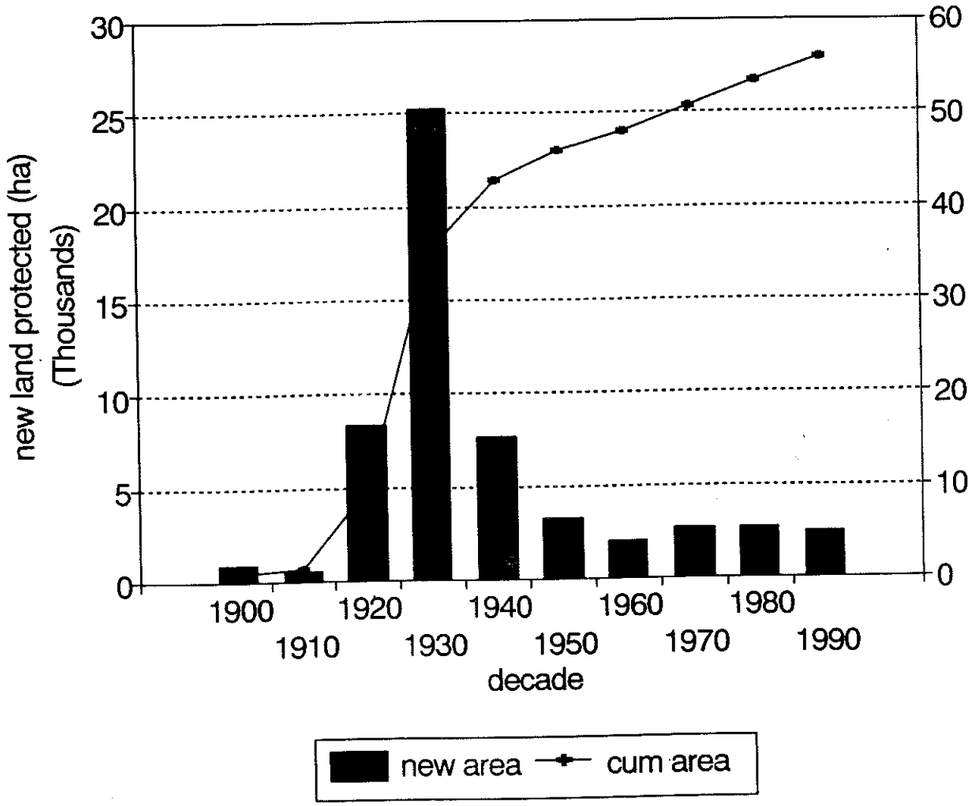


Figure 7. Area of land protected shown as new and cumulative amounts of land each decade. Note that decade 1990 includes data through October 1, 1992 only.

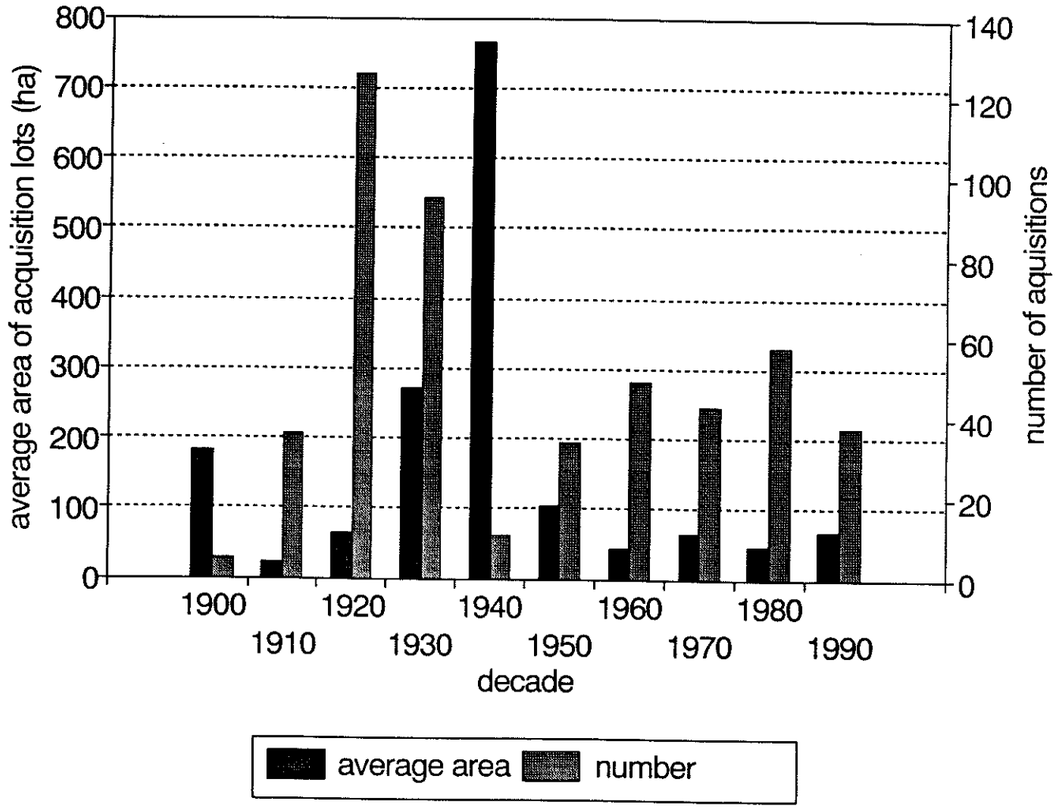


Figure 8. Average size and number of acquisitions of protected land by decade. Note that decade 1990 includes data through October 1, 1992 only.

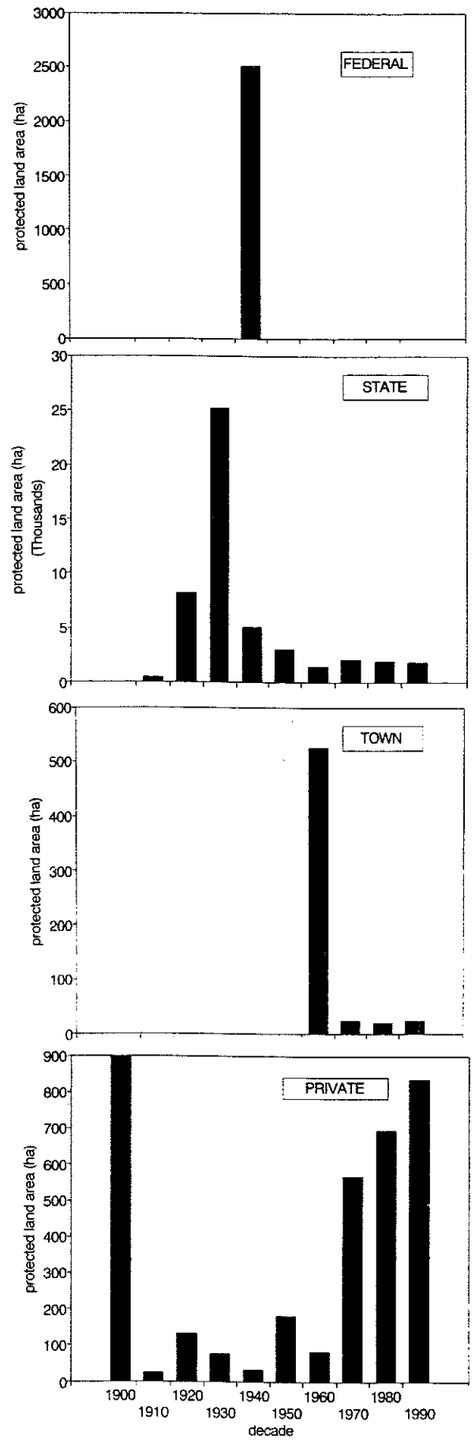
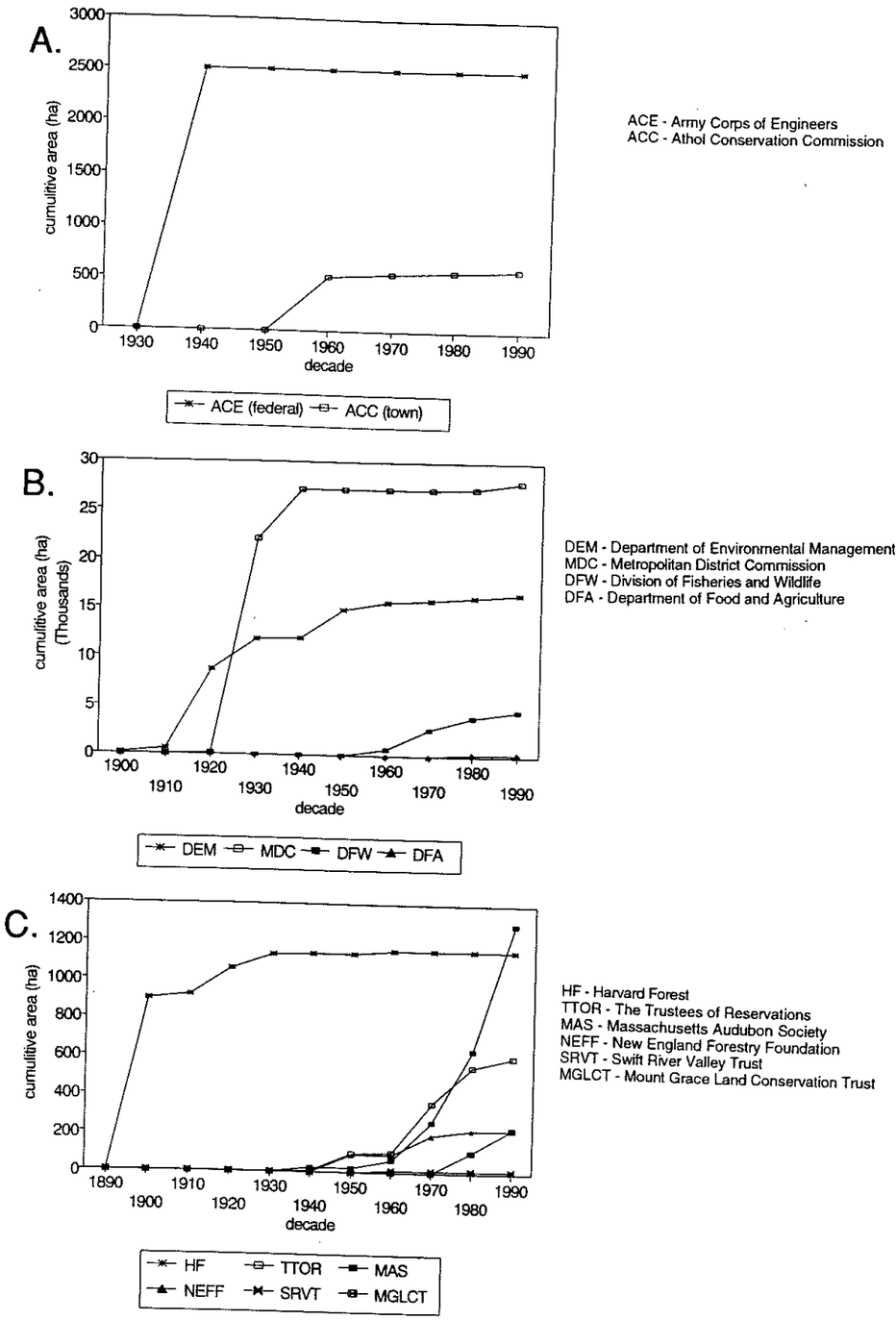


Figure 9. Area of land protected by four landowner categories over time. Note differences in vertical scale, and decade 1990 includes data through October 1, 1992 only.

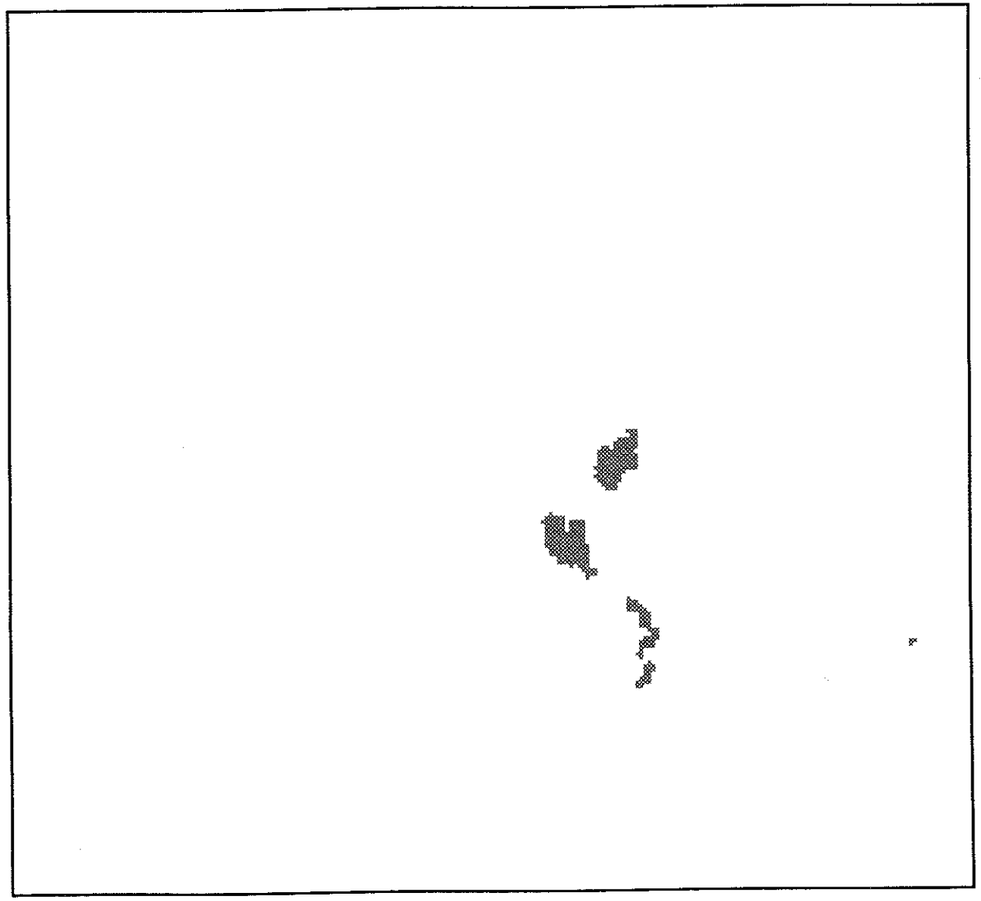


ACE - Army Corps of Engineers
ACC - Athol Conservation Commission

DEM - Department of Environmental Management
MDC - Metropolitan District Commission
DFW - Division of Fisheries and Wildlife
DFA - Department of Food and Agriculture

HF - Harvard Forest
TTOR - The Trustees of Reservations
MAS - Massachusetts Audubon Society
NEFF - New England Forestry Foundation
SRVT - Swift River Valley Trust
MGLCT - Mount Grace Land Conservation Trust

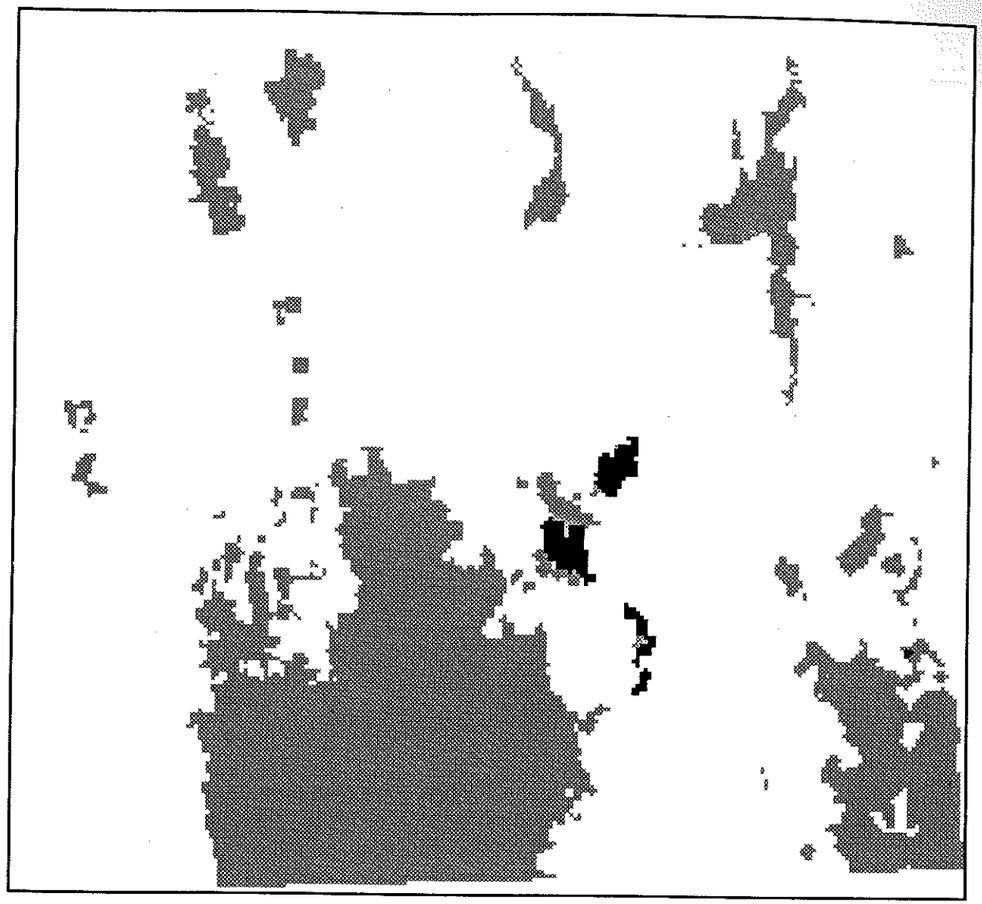
Figure 10. Temporal change in cumulative hectares of land protected by individual groups in four landowner categories: a) federal as well as town government agencies, b) state government agencies, and c) private organizations. Note differences in vertical scale, and decade 1990 includes data through October 1, 1992 only.



Scale 1: 270,000
0 1 2
kilometers
N

newly protected

Figure 11a. Location of lands protected 1901-1919.



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newly protected

prev. protected

Figure 11b. Location of newly and previously protected lands 1920-1949.

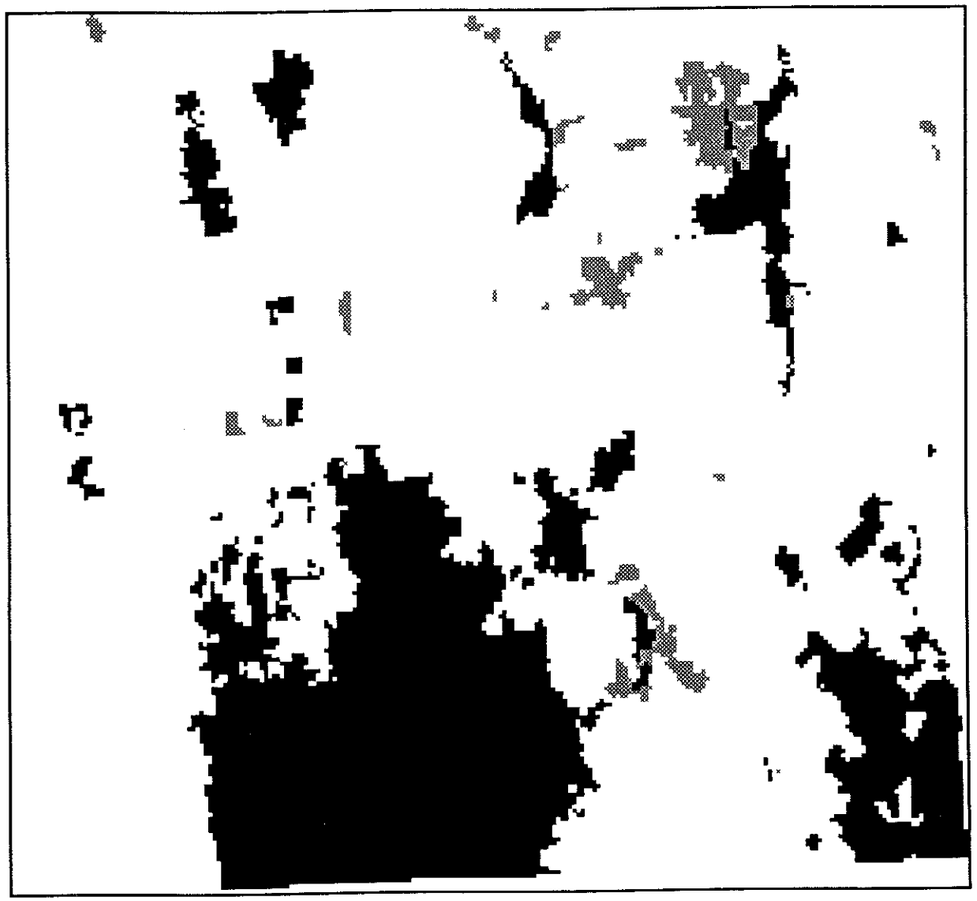


Figure 11c. Location of newly and previously protected lands 1950-1979.

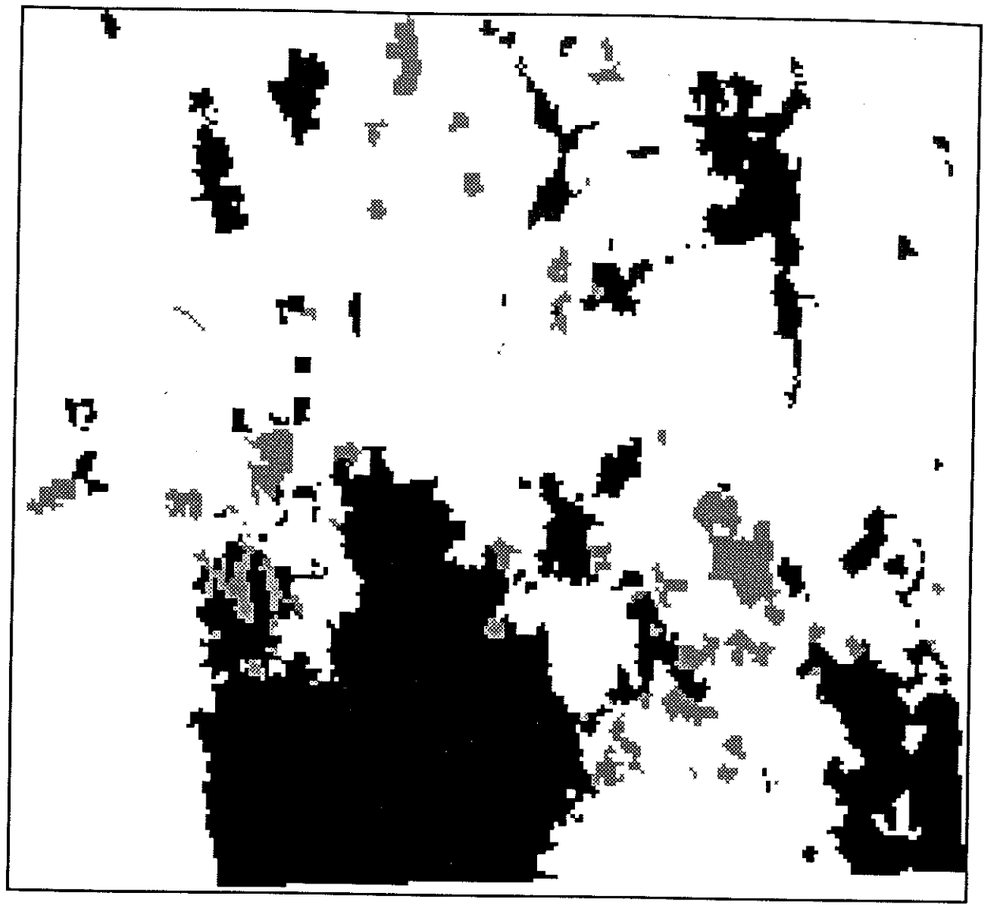


Figure 11d. Location of newly and previously protected lands 1980-1992.

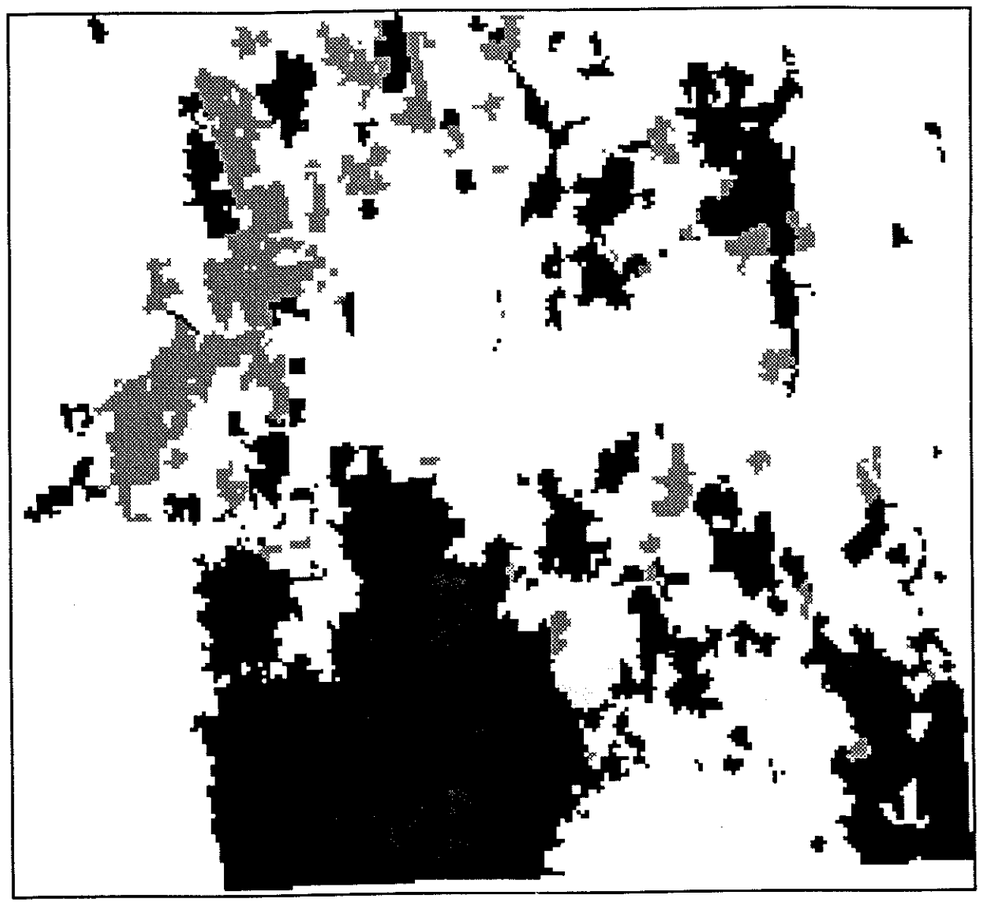


Figure 11e. Location of protected lands with and without known acquisition dates or lot boundaries.

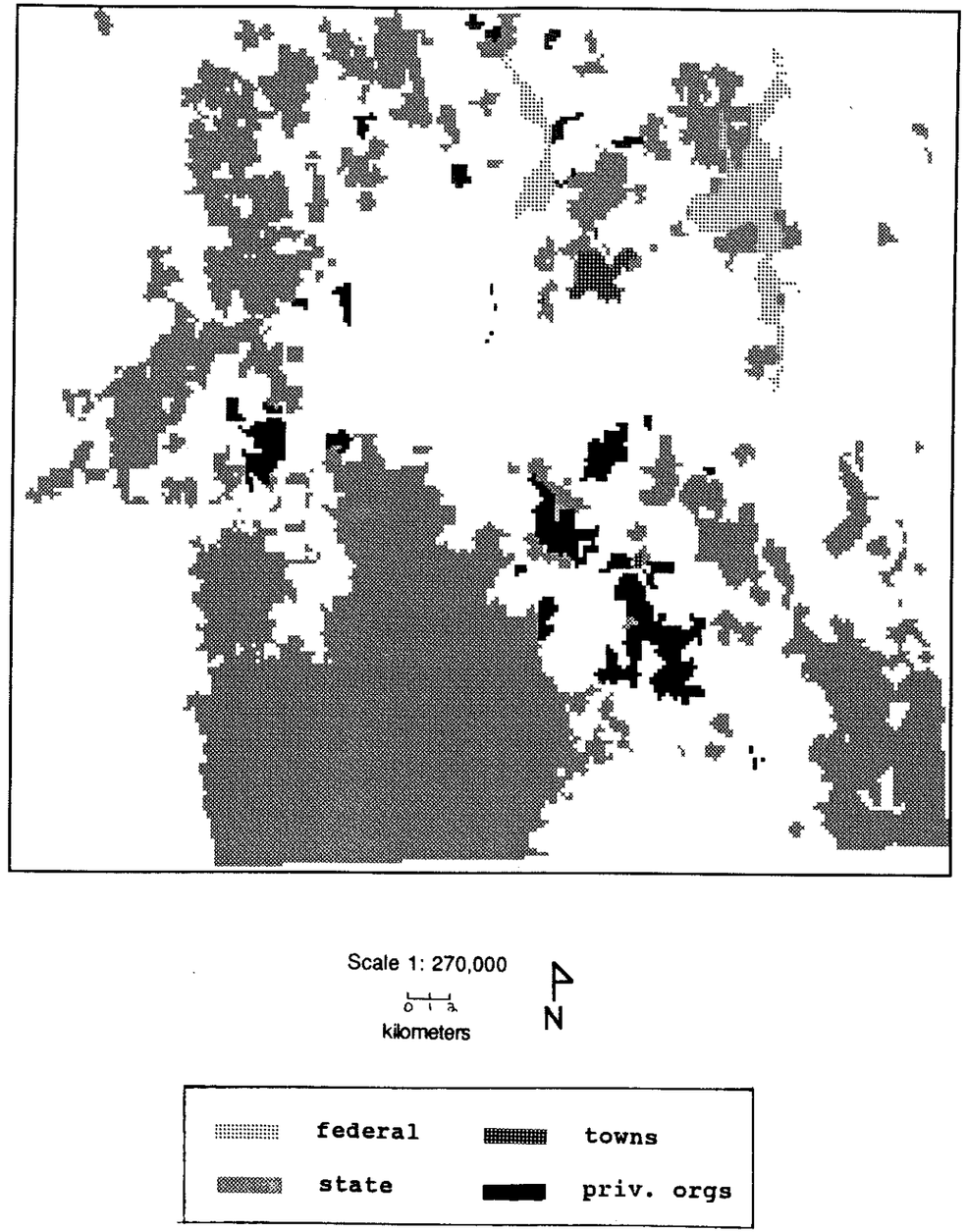


Figure 12. Location of protected lands shown in four ownership classes.

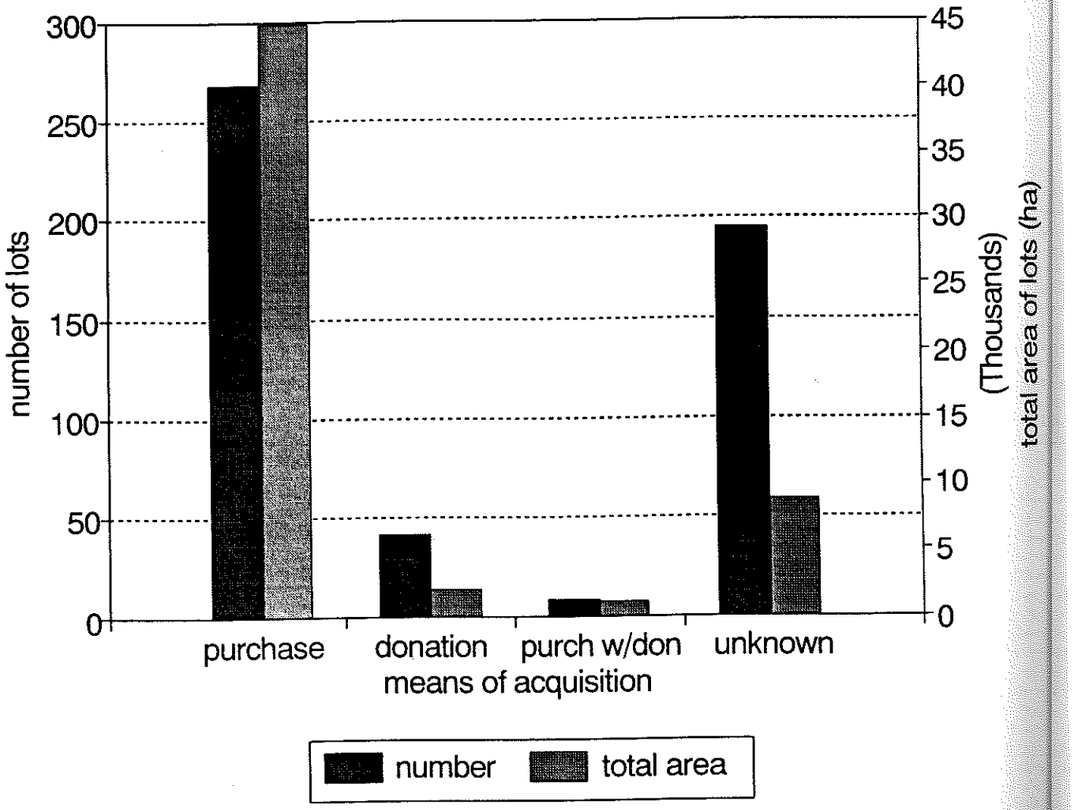


Figure 13. Number versus size of lots protected through various acquisition means.

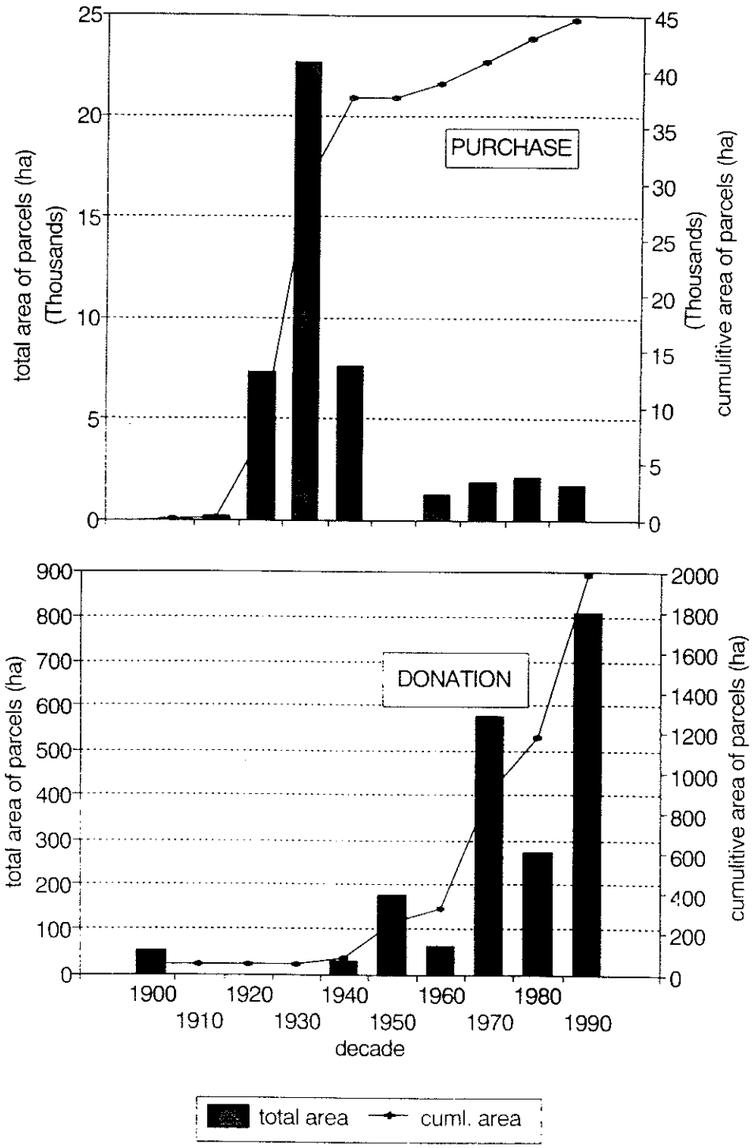
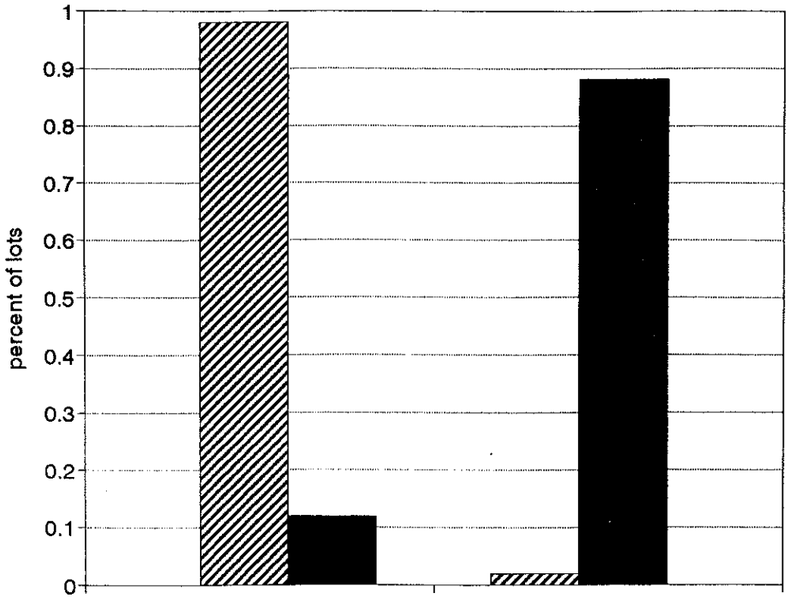


Figure 14. Area of protected land acquired by purchase and donation shown as new and cumulative amounts of land each decade. Note differences in vertical scale, and decade 1990 includes data through October 1, 1992 only.



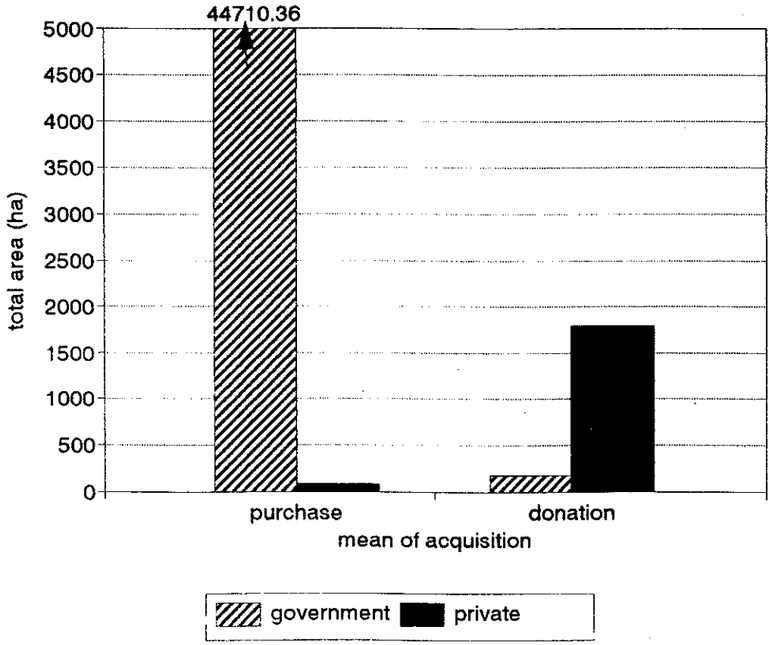


Figure 15. Ownership by government agencies versus private organizations of purchased and donated protected lands expressed in percent and area of lots.

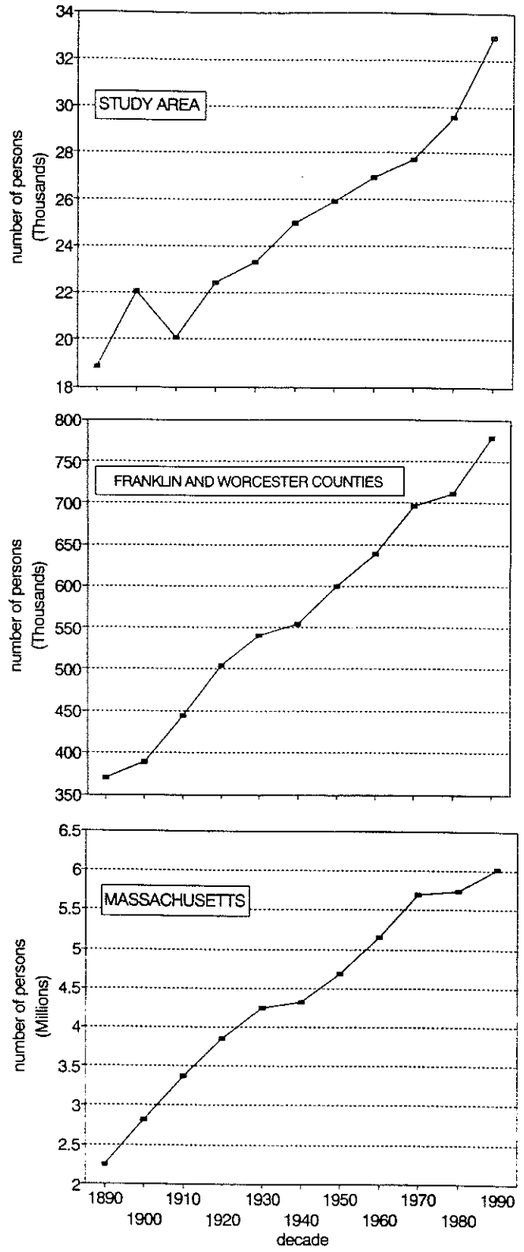


Figure 16. Population numbers for the study area, Franklin and Worcester Counties, and Massachusetts from 1890 to 1990 (United States Department of Commerce 1913, 1942, 1961). Note differences in vertical scale.

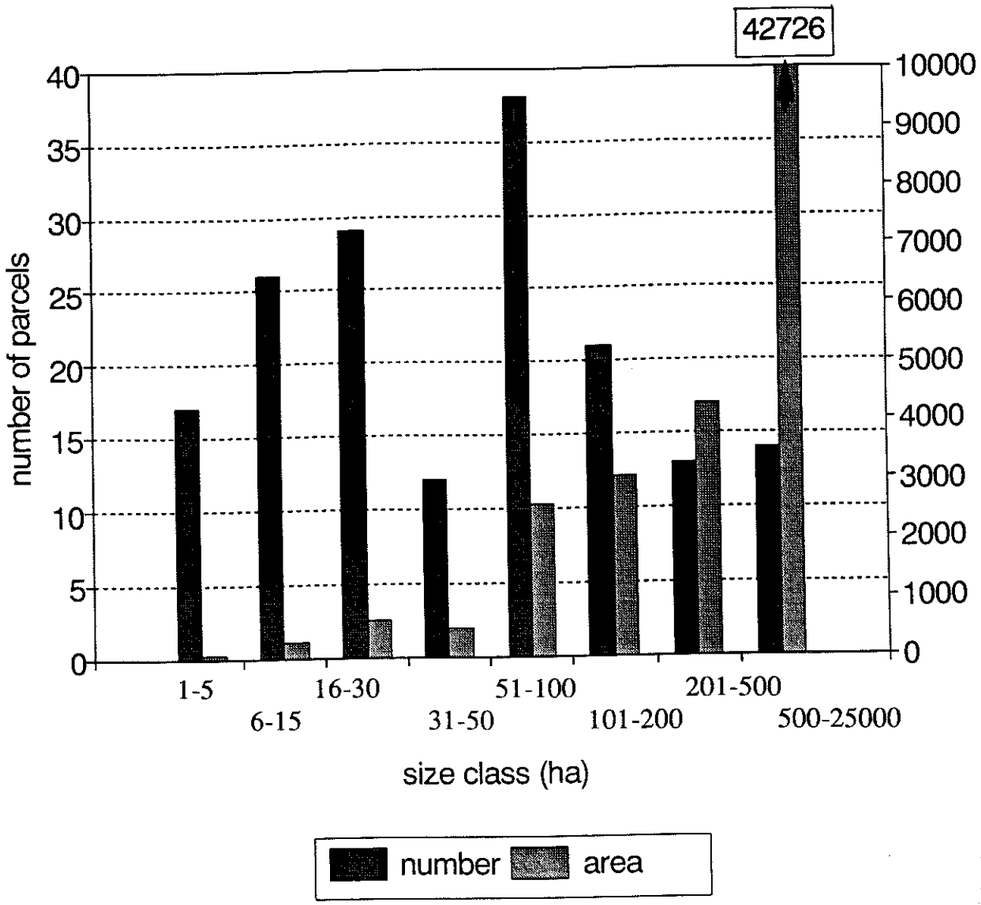


Figure 17. Distribution of the number and total area of parcels in various size classes

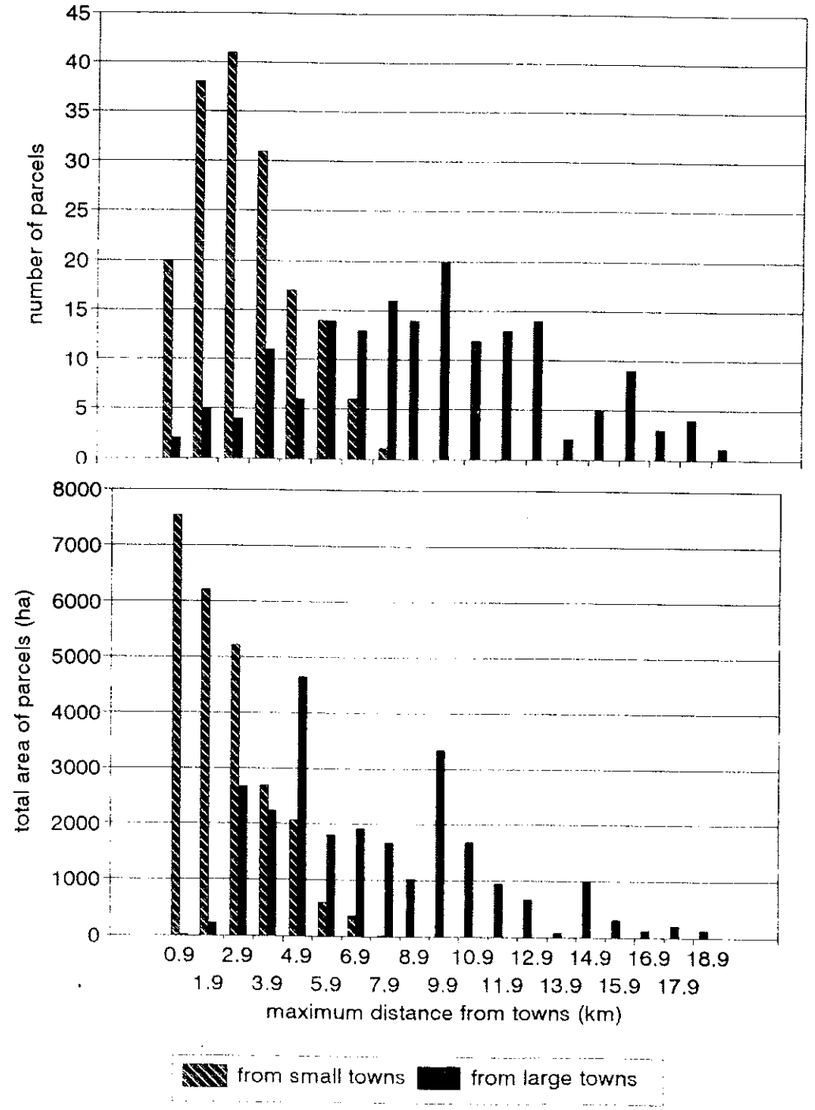


Figure 18. Protected lands which are various distances from small towns (population <7,000) and large towns (population >7,001) expressed in number and area of parcels.

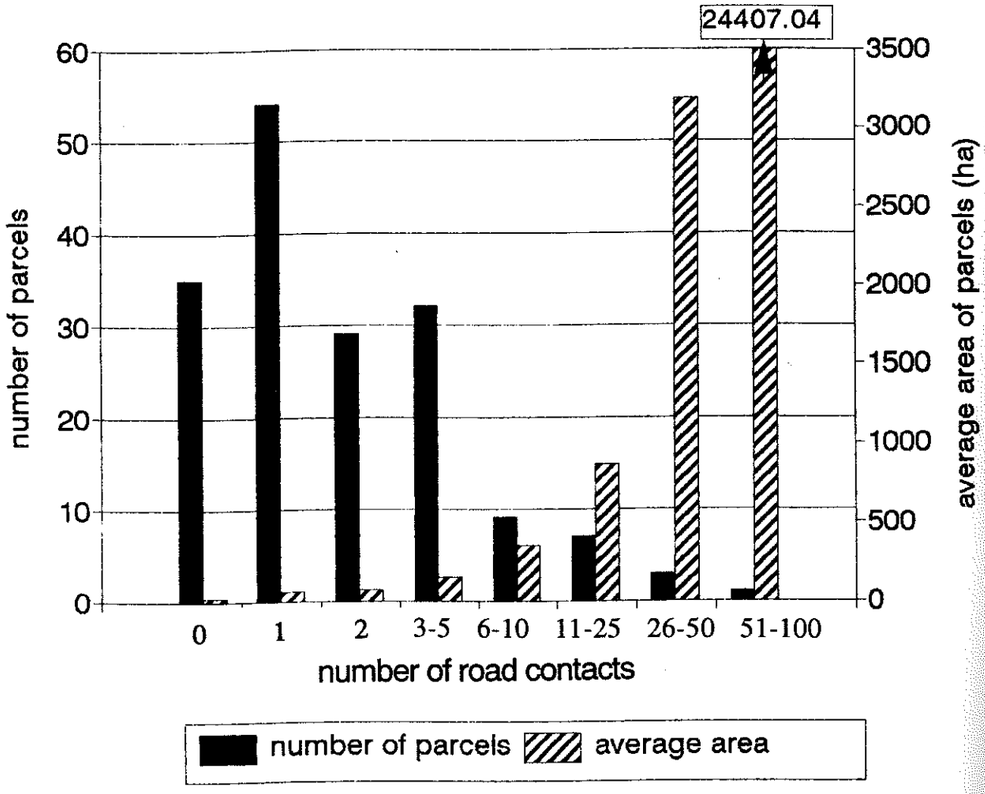


Figure 19. Number and average size of parcels which have various numbers of roads contacting them.

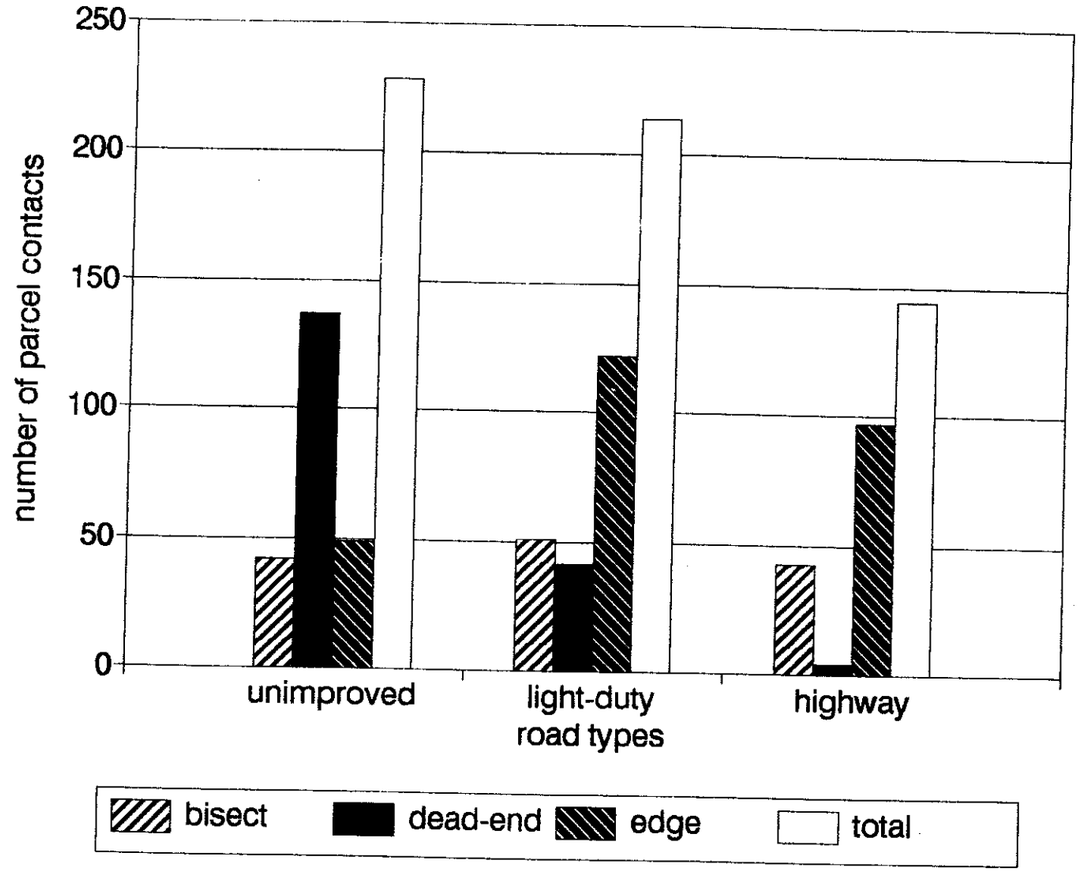


Figure 20. Total number of times three road types contact protected parcels and the number of times these road types bisect , dead-end in, and follow the edge of protected parcels.

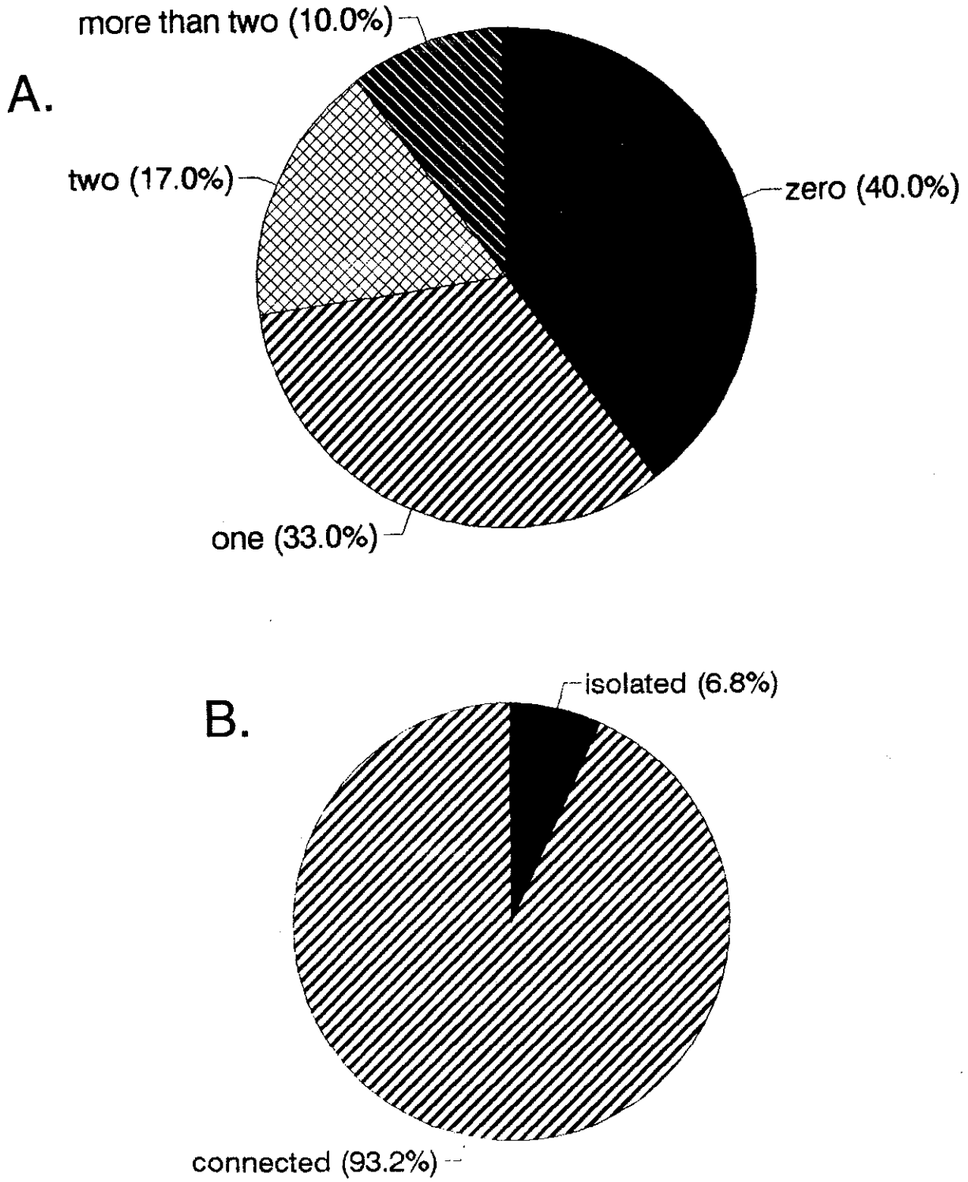


Figure 21. (a) Percent of protected parcels with a range of neighboring protected lands and (b) percent of area of protected lands which are isolated from or connected to other protected areas.

TABLES

Table 1. Land owners' purpose in protecting land.

Protection Purpose	Land Owners
Water	Metropolitan District Commission
Timber	Department of Environmental Management New England Forestry Foundation
Wildlife	Division of Fisheries and Wildlife
Flood control	Army Corps of Engineers
Preservation	Massachusetts Audubon Society The Trustees of Reservations Mount Grace Land Conservation Trust Swift River Valley Trust
Education	Harvard Forest
Multiple-uses	Athol Conservation Commission
Agriculture	Department of Food and Agriculture

Table 2. Temporal change in cumulative hectares of land protected by individual land owners. Note that decade 1990 includes data through October 1, 1992 only.

	Area (ha)				
Owner	1900	1910	1920	1930	1940
MDC	0	0	16.75	22014.79	27103.01
DEM	6.14	535.86	8677.83	11884.42	11900.42
DFW	0	0	0	0	0
ACE	0	0	0	0	2508.66
MAS	0	0	0	0	20.60
HF	898.28	922.72	1055.79	1133.27	1136.95
TTOR	0	0	0	0	7.95
ACC	0	0	0	0	0
MGLCT	0	0	0	0	0
NEFF	0	0	0	0	0
DFA	0	0	0	0	0
SRVT	0	0	0	0	0
Total	959.68	1458.58	9750.37	35032.48	42677.59

	Area in hectares				
Owner	1950	1960	1970	1980	1990
MDC	27103.01	27103.01	27103.01	27295.97	27972.82
DEM	14898.02	15660.10	15858.54	16203.54	16497.94
DFW	0	697.77	2624.88	3879.54	4541.59
ACE	2508.66	2508.66	2508.66	2508.66	2508.66
MAS	20.60	64.58	265.04	637.05	1293.26
HF	1136.95	1156.82	1156.82	1156.82	1156.82
TTOR	97.67	101.44	362.16	551.60	605.90
ACC	0	525.89	549.23	569.68	593.88
MGLCT	0	0	0	106.89	230.97
NEFF	92.08	92.08	197.53	223.34	223.34
DFA	0	0	0	159.41	159.41
SRVT	0	13.22	13.22	13.22	13.22
Total	45856.99	47923.57	50639.09	53305.02	55797.81

MDC - Metropolitan District Commission
DEM - Department of Environmental Management
DFW - Division Of Fisheries and Wildlife
ACE - Army Corps of Engineers
MAS - Massachusetts Audubon Society
HF - Harvard Forest
TTOR - The Trustees of Reservations
ACC - Athol Conservation Commission
MGLCT - Mount Grace Land Conservation Trust
NEFF - New England Forestry Foundation
DFA - Department of Food and Agriculture
SRVT - Swift River Valley Trust

Table 3. Number and hectares of restrictions acquired each year.

Year	Number	Area (ha)
1974	1	1.4
1982	1	17.29
1985	1	3.19
1989	4	208.79
1990	5	347.16
1991	1	84.17
1992	1	5.17
Total	14	667.17

Table 4. Hectares of land protected between 1950 and 1992 through two acquisition means.

	Area (ha)	
Owners	Land Owned in Fee	Land with Restriction
Division of Fisheries and Wildlife	4393.17	148.42
Dept of Environmental Management	4137.52	0
Massachusetts Audubon Society	1097.63	175.03
Metropolitan District Commission	812.79	57.02
The Trustees of Reservations	593.36	4.59
Athol Conservation Commission	593.88	0
Mount Grace Land Conservation Trust	59.02	171.95
New England Forestry Foundation	65.68	0
Department of Food and Agriculture	0	159.41
Total	11753.05	716.42

APPENDIX A

Land Protection Groups in North-Central Massachusetts

FEDERAL

United States Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254-9149
617-647-8237

Contacts: Joe Faloretti, Lower Connecticut River Basin Manager
508-249-2547
Marty Curran, Tully Lake
508-249-9150
Jim Bacon, Birch Hill Dam
508-249-4467

STATE

Department of Environmental Management
Division of Forest and Parks
100 Cambridge Street
Boston, Massachusetts 02202
617-727-3180

Contacts: Robert Wilbur, Director, Land Acquisition and Protection Program
617-727-3160 Ext. 553
Charles Pernaa, Worcester County Regional Office
508-368-0126
Bill Rivers, Connecticut River Valley Regional Office
413-545-5993

Division of Fisheries and Wildlife
100 Cambridge Street
Boston, Massachusetts 02202
617-727-3151

Contacts: Bill Minior, Chief of Wildlife Lands
617-727-3151
Phil Truesdell, Central Wildlife District
508-835-3607
Bill Steinmetz, Connecticut Valley Wildlife District
413-323-7632

Metropolitan District Commission
20 Somerset Street
Boston, Massachusetts 02108
617-727-5215

Contacts: Bruce Spencer, Chief Forester, Quabbin Reservoir
508-544-6343
Clif Read, Director, Quabbin Reservoir Visitors Center
413-323-7221
David Supczak, Quabbin Reservoir Engineer
413-323-6921
Steve Drawbridge, Ware River Watershed
508-882-3789

Department of Food and Agriculture
100 Cambridge Street
Boston, Massachusetts 02202
617-727-0465

Contact: Rich Hubbard, Leominster Regional Field Office
508-792-7712

TOWNS

Athol Conservation Commission
Room 14, Memorial Building
584 Main Street
Athol, Massachusetts 01331
508-249-9376

Contact: J.R. Greene, Chairman

Petersham Conservation Commission
Main Street
Petersham, Massachusetts 01366
508-724-6649

Contact: John Woolsey, town resident

PRIVATE ORGANIZATIONS

Harvard Forest
P.O. Box 68
Petersham, Massachusetts 01366
508-724-3302

contacts: David Foster, Director
Jack Edwards, Forest Manager
508-724-3302

Massachusetts Audubon Society
South Great Road
Lincoln, Massachusetts 01773
617-259-9500

Contacts: Tim Storrow, Director of Land Protection
617-259-9500 and 508-544-8548
Jeanne Anderson, Field Biologist
617-259-9500

Mount Grace Land Conservation Trust
137 North Main Street
New Salem, Massachusetts 01355
508-544-7170

Contact: Keith Ross, President
508-544-7170

New England Forestry Foundation
238 Main Street
Cambridge, Massachusetts 02142
617-864-4229

Contact: Hugh Putnam, Jr., Executive Director
617-864-4229

Swift River Valley Trust
See Harvard Forest, Massachusetts Audubon Society, or The Trustees of Reservations

Contact: John Woolsey

The Trustees of Reservations
572 Essex Street
Beverly, Massachusetts 01915
508-921-1944

Contact: Dick O'Brien, Central Region Supervisor
508-840-4446

APPENDIX B

POSSIBLE PROTECTED LAND PARCELS NOT INCLUDED IN THIS STUDY

Athol Department of Public Works

owns large area of land adjacent to Bearsden Forest (owned by Athol Conservation Commission) in Athol as well as many isolated smaller parcels in the towns of Athol and Phillipston. These lands protect Athol's water supply including several human constructed reservoirs. Although the land has been used this way for as much as 90 to 100 years, it was not clear whether or not it would continue to serve this function in 10 years or 100 years.

Massachusetts Department of Public Works

owns a scenic easement restriction on at least one parcel of land in the study area (located in the town of Orange). The protection offered by this type of restriction remains unclear.

The Town of Petersham

owns at least four small parcels of land within its town lines which are often called "town forests." Although these lands at first appeared protected, as recently as 1992, the town considered selling one of these lots. Even though the town decided to log the lot instead of selling it, the protected nature of these town-owned lots remains ambiguous.

The Society for the Protection of New England Antiquity

holds a conservation restriction on a small portion of land in Petersham. Lack of information about this organization and their land protection activities forced this parcel to be discarded.

APPENDIX C

DATA SHEETS USED IN THIS STUDY

The protected land parcels in the study area were organized into three categories for data collection.

Unit - all land areas which shared the same name were considered a unit and were given a four-letter code (the first two letters represented the unit name and the second two letters represented the land owner).

Parcel - each geographically separate land area was considered a parcel. Each parcel within a unit (a unit contained as few as 1 and as many as 18 parcels) was numbered sequentially.

Lot - each parcel could be sub-divided into one or more lots which were distinguished by their acquisition date. Every lot within a unit was assigned a letter.

Four data sheets were used for each unit.

Cover sheet - provided landowner, location, and size information as well as parcel and lot numbers for each unit. References to the source of information contained in the data sheets were also recorded here.

Data sheet #1 - covered the acquisition history of each lot. If the owner or protection status of a lot changed, a data sheet was filled out for each transaction and numbered sequentially in the comments section.

Data sheet #2 - covered spatial relationships for each parcel.

Data sheet #3 - covered the purpose and management for each unit.

Data categories were ranked in order of importance for efficiency in research.

bold type - necessary information

plain type - important information

italics type - important, but not essential, information

DATA SHEETS 1-3
cover sheet

Name of Unit _____ **code** _____
town _____ **county** _____
owner category _____ **owner** _____
parcel and lot numbers _____ _____ _____
_____ _____ _____ _____ _____
_____ _____ _____ _____ _____
total number of hectares _____

References:

DATA SHEET #1
acquisition and land-use history

unit/parcel/lot _____ **hectares** _____
id. descrip. _____
date of acquisition _____ from _____
purchase ____ **donation** ____ **purchased with donations** _____
appraised value _____ purchase price _____
reason for disposal
___ capital gain ___ land unproductive ___ conservation values
____ eminent domain ___ tax reduction ___ no heirs
____ other _____
reason for acquisition
___ reforestation act ___ aesthetic values ___ timber values
___ wildlife values ___ recreation values ___ habitat/spp. values
___ opportunity ___ flood control ___ watershed ___ education
___ research ___ protection ___other _____
immediate previous land-use (indicate duration in years)
___ residential ___farmland ___ woodlot ____ natural state
___ abandoned ___ other _____

previous land-uses	dates		dates
___ residential	_____	___ farm	_____
___ woodlot	_____	___ abandoned	_____
___ natural state	_____	___ other	_____

_____

notes:

DATA SHEET #2
landscape and physical description

unit/parcel _____ **hectares** _____
shape _____

slope	%total	aspect (% total)		elevation (m)
flat	_____	N ____	S ____	minimum _____
gentle	_____	NE ____	SW ____	maximum _____
steep	_____	E ____	W ____	mean _____
		SE ____	NW ____	median _____

landscape type	# ha	% total	names
upland wooded	_____	_____	
upland open	_____	_____	
lakes/ponds	_____	_____	_____
rivers/streams	_____	_____	_____
marshes/swamps	_____	_____	_____
other	_____	_____	_____

distance from (m)		**abutters** (protected land)
unimproved road	_____	_____
light-duty road	_____	_____
highway	_____	_____
		_____
building	_____	_____
2-10 buildings	_____	_____
town center	_____	
big town center	_____	(Athol, Orange, Winch., Gardener)

notes:
_____
_____
_____
_____
_____
_____

DATA SHEET #3
purpose and management

unit _____

purpose of land	original	current
recreation	_____	_____
watershed protection	_____	_____
timber management	_____	_____
wildlife management	_____	_____
multiple-use	_____	_____
flood control	_____	_____
preservation of - scenic, historic, wildlife, ecology, agriculture, general	_____	_____
education	_____	_____
other _____	_____	_____

current management

public access:	human use:	management:
none ____	none ___	none ____
restricted ____	very limited ___	timber extract. ____
limited ____	limited ___	wildlife improv. ____
unlimited ____	some limits ____	watershed control ____
	unlimited ____	historic creation ____
		recreation ___
		research ____
		potential flooding ____
		current conditions ____
		other ____
		_____

protection class:
1) little protection ____
2) some protection ____
3) much protection ____
4) preserved ____

notes:
_____
_____
_____

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Rivers, Bill (18 June 1992) Forester, Department of Environmental Management.

Ross, Keith (April 1992 - October 1992) President, Mount Grace Land Conservation Trust.

Spencer, Bruce (June 1992) Chief Forester, Quabbin Reservoir.

Steinmetz, Bill (20 August 1992) Land Agent, Division of Fisheries and Wildlife.

Storrow, Tim (20 October 1992) Director of Land Protection, Massachusetts Audubon Society.

Woolsey, John (June-August 1992) Resident, town of Petersham.