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Recreational Development at Pelican Lake, Minnesota: An Analysis of Factors Affecting Site Selection

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Recreational Development at Pelican Lake, Minnesota: An Analysis of Factors Affecting Site Selection

by
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This thesis submitted by Robert L. Stoll in partial fulfillment of the requirements for the Degree of Master of Science from the University of North Dakota is hereby approved by the Faculty Advisory Committee under whom the work has been done.

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This thesis meets the standards for appearance and conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

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ABSTRACT

In order to better predict those areas which have the potential to be developed more rapidly than others, research concerning physical land use characteristics which determine current lakeshore patterns needs to be implemented. This study is designed to assess which physical land use/cover characteristics have affected lake home development at Pelican Lake in north central Minnesota.

Analysis involves the interpretation of aerial photographs from the years 1939, 1960, 1969, and 1978 which were used to map location and extent of land use/cover change in the Pelican Lake area. Archival data is utilized in order to determine number and location of recreational homes existing on the shoreline of Pelican Lake. Finally, correlation and regression techniques are used in order to ascertain relationships between the physical parameters of the watershed and location of lakeshore homes.

Length of shoreline is found to be the leading indicator in number of homes in each section bordering Pelican Lake. Distance to nearest improved road also proves to be a significant factor. Of the land use/cover data obtained from aerial photographs, only acres of that land covered by water and acres in Pelican Lake are determined to be of significance in location of lakeshore homes.

INTRODUCTION

PROBLEM STATEMENT

Lakeshore development for recreational use in northern Minnesota has been rapidly increasing over the past fifty years. One of the areas most affected by this increase in development is Crow Wing County and, in particular, Pelican Lake, which ranks among the ten most developed lakes in the state (Borchert, 1970). Because of potential environmental and economic impacts caused by development at Pelican Lake and elsewhere in Minnesota, there is a need for accurate baseline data and an understanding of what environmental attributes attract development. Many problems may arise because of insufficient planning in the development of certain fragile areas which may result in environmental degradation. Responsible and problem-negating planning for recreational development can be made only when there is an increased understanding and basic awareness of what physical land use characteristics determine current lakeshore development patterns.

Most assessment techniques currently in use are concerned with three facets of development suitability: physical suitability, climatic suitability, and visual suitability. Physical development suitability is a function of several landscape variables, such as slope and depth to water table. These characteristics may affect the cost of a given development as well as the impact of that development on surrounding developments. Climatic development suitability is a function of local landscape characteristics that affect the microclimate of a given area. Forest vegetation, for example, can provide shelter from cold winds during the winter season, and south-facing slopes usually receive much more sun in the winter than northern slopes. Visual development suitability, finally, is a measure of the level of general amenity on any given piece of land. Although the presence of very high quality visual-values in an area may suggest that it be protected or preserved from development, a view of moderately high quality will nearly always enhance the development suitability of an area.

While these assessment techniques are useful in determining suitability limitations for development of particular parcels of land, little has been done to assess past development patterns as an indication of probable future development pressure and environmental degradation. Therefore, there is a distinct need for such an assessment to determine if recreational developments were, and are, haphazard or if there are traditionally perceived environmental variables which tend to determine location of such developments.

RESEARCH OBJECTIVES

It is the intent of this study to examine patterns of recreational development and land use/cover within the Pelican Lake watershed and to determine which characteristics of the environment play a major role in determining the locations of lakeshore homes. These analyses will involve the interpretation of aerial photographs from the years 1939, 1960, 1969, and 1978 which will be used to map location and extent of land use/cover changes in the Pelican Lake area. Maps constructed from these photos will be used for measurement of each appropriate land cover class. Archival data will be used to determine the number of recreational dwellings constructed and their location in the Pelican Lake area. Data on physical and cultural variables will be analyzed by correlation and regression techniques in order to ascertain their relationship with location of lakeshore homes.

RESEARCH HYPOTHESIS

It is hypothesized that specific land use and distinctive physical characteristics of the watershed and lake will correlate significantly with recreational development patterns at Pelican Lake.

REVIEW OF THE LITERATURE

STUDY AREA DESCRIPTION

Pelican Lake is in Crow Wing County of north central Minnesota and, with an area of 8,253 acres, a maximum depth of 104 feet, and a mean depth of 22 feet, is the largest of the county's 1?1 lakes. Shoal areas are abundant, with a littoral area of 3,910 acres. The basin is roughly oval in outline and includes 25.4 miles of shoreline. Greatest length is that from north to south, which is approximately 5.9 miles (Minnesota DNR, 1983).

Continental glaciation is responsible for the formation of Pelican Lake, which occurs in a pitted outwash plain, an area of extensive outwash characterized by many ice-block pits. Radiocarbon dating indicates the origin of the lake to be approximately 14,000 to 12,300 years BP, during the late Wisconsinan stage of the Pleistocene epoch (Clayton and Moran, 1982). Pelican Lake formed when an ice block was seperated from the main mass of a retreating glacier and was partially buried by outwash, sorted and stratified material (commonly composed of sand and gravel) laid down by glacial meltwater streams. Ice-block pits are commonly circular or elliptical in outline, whose shape is the result of shore modification rather than the result of the original shape of

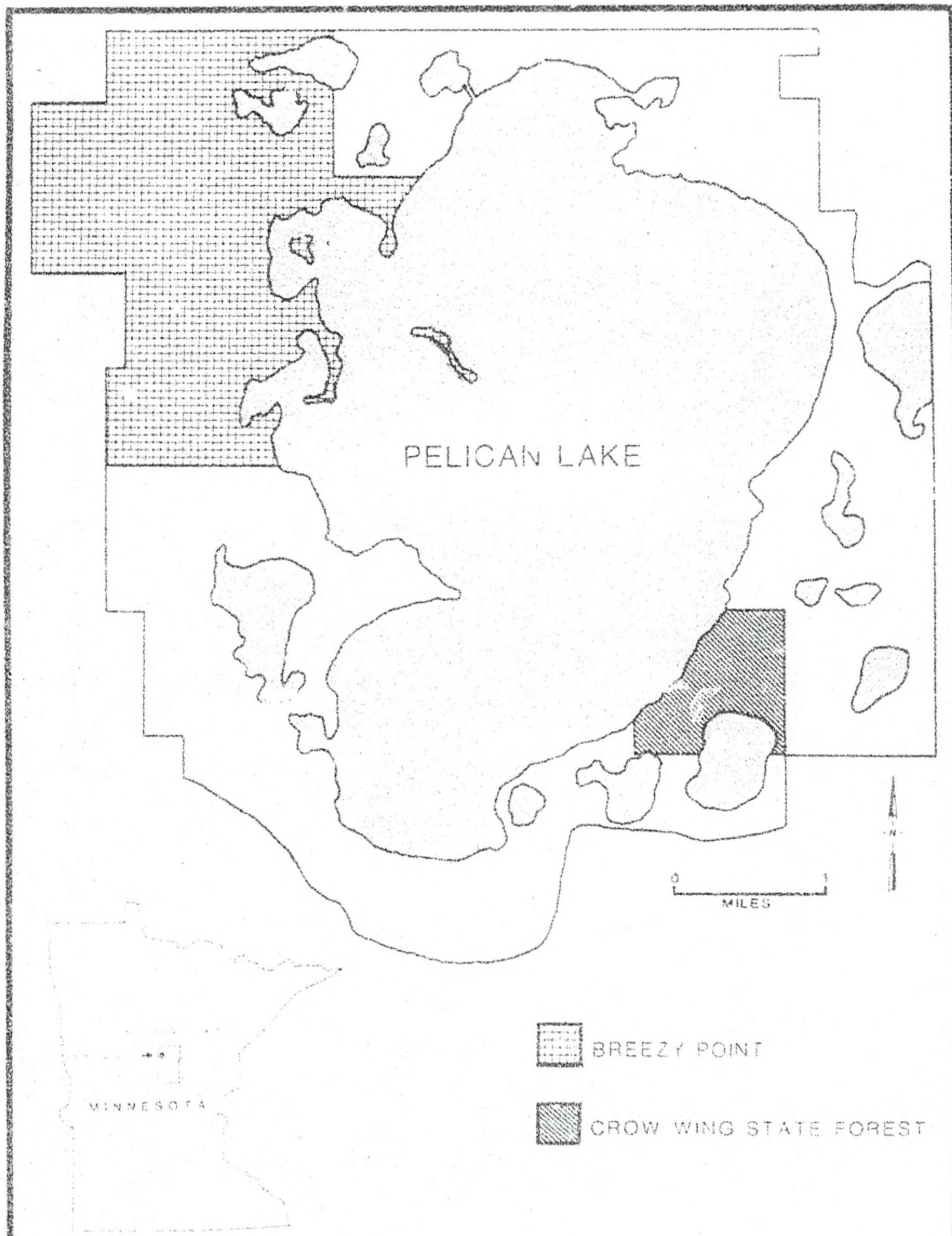


Figure 1: Pelican Lake Watershed.

Figure 2: Bathymetric Map of Pelican Lake (Nelson, 1982, p. 24)

the ice block. A very common term used for such a lake is kettle or kettle hole (Cole, 1975).

The Crow Wing outwash plain, in which most of the study area lies, formed as the last glacier retreated westward from the Brainerd area and is one of the best-known examples of a pitted outwash plain in Minnesota (Zumberge, 1952). Topography is gently rolling to nearly level and is characterized by numerous lakes, ponds, and swamps. Soils are light-colored and the area is well- to excessively-drained (University of Minnesota, 1969). The region bordering Pelican Lake on the west is part of the St. Croix Moraine Complex, in which topography is very irregular and numerous, small, poorly drained areas exist (Figure 3). This moraine was formed primarily by ice advancing from the east-northeast (the Patrician Ice Sheet), and contains a mixture of sand, gravel, and till of sandy loam texture. Hills here rise from 100 to 135 feet above the elevation of Pelican Lake, which lies at 1,206 feet above sea level. Soils are light-colored and the area is well- to excessively-drained (University of Minnesota, 1969). While parts of Minnesota include numerous rock outcrops, few if any exist within the study area. The same glaciers that helped to form such outcrops in other areas generally covered them here with glacial sediment. Thickness of glacial drift in Crow Wing County measures about 195 feet (Ojakangas and Matsch, 1982).

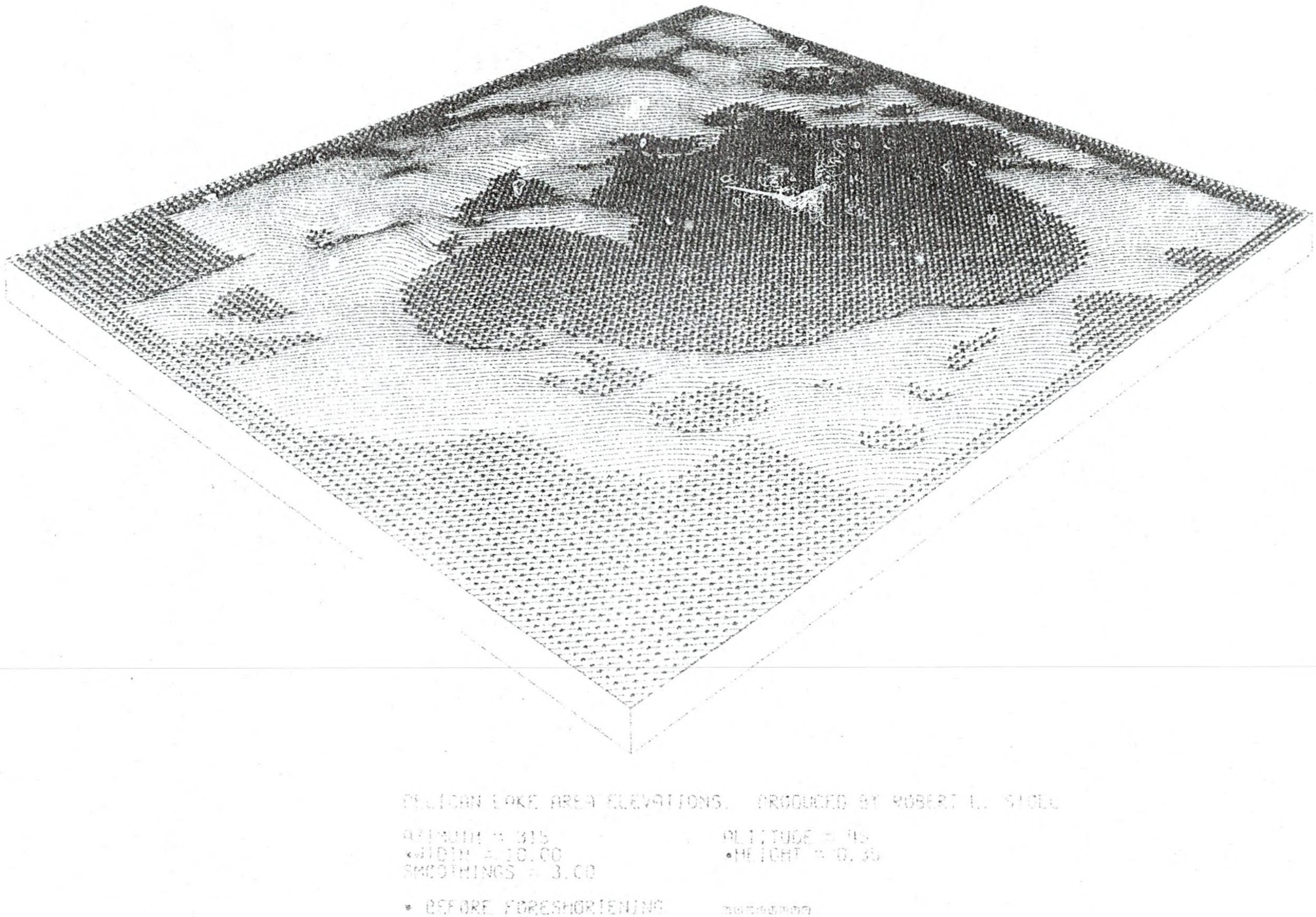


Figure 3: SYMVU Map Depicting Topography of the Pelican Lake Area.

Until construction of a diversion ditch on the north shore leading to Ossawinnamakee Lake in 1939, Pelican Lake was a closed basin. With the addition of the diversion ditch, water from Pelican Lake now travels to the Mississippi River by way of Ossawinnamakee Lake, Pelican Brook, and Pine River. The diversion ditch also served to raise the falling levels of Pelican Lake, which had an estimated decline of twelve feet in the 50-100 years prior to 1938 (Minnesota DNR, 1977). Flow is controlled by a six-bay dam and is maintained primarily by the state of Minnesota. Aside from the diversion ditch, Pelican Lake, which lies within the Mississippi Headwaters Watershed, is fed by surface runoff and groundwater seepage.

The climate of the area, which is characterized by large annual and diurnal temperature ranges, is classified as humid continental (Dfb) in the Koppen Climate Classification (Koppen and Geiger, 1954). Summers are warm and relatively short, and winters are cold and long. Mean July temperature is 69 F and the mean temperature of January is 6 F; the average annual temperature is 39 F (NOAA, 1974). Annual rainfall averages approximately 26 inches, eighty-percent of which falls during the frost-free period of May through August (NOAA, 1974).

Large stands of jack pine, aspen, birch, and red oak are characteristic of the study area. Approximately seventy-five percent of the study area surrounding Pelican Lake is covered by forest. Another seventeen percent is comprised of water or wetlands. Little farming is practiced due to extensive lakes and wetlands along with the sandy nature of the soil. Because of the vast number of lakes and associated recreational opportunities, one of the principal sources of income for county residents continues to be tourism and related activities. One square-mile section of Pelican Township on the southeast side of Pelican Lake is within Crow Wing State Forest which, for the most part, lies approximately three miles to the east.

OVERVIEW OF RECREATIONAL DEVELOPMENT

Primary reasons for increased travel, leisure time, and recreation in America are many and extensive efforts will not be made to describe them here. The Bureau of Outdoor Recreation (1973) estimated that in 1960, Americans engaged in major forms of summertime outdoor recreational activities on 4.28 billion occasions. By 1970 the number had increased to 7.42 billion, and in 1975 it was 8.33 billion. These trends indicate that outdoor recreation is increasing faster than population (Jensen, 1977).

PUBLIC VS. PRIVATE RECREATION

Large sums of both public and private investment go into recreational resources and programs, and tens of billions of personal consumption dollars are spent on leisure-time pursuits (Knudson, 1980). Though public lands serve as the major base for outdoor recreation, they cannot accomodate all the diverse and rapidly growing recreational demands. Therefore, private lands will play an increasingly vital role in outdoor recreation (Brockman and Merriam, 1979).

Approximately seventy percent of our land is privately owned (U.S. Bureau of Census, 1983). Large portions of private land are more readily accessible to population centers than much of our public land and, thus, are available to grea er numbers of people. Estimates indicate that at least fifty percent of recreational opportunity is directly attributable to the private sector (Bureau of Outdoor Recreation, 1973).

Recreational use of private land is highly diversified and encompasses a wide variety of activities, facilities, and types of land. These include areas important for hunting and fishing, privately operated campgrounds and trailer parks, organization camps, privately owned summer or winter homes, and highly developed commercial resorts (Jensen, 1977). In many cases recreational use of private lands offers opportunity for profit, as well as other benefits, to landowners (Hodges, 1977). Many privately owned recreational enterprises are full-time undertakings, while others operate part-time or seasonally. Some exist entirely on private land; others depend largely upon interests in nearby recreation areas on public lands, or are developed on public land by agreement with public land management agencies (Wheeler, 1977). A number of government agencies and various private organizations provide assistance in developing the recreational potential of private land and in the solution of many problems related to such developments (Bureau of Outdoor Recreation, 1973).

Public and private recreation services were an outgrowth of increased recreational demand, but had their beginnings independently. Private recreational opportunities preceded public-supported recreational services by many years and were conceived as a result of one or more of the following reasons: 1) individuals with higher incomes could afford to pay for the kinds of recreational experiences they desired rather than be associated with those of low income and the crowded recreational facilities of the inner city, and; 2) the desire for travel and a combination of lodging, meals, and recreation services that could be provided by recreation complexes that a public agency could never develop financially (Gunn, 1979). A wide variety of outdoor recreational needs can be satisfied on private lands, some of which are better adapted to certain outdoor recreational uses than public lands. In particular, they are often the most logical sites for the more elaborate facilities and services desired by many people. In this way, disturbance of high-quality recreational values perceived on nearby public lands may be minimized (Epperson, 1977).

Important factors which infuence use of private lands for outdoor recreation include: 1) the desire of landowners to earn a profit; 2) provision of facilities, services, and recreational opportunities adapted to needs of special groups; 3) philanthropic programs of protection, management, and use which, although in the public interest, typify various types of land not administered by public agencies, and; 4) provision of public recreational facilities and services for public relations purposes, or the improvement of the "image" of an industry (Brockman and Merriam, 1979).

Commercial resorts on private lands are the oldest and most familiar type of outdoor recreational operations (Brockman and Merriam, 1979). They range from simple developments to elaborate, extensive areas with a wide variety of overnight accomodations, food services, entertainment, and recreational facilities. While most commercial operations are owned and operated by individuals or families, many of the more extensive operations are controlled by companies or corporations (Jensen, 1977). They exist in all parts of the country, but are most common in regions which offer a variety of scenic or related interests (mountains, ocean or lake shore, areas of prime hunting or fishing, water-related activities, or winter sports) and have a favorable climate (Epperson, 1977). According to the Bureau of Outdoor Recreation, about three-fourths of the land included in resorts is managed especially for recreational purposes (Jensen, 1977). Water sports are by far the most popular activities at resorts, with swimming being the most popular single activity. Fishing, boating, golf, and water skiing follow in that order (Epperson, 1977).

SUBDIVISIONS AND RECREATIONAL LOTS

Prior to the 1960s, most recreational property occurred as individually scattered lots and second homes, but today's recreational land development is almost synonymous with large-scale subdivisions similar in design to most conventional suburban subdivisions, although typically with fewer improvements and facilities (Urban Land Institute, 1978). In spite of its "recreational" label, much of this property has been marketed to consumers interested in speculative investments rather than vacation or permanent homesites (Martin, 1971).

The best available data indicated that there were at least 10 million subdivided recreational lots in the United State in the late 1970s, and possibly many more (American Society of Planning Officials, 1976). Extent of recreational land development becomes much greater when viewed from a local rather than a national perspective. One large development in a few years could produce more growth than has occurred in the entire history of a rural county (Stroud, 1983). In many counties and even some states, there have already been enough recreational lots subdivided to accomodate more than double the existing population. For example, in 1971, Nevada County of California had enough recreational lots to house three times its existing population (Harrell, 1971).

Possession of a parcel of property, however small, in a pleasant and somewhat remote area has become a widely held middle class ambition. "It has become encouraged by an intensive and continuing advertising campaign by real estate promoters and speculators proclaiming the 'investment' potential of such remote land" (Parsons 1972, p. 1). However, though developers often stress the importance of a remote or rural setting in their promotional literature, Stroud (1983) found major concentrations of large subdivisions (1,000 acres or more) near or within Standard Metropolitan Statistical Areas (SMSAs). Fifty-six percent of large subdivisions were found to be less than fifty miles from a SMSA, with an additional thirty percent between 50 and 100 miles.

Recreational land development expanded steadily during the late 1960s and early 1970s. Speculation was also heaviest during this period until the economic recession in 1973, when much of the recreational development activity declined sharply. Land markets recovered somewhat in 1978 and 1979, but remain depressed because of the economic recession and high energy costs (Stroud, 1983). In 1971, the year which some observers consider to be near the peak of the recreational land boom, the American Land Development Association (ALDA) estimated that some 650,000 recreational lots were sold ("Leisure Boom..." April 17, 1972).

Today's recreational lots range in size from less than one-fourth acre to five acres or more. Typical lot sizes, such as those in Minnesota, are one acre or less (American Society of Planning Officials, 1976). Recreational subdivisions vary widely in total size from as few as twenty acres to more than 10,000 acres. Two-thirds of the projects reported in the ALDA survey were less than 1,000 acres in size, while twenty-seven percent were between 1,000 and 5,000 acres. One-fourth of the projects were less than 100 acres (American Land Development Association, 1973).

Recreational lot prices vary depending on their location, the level of physical improvements in the project, and the quality and type of recreational amenities available. Lake and seaside lots are in the greatest demand and command some of the highest prices. Lots with scenic views and those in highly developed resort communities also sell for a premium. The ALDA survey reported average selling prices for recreational lots in 1972 at $6,548, ranging from a low of $300 to a high of $125,000 (American Land Development Association, 1973). Shoreline property on Pelican Lake in Minnesota can sell for as much as $650 per square foot of lakefront (Luekenenon, 1984).

Site improvements such as water and sewer systems, and roads, vary from project to project depending on local land use regulations and the developer's own marketing objectives. While most recreational subdivisions are designed at typical suburban densities, the majority do not have suburban levels of imrovements (Urban Land Institute, 1978). Individual septic tanks are the predominant means of sewage disposal in recreational subdivisions. In a survey conducted in 1973 by the Office of Interstate Land Sales Registration (OILSR), over two-thirds of the subdivisions used septic tanks as the only means of sewage disposal, while less than ten percent had sewer systems. Another 8.5 percent reported plans to install sewer systems in the future. Central water systems were more common than sewer systems, yet private wells were the only source of water for recreational lots in almost one-third of the projects. In only one-third of the projects had a health authority issued a report on water quality from private wells at the time the project was filed with OILSR. No arrangements were made for solid waste collection in 37.5 percent of the projects filed with OILSR. In another one-third of the projects garbage collection was available through private companies. Municipalities or public authorities were designated as responsible for garbage collection in only 6.7 percent of the projects.

Most recreational lots are bought for use as a second or permanent homesite or for investment. Only a small percentage of recreational lots have been developed as homesites to date. In general, the build-out rate, the ratio of lots with homes on them to the total number of subdivided lots in a project, is very low. This low build-out rate provides some indication of the high degree of speculation in the recreational lot market (Platt, 1973; Parsons, 1972).

SECOND HOMES

Dwelling units used as second homes are much less plentiful than recreational lots. Approximately 3.5 million households owned second homes in 1973, or 5.1 percent of all households (American Society of Planning Officials, 1976). Second homes are more evenly distributed around the country than recreational lots, but many are still concentrated in a few subregions. There are approximately 1.55 million second homes in the United States, with thirty-eight percent located in the northeast, thirty percent in the northcentral, seventeen percent in the south, and fifteen percent in the west (Epperson, 1977). Ten states account for half of the second homes in the country.

Accessibility from the owner's primary residence and the natural amenities at second home sites are two major factors influencing second home locations. Second home owners in a 1970 Minnesota survey ranked accessibility as the most important factor in choosing their home locations, just ahead of natural site amenities (Borchert, 1970). The majority of second homes are located within one hundred miles of their owners' primary homes and the number decreases sharply at commuting distances above two hundred miles (American Society of Planning Officials, 1976). In terms of amenities, water appears to be the biggest natural attraction to second home owners (Tombaugh, 1970). Snyder and Adams (1967) note that in a Minnesota study, ninety-five percent of the owners had water frontage, while the rest had access to water by other means. Hart (1984, p. 241) found that approximately one-fourth of the population increase of townships in Minnesota, Wisconsin, and Michigan between 1970 and 1980 was concentrated in the north, "where water-oriented resort areas have been growing since well before World War II." The growth of lake developments in Missouri has forced the state to develop special publications on "guides to home-buying" near lakeshore developments (Johannsen and Barney, 1976).

The typical second home is used two or three months a year. Occupancy rates for second homes (the number of days they are occupied per year) vary according to season, depending on such factors as the distance between the owner's second and primary home, vacation and employment cycles, and seasonal recreational activities available at the second home site. Nationally, the median duration of occupancy in 1966 was fifty-three days, while in Minnesota the number was approximately fifty days per year (U.S. Bureau of the Census, 1970; Borchert, 1970). Seasonal occupancy rates vary according to such factors as recreational opportunities available at different times of the year, the times when families traditionally take their vacations, and the climate. Most second homes are used intensively during one particular season and remain vacant during the rest of the year. In the midwest, peak periods are reached in July and August, while the lowest use occurs in December and March (Thorsen et al., 1973).

Over time, some second homes are converted into permanent residences. Retirees moving into their second homes on a year-round basis account for many such conversions (Hart, 1975). In his study of changes in rural population, Zelinsky (1962, p. 519) notes "a third migrational trend, which has become conspicuous only in recent years and is again largely a movement into the rural-nonfarm category, appears in the growth of areas in which tourism, recreation, and the settlement of retired persons are major elements in the economy." In addition, as industries move into suburbs and commuting patterns extend further into the hinterlands, some people are finding it possible to convert their second homes to permanent use while remaining fully employed in their current jobs (American Society of Planning Officials, 1976). Converting second homes to permanent use has been going on for years. A 1959 report by the American Society of Planning Officials stated that "in metropolitan areas, some summer cottages are being converted to year-round residences; and areas platted for summer cottage development have become full-scale residential developments" (American Society of Planning Officials, 1959, p. 30).

Since 1974, resorts and second home developments are no longer the thriving business they once were, and face a cloudy future because of a number of factors including high prices, tight money, over-saturation and over-construction, and increased gasoline prices (Epperson, 1977). In Itasca County of Minnesota, the number of resorts declined from 267 in 1966, to 115 in 1983, and only one-fourth of those were profitable as of 1980 ("Number of Resorts..." October 31, 1983). Experts believe there is still a market for the smaller townhouses or condominiums at single-sport resorts close to urban areas (Epperson, 1977; Stroud, 1983). Condominiums can be sold on a multiple ownership basis with each owner paying a part and sharing the facility at different times. Such a concept has been undertaken at Breezy Point Resort on Pelican Lake in Minnesota, along with five similar projects around the state ("Time-Sharing..." February 26, 1984). The principle advantages for the developer in the time-share approach are the ability to spread building and operating costs among many buyers and to create a year-round business.

SECOND HOMES IN MINNESOTA

Minnesota is one of the leading states in number of second homes. In 1969, Minnesota ranked seventh nationally with 83,855 homes, and fourth in number of seasonal homes per capita (Snyder, 1969). Accessibility of lake areas to population centers, especially to the large Twin Cities Metropolitan Area, is the single most important factor in the the distribution of lakeshore homes in Minnesota (Table 1). With increasing distance from the Twin Cities, Fargo, Grand Forks, and Duluth, the number of homes per mile of shore decreases.

TABLE 1

MAJOR FACTOR CONSIDERED IN SELECTION OF LOCATION FOR A LAKESHORE SEASONAL HOME IN MINNESOTA.
(From Responses to Study Questionnaire)

% of Respondents	Reasons Offered
42	Accessibility - driving distance from permanent residence or work; local road conditions
19	Physical Site - scenery; water and shore characteristics
14	Familiarity - familiar with people, area
13	Isolation - distance from crowded and commercial areas
4	Other Nearby Recreation - other lakes; skiing, hunting, etc.
3	Climate - cleaner air; temperature
2	Service Availability - nearby shopping facility and good community
2	Price Investment - initial cost, resale value
1	Other - taxes, retirement

Source: Borchert, 1970, p. 35.

In terms of seasonal homes, the larger numbers tend to be in areas where the major high-quality lake resource is nearest the Twin Cities Metropolitan Area. Crow Wing County, which has the highest number of seasonal homes in the state, is the closest major lake-coniferous forest area to the seven metropolitan counties (Borchert, 1970). The location of permanent homes, however, is not as strongly related to the Twin Cities Area. Accessibility to a larger number of outlying urban centers, such as Alexandria and Brainerd, tends to have a greater impact on the location of these homes (Borchert, 1970).

Shoreline development outside the seven metropolitan counties is concentrated on a relatively few lakes. Minnesota has more than 11,500 lakes of more than ten acres outside the seven-county metropolitan area, but virtually all of the development is on only 1,600 lakes, or fourteen percent of the total. The ten most developed lakes in the state account for twelve percent of the state's lakeshore seasonal and permanent homes. Excluding the Twin Cities Metropolitan Area, Crow Wing County ranked second among counties in both number of seasonal homes (4,720), and in number of permanent lakeshore homes (1,820) in 1970. By 1980, it ranked third in number of second homes with 8,136 (Borchert, 1970; U.S. Bureau of Census, 1980).

Minnesota residents own eighty percent of the seasonal lake homes in the state; out-of-state owners are primarily residents of surrounding states with more limited recreational opportunities than Minnesota. Five percent of Minnesota residents own a permanent or seasonal lake home (excluding such homes in the Twin Cities Metropolitan Area and in other Minnesota municipalities located on lakes). This is approximately the same as that of the national average (Borchert, 1970).

PELICAN LAKE

Pelican Lake is considered to be among the most developed lakes in Minnesota. In 1970, the lake ranked fifth in number of seasonal homes and tenth in number of seasonal and permanent homes combined. In addition, as many as eight resorts and two campgrounds have been developed on the shores of Pelican Lake (Borchert, 1970; Minnesota DNR, 1983).

Two major reasons for Pelican Lake being a popular lake are its location and its recreational amenities. It has a centralized location, can draw from the Twin Cities area, Duluth, Fargo, and Grand Forks, and also also enjoys a good reputation with residents from the surrounding states which lack desirable lake environments. The physical shore type of Pelican Lake is sand-coniferous, one of the most desirable lakeshore types for development in Minnesota. Borchert (1970) defines a sand-coniferous area as having sandy soil and coniferous shore vegetation. In addition, the lake is well-suited for swimming, recreational boating, and fishing.

Breezy Point is by far the largest of the resorts on Pelican Lake and, in fact, is one of the largest and oldest resorts in Minnesota. Originating in 1922, Breezy Point has grown steadily through the years, reaching the status of village in 1939, and incorporated city in 1971. Encompassing sixteen-and-one-half square miles (10,560 acres) on the northwest side of Pelican Lake, it included a year-round population of 383 persons in 1980. Facilities include two golf courses, tennis courts, horseback riding, dining and entertainment, shopping center, airport, and marina, in addition to 8,470 acres of water.

CLASSIFICATION SYSTEMS

Difficulties often arise when attempting to consistently classify various kinds of land. Land surfaces can be measured accurately in units of area and can also be classified quite readily in broad terms by geological or soil features, or by climatological and related ecological-vegetative groupings. Land use, however, introduces a number of classification problems because particular purposes and viewpoints must be considered. These vary widely by location, ownership, kind of use, and specific land characteristics (Davis, 1976).

Effective application of land management requires the collection and organization of much information regarding characteristics and use capabilities of the land. Outdoor recreation planners and developers utilize much of the data obtained through classifications based on the land only, without regard to land uses. These classifications are applied in much the same general way as for agriculture, engineering, and forestry. Soils and surficial geology are often extremely critical in regards to drainage and capacity to sustain different kinds of uses. Similarily, topography, weather, and climate are critical in site selection and in defining use possibilities. Ecological-vegetative data are likewise necessary in appraising land carrying capacity and the aesthetic qualities of the site (Marsh, 1978).

Orning (1976) combined resource variables in an attempt to define and locate scenically attractive areas in a region. Relief, water orientation, and forest cover were combined to create a fourth variable which was then used to generate maps, frequency counts, and other data relationships. These, in turn, were used to produce resource summaries which would systematically solve planning objectives. Another of his studies includes land suitability for outdoor recreation, whereby basic parameters such as scenic attractiveness, accessibility, and present urban development of lakeshore and rivershore were used to define outdoor recreation sites. The study was conducted on the Arrowhead Region of Minnesota and produced these results: 1) the largest class was determined to be forest-rough land; 2) about one-quarter of the potential outdoor recreation sites were on lakeshore, and; 3) one-third of the potential outdoor recreation sites had river frontage.

Borchert's lake home study (1970) developed Minnesota's first system for the physical classification of lakes within the state. This system, developed as a basic framework for describing the state's lake resources and human's development and use of them, uses three principal classification criteria: 1) the dominant types of lakeshore soils and vegetation; 2) water ecology, and; 3) the size-shape relationship of lake basins. Seven basic physical types of Minnesota lakeshores were classified by combining three shore vegetation classes (absence of trees, deciduous trees, coniferous trees) with four shore soil types (wet-swampy, clay, sandy, and rock-bedrock-boulders). Ecological classes were characterized by different fish types, chemistry of lake water, shape and depth of lake basins, and characteristics of the surrounding shore and vegetation. The level and type of water chemical constituents is related to lake fertility and to fish production (more fertile waters have more aquatic growth and denser fish populations). Lake fertility increases from northeast to southwest in Minnesota. The third criteria, size-shape relationship of lake basins, was used to determine crowding potential for individual lakes. Lakes that include many points, bays, and islands have a higher ratio of shoreline-to-water area than large, round lakes with regular shorelines. Consequently, if shorelines are developed to the same density on all lakes, the competition for water space on small and irregular lakes will be far greater than on large, round lakes. Four potential crowding classes based on water acres per mile of shore were developed for Minnesota lakes. The classes include: 1) less than 60 acres per mile, high crowding potential; 2) 60-109 acres, medium crowding potential; 3) 110-224 acres, low potential, and; 4) 225 acres or more, negligible crowding potential.

A similar study was prepared by planning agencies in Michigan which included several detailed processes for the selection of the most appropriate sites for various recreational uses. Part of this study was concerned with ranking all of the lakes in Michigan in terms of their attraction for boating on the basis of size, depth, water quality, surrounding landscape quality, and other characteristics (Fabos, 1979). Advisory agencies in the United States have also developed processes for the site selection of recreational uses. The New Hampshire Cooperative Extension Service, for example, has developed a process in which water, topography, soil, vegetation, and visual quality are among the factors evaluated. Similarily, the United States Soil Conservation Service has developed a systematic approach for assessing twelve standard categories of outdoor recreation areas, an approach which can be used either by state and local planning agencies, or by private recreation developers (Fabos, 1971).

DATA SOURCE AND METHODOLOGY

Data collected and utilized in this study are classified into two categories -- those describing recreational development around Pelican Lake and those describing other land use/cover characteristics.

RECREATIONAL DEVELOPMENT

An investigation of tax lists in the Crow Wing County Auditor's office provided the necessary information regarding the number of homes on Pelican Lake over the past 54 years. Total number of homes were calculated at ten-year intervals beginning in 1930 and ending in 1980, with an additional total for the year 1984 (Appendix A). The County Assessor's office was able to supply additional information regarding development for the period 1970-84. Only those structures located on property bordering Pelican Lake were used in the study. As the result of a new phenomenon, the condominium, appearing on Pelican Lake in the 1960s, it was concluded that a new category that would include both homes and condominium units was necessary. Hence, the category "dwellings" (number of homes + number of condominium units) was established and is included in the data for the years 1970, 1980, and 1984.

LAND USE/COVER DATA

A land classification of the study area was deemed necessary to fully explain changes and conditions in land use/cover which affected building patterns on the shores of Pelican Lake. Black and white aerial photographs of the study area were analyzed from four dates: September 20, 1939; July 22, 1960; August 16, 1969, and; August 4, 1978. All photographs are approximately the same scale (1:16,000), except for the 1939 coverage which is about 1:21,000. The Minnesota Department of Natural Resources Area offices in Brainerd and Pequot Lakes provided the photographs for use in this study (Appendix B).

STUDY AREA

The study area includes parts of 36 sections in Crow Wing County of north central Minnesota and encompasses approximately 19,050 acres (Figure 4). Twenty-five sections lie in Pelican Township, five lie in Mission Township, and the other six are part of Lake Edward Township.

Boundaries for the study area were determined by both political and physical means, along with Pelican Lake's position within the Thirty Lakes Watershed District and the Mississippi Headwaters Watershed. The Thirty Lakes Watershed District was established by the Department of Natural Resources and the Water Resources Board in 1972 in an effort to regulate and restrict the density of population and con-

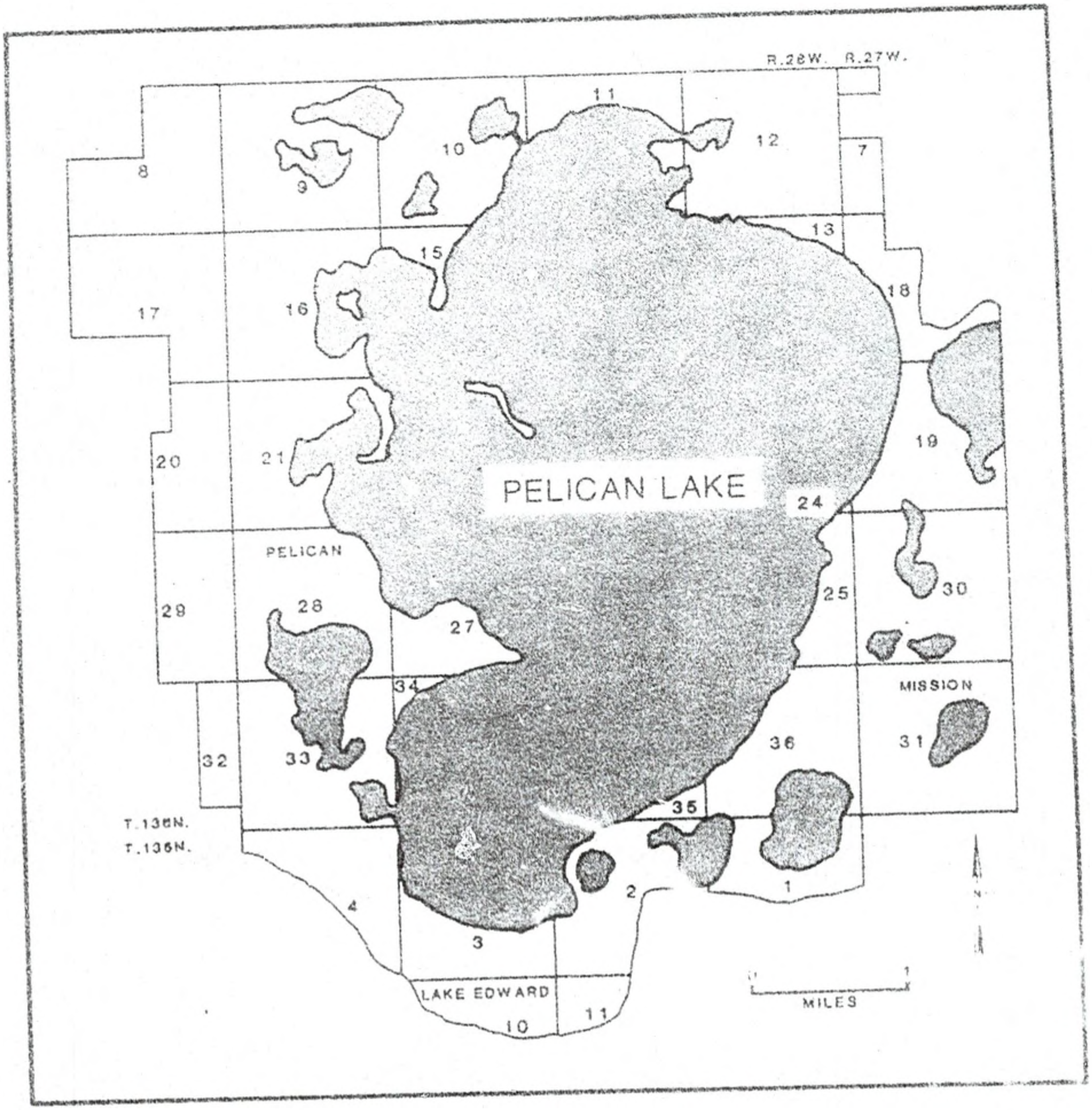


Figure 4: Townships and Sections within the Pelican Lake Watershed.

trol of pollution of waters within the District. Pelican Lake lies at the northern end of the District and, as a result, the study area boundaries on the west, north, and east portions of the lake coincide very closely with those of the District (Thirty Lakes Watershed District, 1972).

The southern boundary of the study area is the boundary of the Mississippi Headwaters Watershed of North Central Minnesota as established by the state of Minnesota. This watershed is a 7,068 square mile area in north central Minnesota including all land drained by the Mississippi River above the Crow Wing River. Lying along the southernmost boundary of this watershed, water within the study area drains toward Pelican Lake, and finally east toward the Mississippi River (Oakes and Bidwell, 1968).

ANALYSIS OF THE PHOTOS

Photographs were initially arranged and identified according to their location within the study area. Each photograph was individually interpreted using a land use/cover classification system developed by Anderson et al. (1976) (Table 2), concentrating on the center two-thirds of the photographs to limit radial displacement error. The photographs were then used to develop four maps depicting the entire study area for the years 1939, 1960, 1969, and 1978. These years were chosen because of the availability of photos.

TABLE 2

ANDERSON LAND USE/COVER CLASSIFICATION

Level I	Level II
1. Urban or Built-Up Land	11. Residential
	12. Commercial and Services
	13. Industrial
	14. Transportation, Communications, and Utilities
	15. Industrial and Commercial Complexes
	16. Mixed Urban or Built-Up Land
	17. Other Urban or Built-Up Land
2. Agricultural Land	21. Cropland and Pasture
	22. Orchards, Groves, Vineyards, Nurseries, and Ornamental Horticulture
	23. Confined Feeding Operations
	24. Other Agricultural Land
4. Forest Land	41. Deciduous Forest Land
	42. Evergreen Forest Land
	43. Mixed Forest Land
5. Water	51. Streams and Canals
	52. Lakes
	53. Reservoirs
	54. Bays and Estuaries
6. Wetland	61. Forested Wetland
	62. Nonforested Wetland
7. Barren Land	71. Dry Salt Flats
	72. Beaches
	73. Sandy Areas other than Beaches
	74. Bare Exposed Rock
	75. Strip Mines, Quarries, and Gravel Pits
	76. Transitional Areas
	77. Mixed Barren Land

Source: Anderson et al., 1976, p. 8.

A Talos Systems, Inc. series 600 CYBERGRAPH Digitizing System was used to determine acres of land found within each classification for each of the four years (Appendix C).

TIME SERIES ANALYSIS

Time Series Analysis was utilized on selected data in order to ascertain possible changes in these variables which may have occurred in the past forty-five years. Selected data include those land use/cover values determined from the photographs.

CORRELATION-REGRESSION MODELS

The primary focus of this study is to examine what physical characteristics of an environment play a role in determining the location of recreational homes in the Pelican Lake area. In order to explain the location of preferred building sites on Pelican Lake and better predict future building patterns, a stepwise multivariate regression model was constructed within the structure of the Statistical Analysis Systems (SAS) computer package (SAS Institute Inc., 1982). Prior to developing the regression model, a correlation routine was utilized in order to delineate the degree of association between variables. Correlation analysis was essential since regression analysis is of limited value unless the variables to be analyzed through regression are significantly correlated. In addition, because the stepwise procedure "screens out" those variables not contributing significantly to the model, it was critical to note which variables initially correlated highly with one another in the event that certain variables were not chosen by the stepwise procedure (Hammond and McCullagh, 1978). Finally, the SAS program was used to compare R-square values (coefficients of determination) in order to explain the contribution of those variables not selected by the stepwise procedure.

DATA SELECTION AND AQUISITION

In the analysis of distribution of recreational homes, land use/cover data within the Pelican Lake watershed for the year 1939 was selected as base year. This year was chosen because of the minimal appearance of recreational homes prior to this time on Pelican Lake, and because much of the land area had not yet been developed or altered. Values of land use/cover types pertaining to the number of acres of each land class within the thirty-six sections were obtained from photographic analysis of the watershed. Twenty sections border Pelican Lake and can be used in analysis with corresponding data concerning homes and condominium units. However, three of these sections consist of less than 640 acres due to study area boundaries of the watershed, and were therefore dropped from the analysis. Values for the remaining seventeen sections obtained from photographic interpretation were used as variables in the analysis, and include:

1) acres in agriculture

2) acres in forest

3) acres in wetland

4) acres in urban

5) acres in Pelican Lake

6) acres in water other than Pelican Lake

Classification of land within the study area as urban needs some clarification. Although Breezy Point's city limits encompass sixteen-and-one-half square miles of land bordering Pelican Lake (most of which does not appear in the study area), very little of it can be considered urban or built-up. A significant portion of what would meet Anderson's (1976) land use/cover classification of urban or built-up area (Table 2), however, can be found in two sections of Breezy Point in the northwest portion of the watershed. These two sections include what is considered to be the resort area, and include a shopping center, dining and entertainment facilities, hotel and other lodging, condominiums, convention center, airport, golf courses, and a sewage treatment facility. While the majority of these facilities did not exist in 1939, a significant number of homes and buildings were in existance. As a result portions of these two sections were classified as urban. No where else in the watershed do conditions meet those to be classified as urban.

Additional information for use in the model was obtained from a United States Geological Survey map, a bathymetric map published by the Minnesota DNR, and the four map sequence developed for this study. They include:

7) relief within each section, measured from highest point to lowest point

8) length of shoreline of Pelican Lake in each section

9) closest distance from shoreline to the nearest medium-duty road (an improved road, as determined on the 1959 USGS map)

10) maximum depth of Pelican Lake within each section (Table 3)

Two analyses were conducted: one using the number of homes in 1984 within each of the seventeen authorized sections, and the other using the number of dwellings (homes + condominium units) in 1984 within each section. These two forms of data were selected in an attempt to gain a clear understanding of which variables contribute significantly to the model. The occurrence of urban area and condominium units in only two sections tends to dramatically influence other variables, thus the reason for using a homes-only model.

TABLE 3

PHYSICAL CHARACTERISTICS UTILIZED IN STATISTICAL ANALYSIS

Section	Max. Relief (ft.)	Max. Depth Pelican Lake (ft.)	Distance To Road (mi.)	Length Of Shoreline (mi.)
		Pelican Township		
10	38	12	.45	.90
11	34	35	.19	1.68
12	44	8	.35	1.62
13	14	35	.50	.80
15	34	60	.75	1.33
16	94	22	.28	1.76
21	69	28	.05	3.08
24	6	35	.50	.22
25	21	50	.63	1.65
27	24	50	.19	1.60
28	64	25	.04	.79
33	64	25	.05	1.79
34	14	100	.15	.38
35	14	80	.75	.54
36	14	90	.65	1.02
		Mission Township		
18	24	35	.10	.93
19	16	40	.10	.98
		Lake Edward Township		
2	16	50	.09	1.29
3	18	80	.10	1.33
4	123	10	.16	.24

RESULTS AND DISCUSSION

LAND USE/COVER

In order to include maps depicting land use for the years 1939, 1960, 1969, and 1978, it was necessary to divide each map into six portions, each portion portraying approximately one-sixth of the study area. Figure 5 should be used as a guide to illustrate the method of division.

1939 Map

The most obvious aspect of the 1939 map (Figures 6-11) depicting land use within the Pelican Lake watershed is the relatively small size of Pelican Lake when compared with the maps of subsequent years. In order to fully understand the various sizes of Pelican Lake, it is first necessary to review a portion of its history. Prior to 1938, Pelican Lake depended entirely upon groundwater and runoff to replenish water lost through evaporation. Because of a number of dry years during the 1930s, water level fell steadily, reaching a low of 1,203.5 feet above mean sea level in 1933. The Minnesota Department of Natural Resources, then known as the State Conservation Department, was called upon to construct a diversion ditch from Pelican Lake to Ossawinnamakee Lake, which lies one mile to the north. Ossawinnamakee Lake has

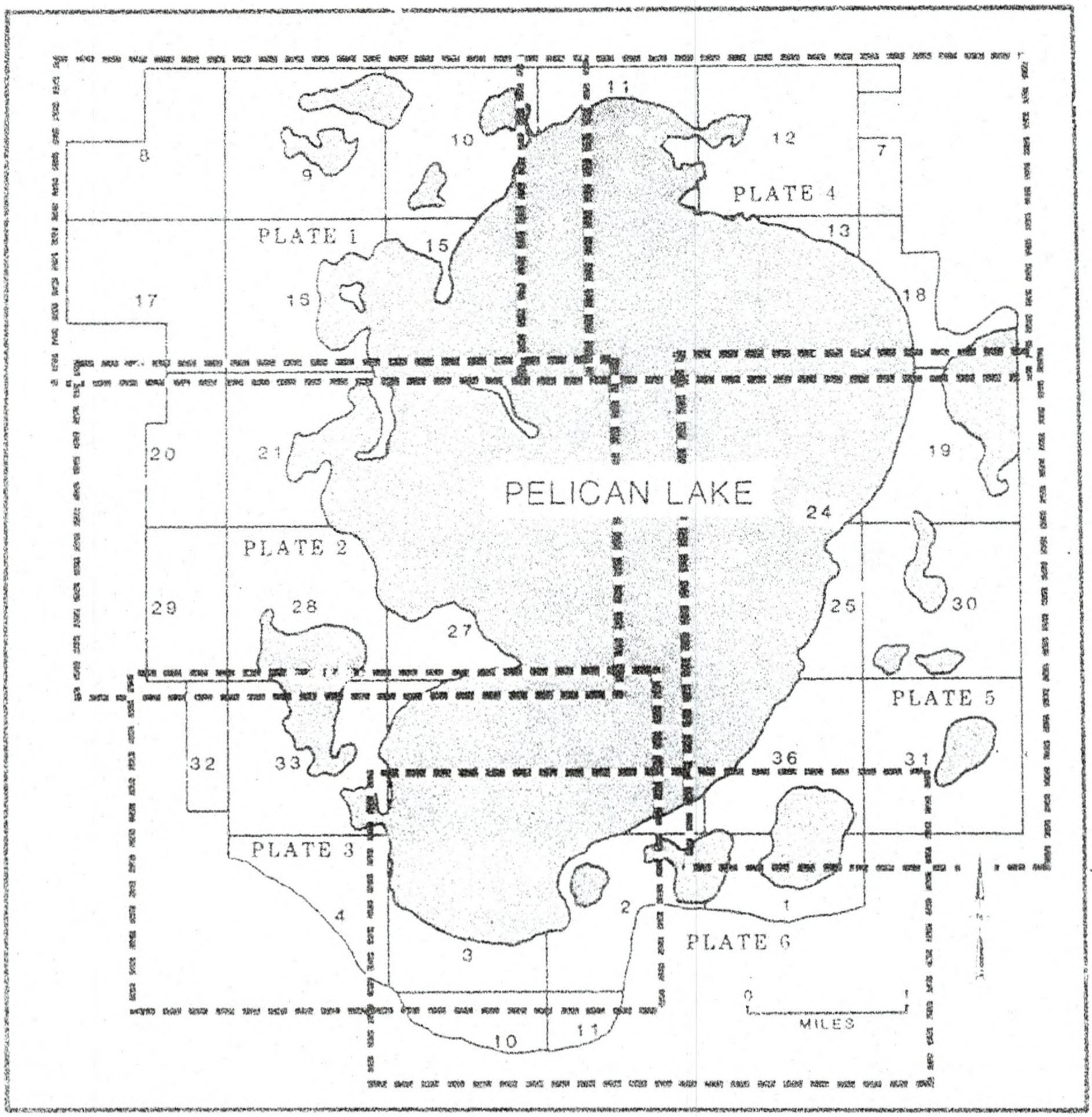


Figure 5: Method in which Study Area was divided for Illustration.

numerous outlets, one of which leads to the Mississippi River to the east. With an average width of three feet, an average depth of four feet, and a six-bay cement dam in place, the diversion ditch allowed water to flow into Pelican Lake beginning in 1939, soon restoring the lake to its normal level of 1,206-1,207 feet above sea level. The Normal Ordinary High Water Level for Pelican Lake was later determined to be, and remains today, 1,207.4 feet (Minnesota DNR, 1943; Minnesota DNR, 1983). (A 1979 Minnesota law defines the Normal Ordinary High Water Level as the point where the vegetation changes from predominantly aquatic to predominantly terrestrial) ("Politics of Water..." September 10, 1984).

Figure 6 indicates that the diversion ditch is obviously in place but apparently had not been in use long enough to raise the lake levels to their present elevation. Because of the low water level, a number of conditions result, including:

1) a number of small lakes exist (Figures 7, 8, and 9) which became a part of Pelican Lake in later years.

2) a large expanse of beach (classified as barren) encompassed the lake, much more than in later years.

3) Pelican Lake's two islands (Figures 6 and 7) were noticeably larger in 1939 than in following years.

The watershed was dominated by forest cover with relatively few acres in agriculture, although agriculture's percentage of total land area was the highest of the four years studied. Most of the agricultural acres were found in the northwest corner of the watershed (Figure 6). Breezy Point, located on the western shore of the lake (Figures 6 and 7), is the only area classified as urban. A number of small lakes and wetland areas surrounded Pelican Lake, particular-ily on the southeastern portion (Figures 10 and 11), which is an area of minimal relief and low elevation. Most of the areas classified as barren are beaches along the shores of Pelican Lake, while the rest are primar'ly transitional areas found farther from the lake. Transitional areas within this watershed are primarily those which are former agricultural areas that have since been abandoned or left as fallow. Also included are areas which had been wetland, but have since become filled with emergent vegetation, primarily around their perimeters.

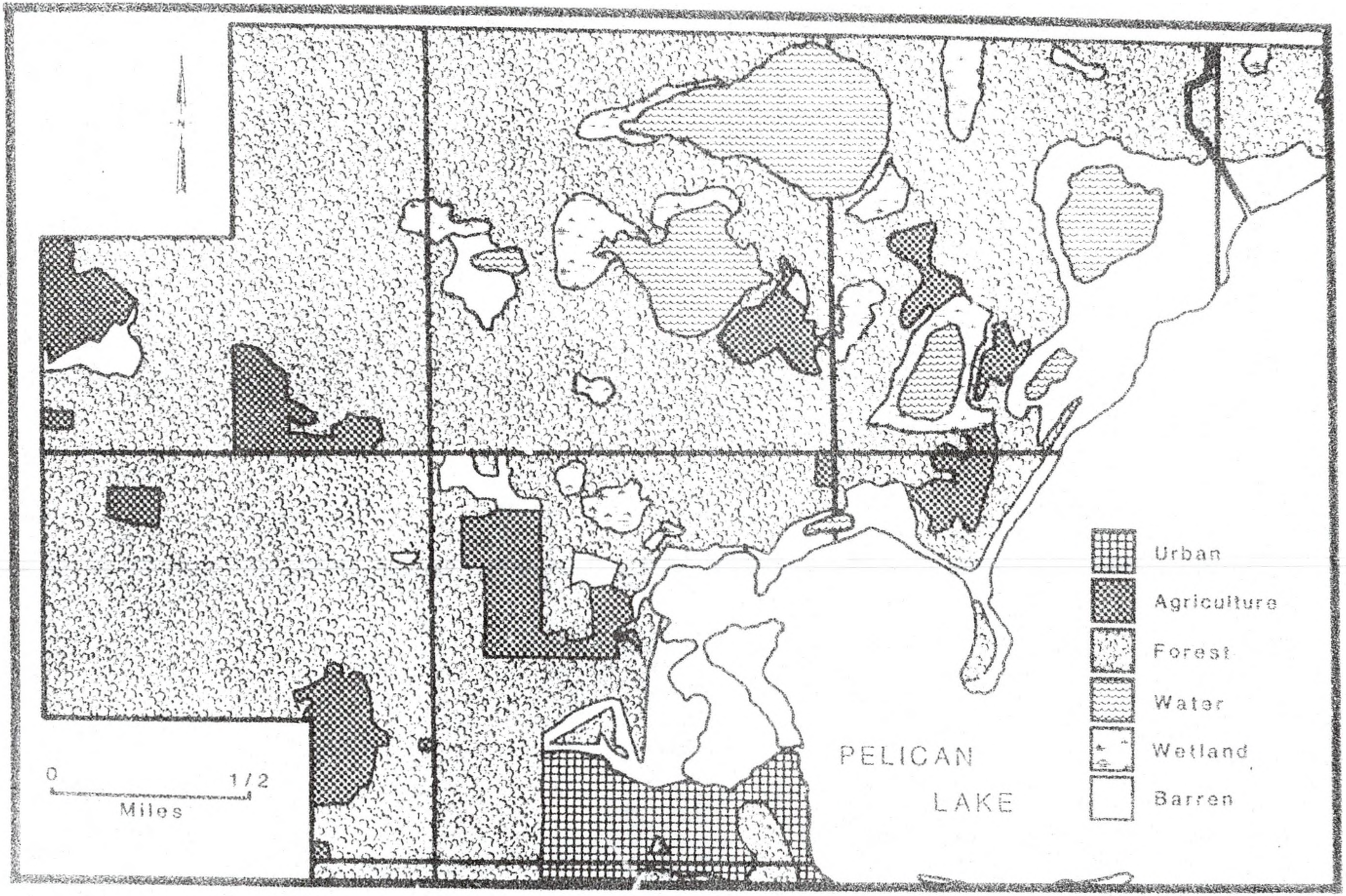


Figure 6: Plate 1 of 1939 Land Use/Cover Map.

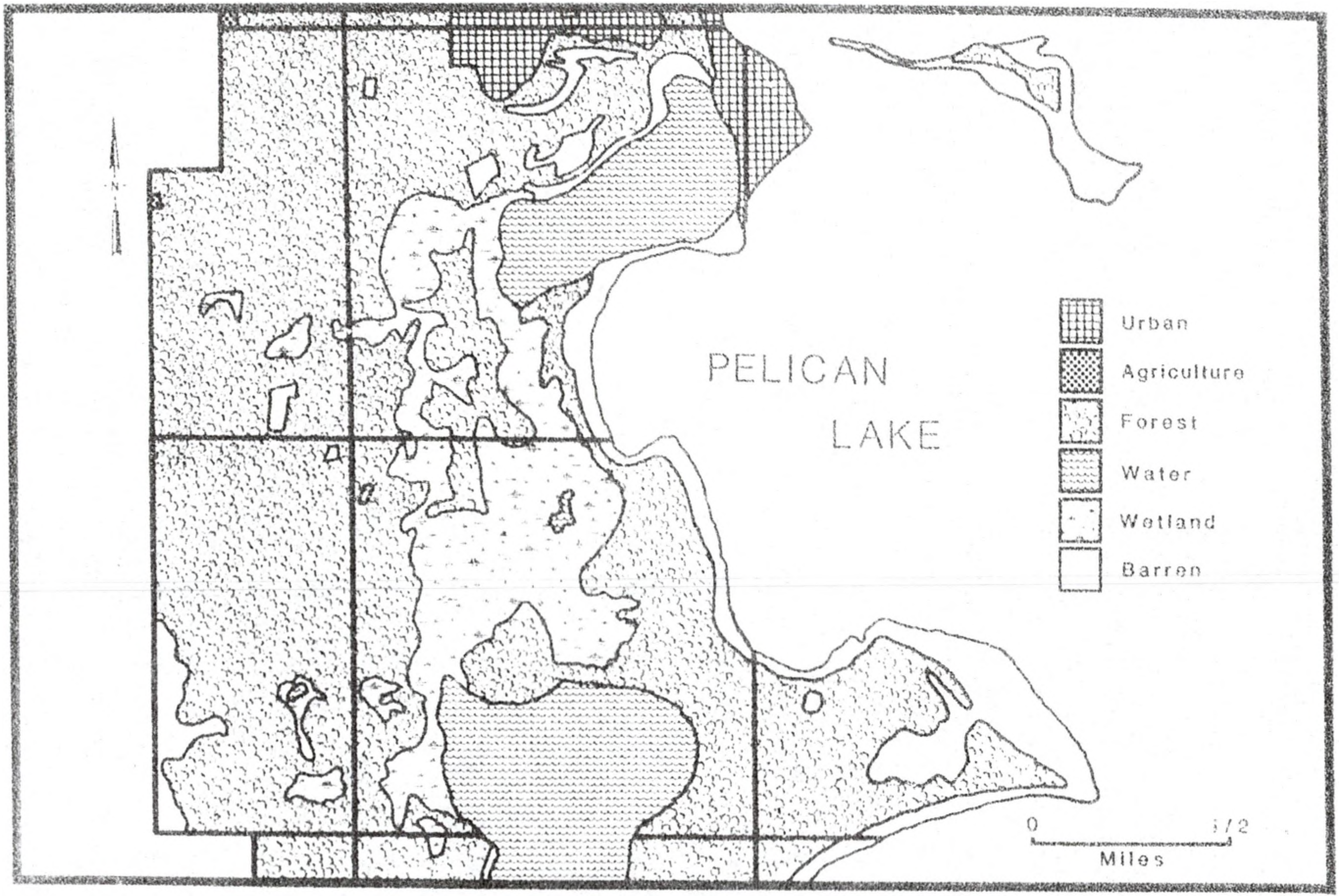


Figure 7: Plate 2 of 1939 Land Use/Cover Map.

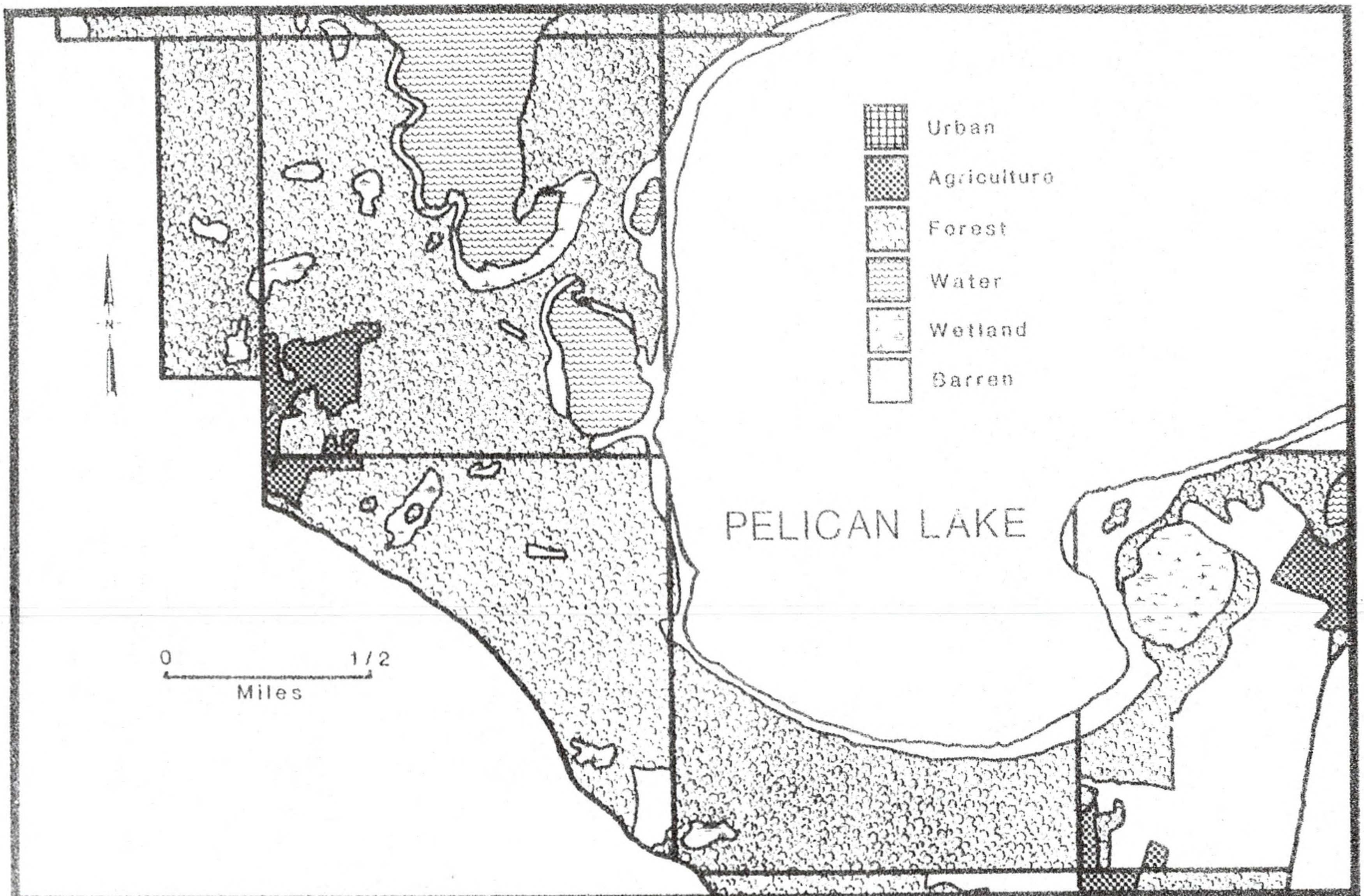


Figure 8: Plate 3 of 1939 Land Use/Cover Map.

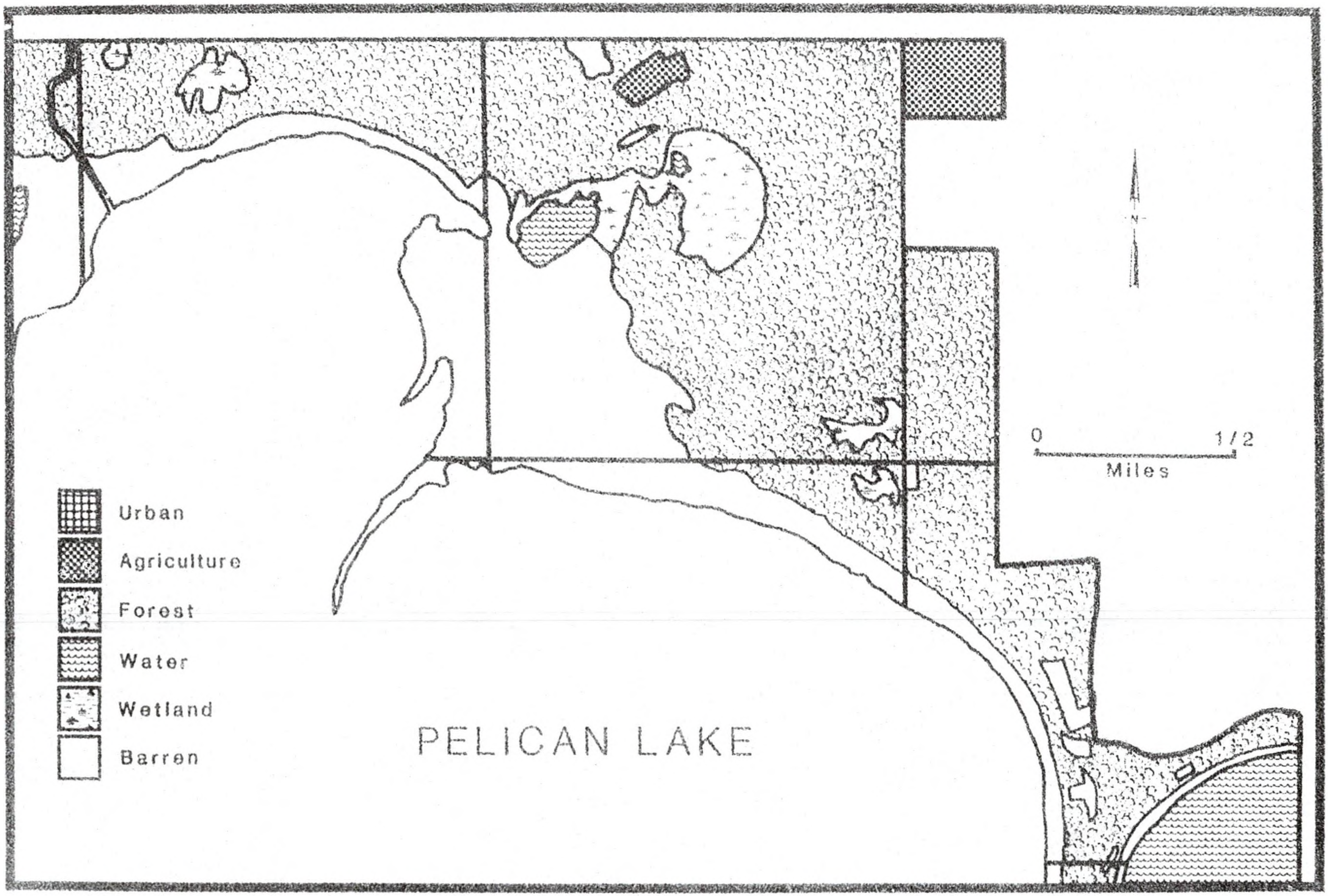


Figure 9: Plate 4 of 1939 Land Use/Cover Map.

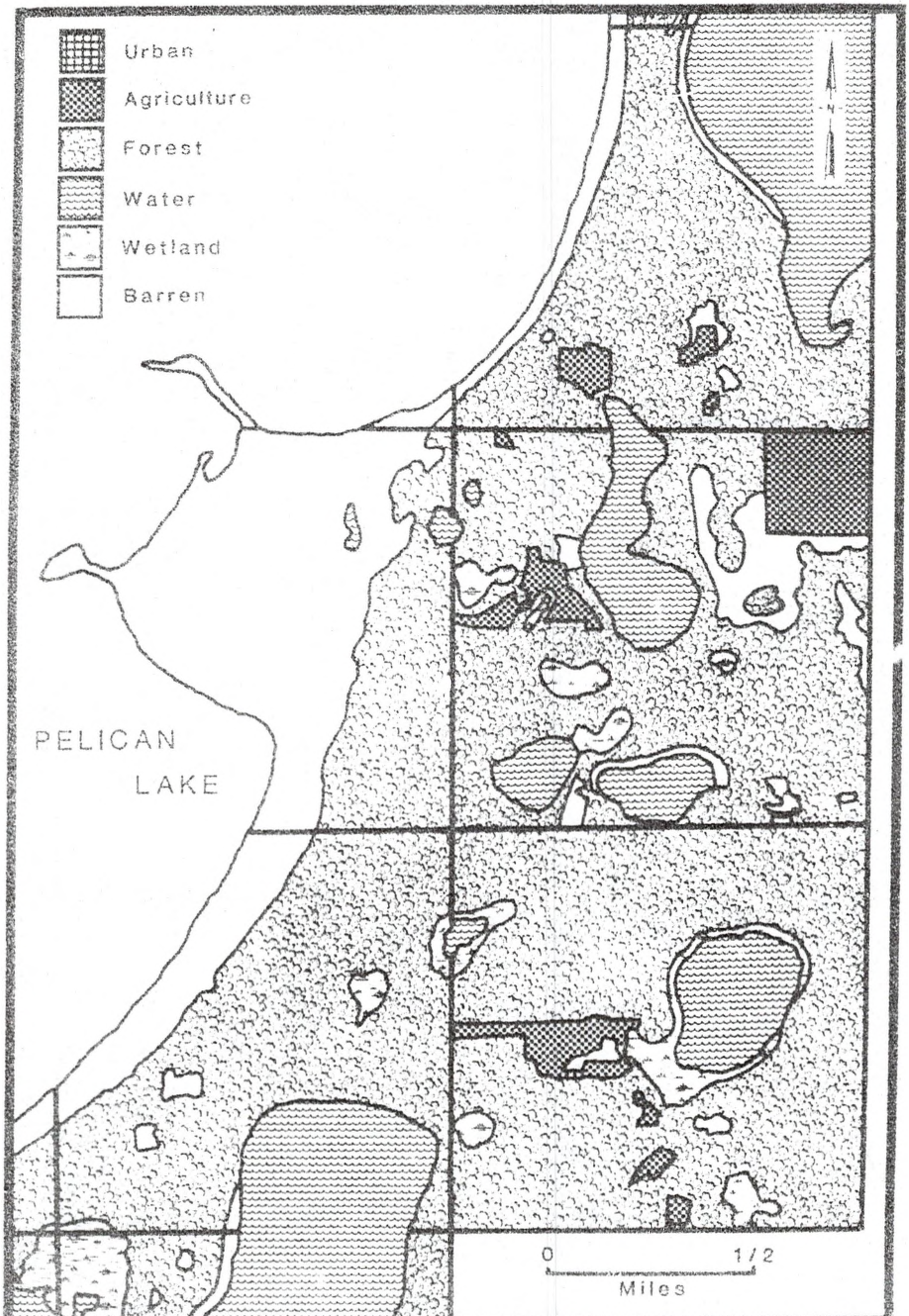


Figure 10: Plate 5 of 1939 Land Use/Cover Map.

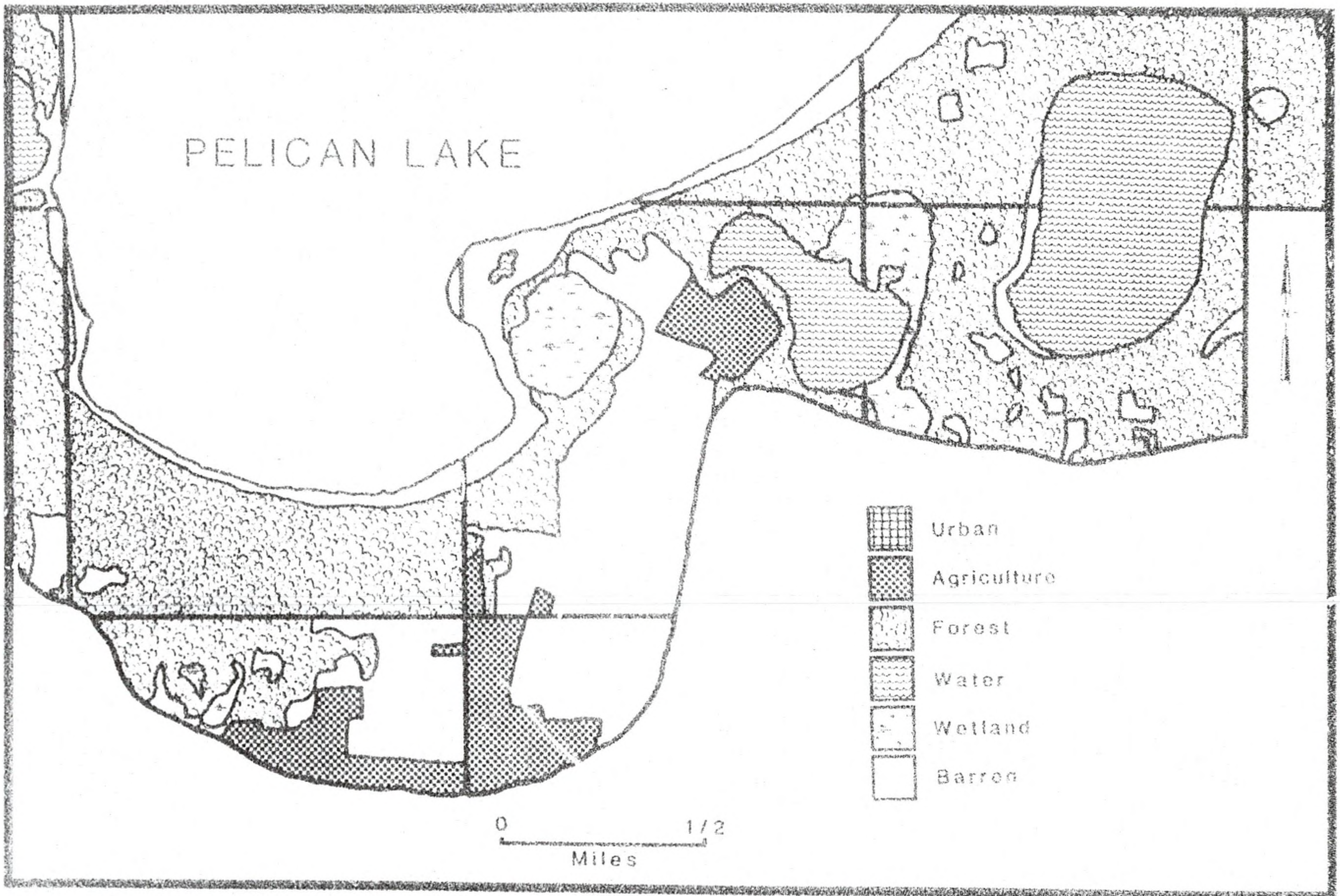


Figure 11: Plate 6 of 1939 Land Use/Cover Map.

1960 Map

Pelican Lake's shape in 1960 (Figures 12-17) is considerably different from that of 1939, but very similar to the present shape of the lake. As a result of the increased water level of Pelican Lake:

1) a number of new bays were created (Figures 13, 14, and 15).

2) the acres of beach encompassing the lake greatly diminished.

3) two areas adjoining Pelican Lake became wetland (Figure 15 and 16).

4) the size of the two islands diminished (Figures 12 and 13).

5) a few former wetlands became lakes (Figure 17).

6) the size of a few peripheral lakes and wetlands were increased (Figures 12, 15, 16, and 17).

Additional determinations of the watershed include:

1) forest cover continued to dominate the watershed, and acres of forest had increased substantially since 1939, replacing acres which had been agriculture or barren in 1939 (Figures 12, 13, and 17).

2) acres in agricultural land had substantially decreased since 1939, particularily in the northwest corner of the watershed where it previously had been more prevalent (Figure 12). Forested acreage primarily covers areas once cleared for agriculture but, apparently, later found submar-

ginal for such use. As a result, the southern end of the watershed became the principal area of agricultural acreage, along with the northwest.

3) Breezy Point (Figures 12 and 13) remained basically the same size it had been in 1939, and continued to be the only area within the watershed classified as urban.

4) acres of barren land, besides those found along the shore of Pelican Lake, diminished between 1939 and 1960 (Figures 13, 16, and 17).

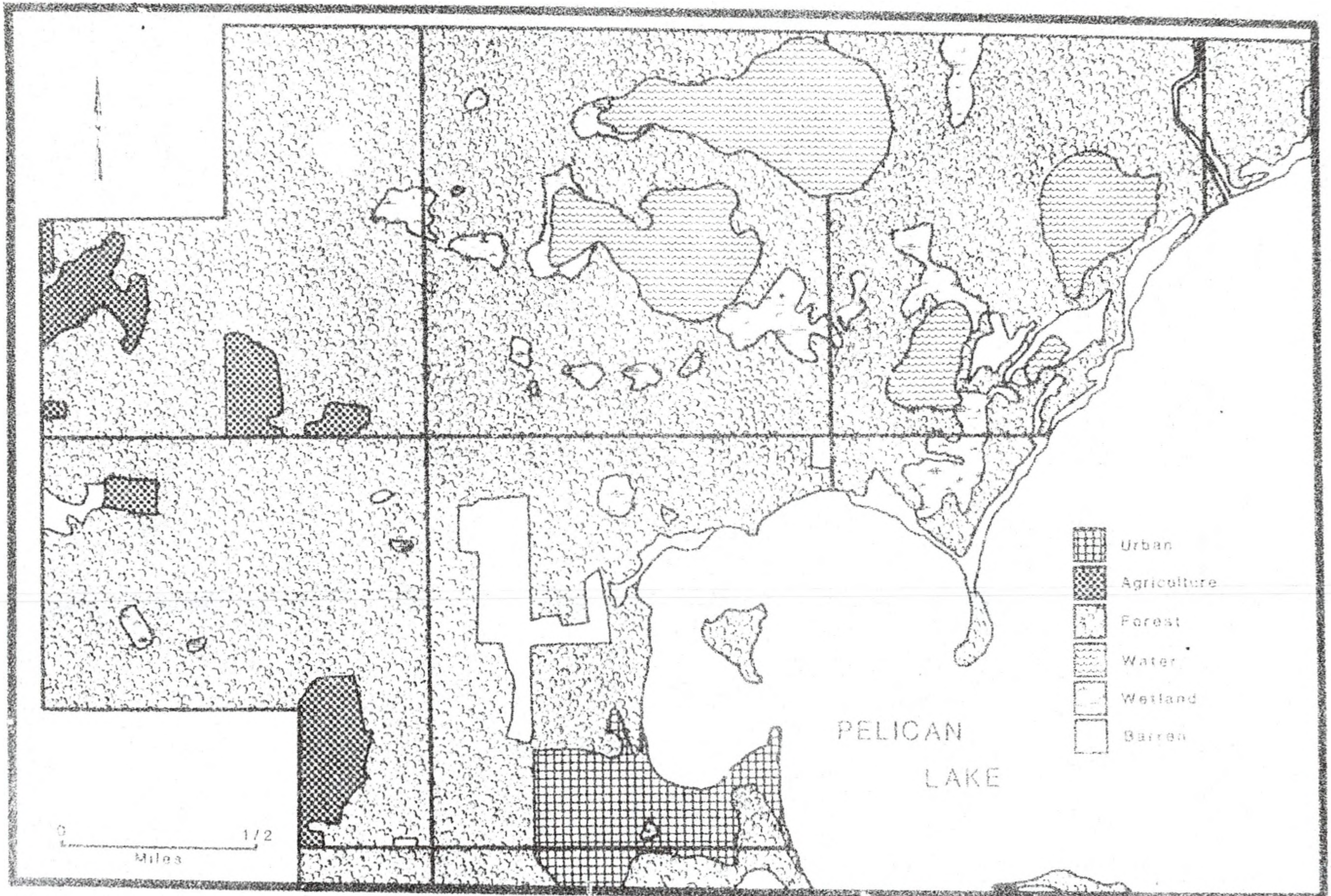


Figure 12: Plate 1 of 1960 Land Use/Cover Map.

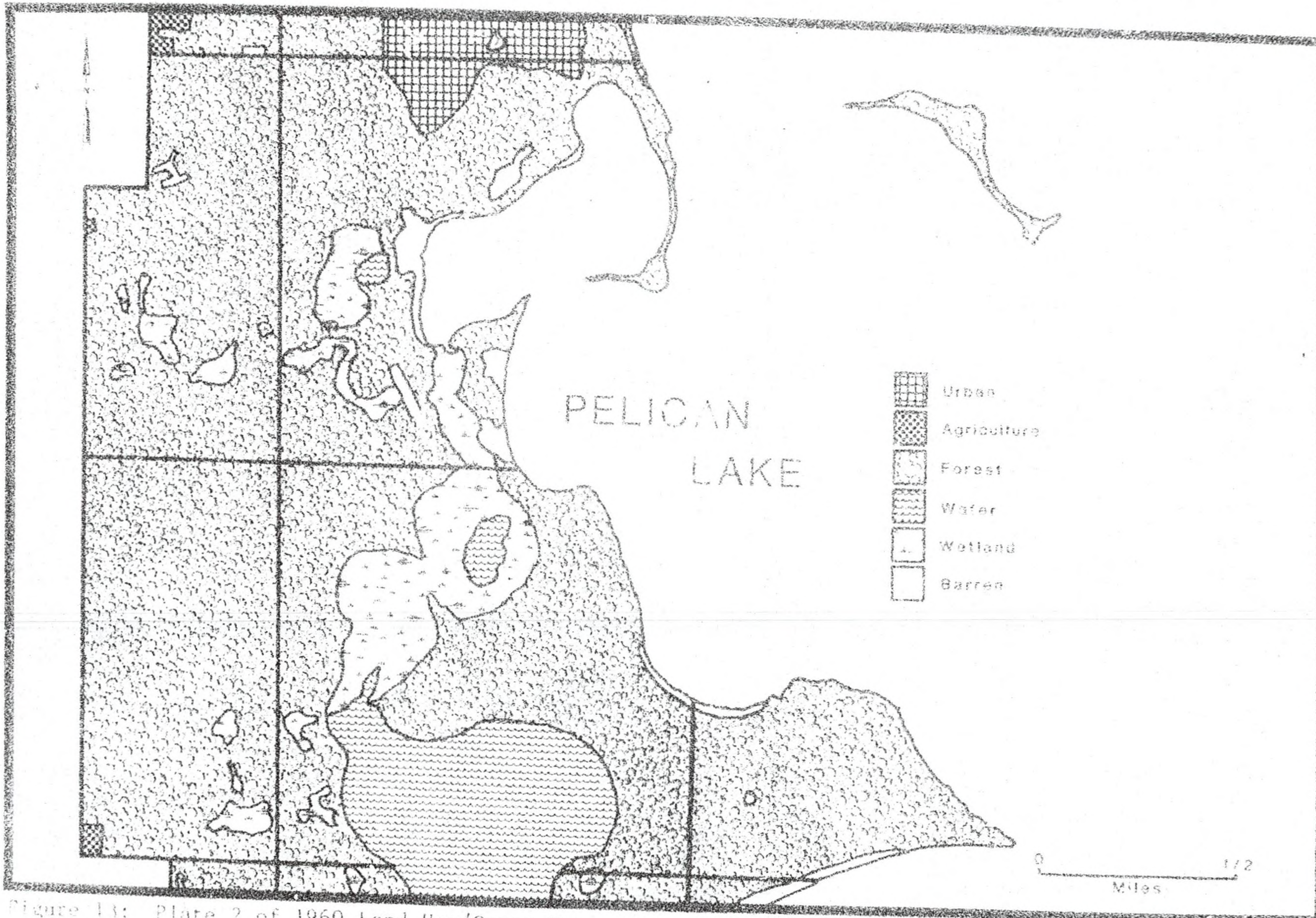
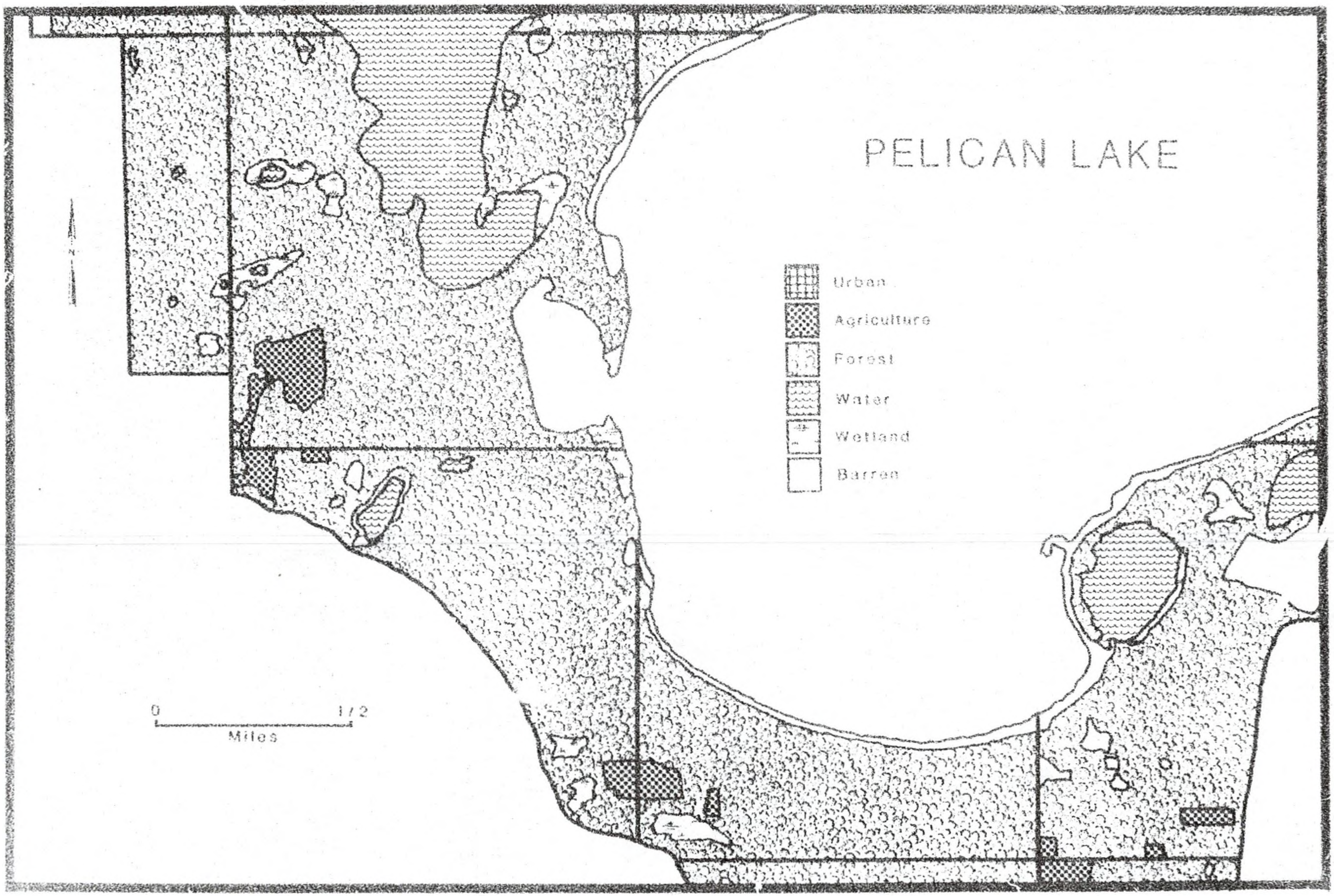


Figure 13: Plate 2 of 1960 Land Use/Cover Map.



ure 14: Plate 3 of 1960 Land Use/Cover Map.

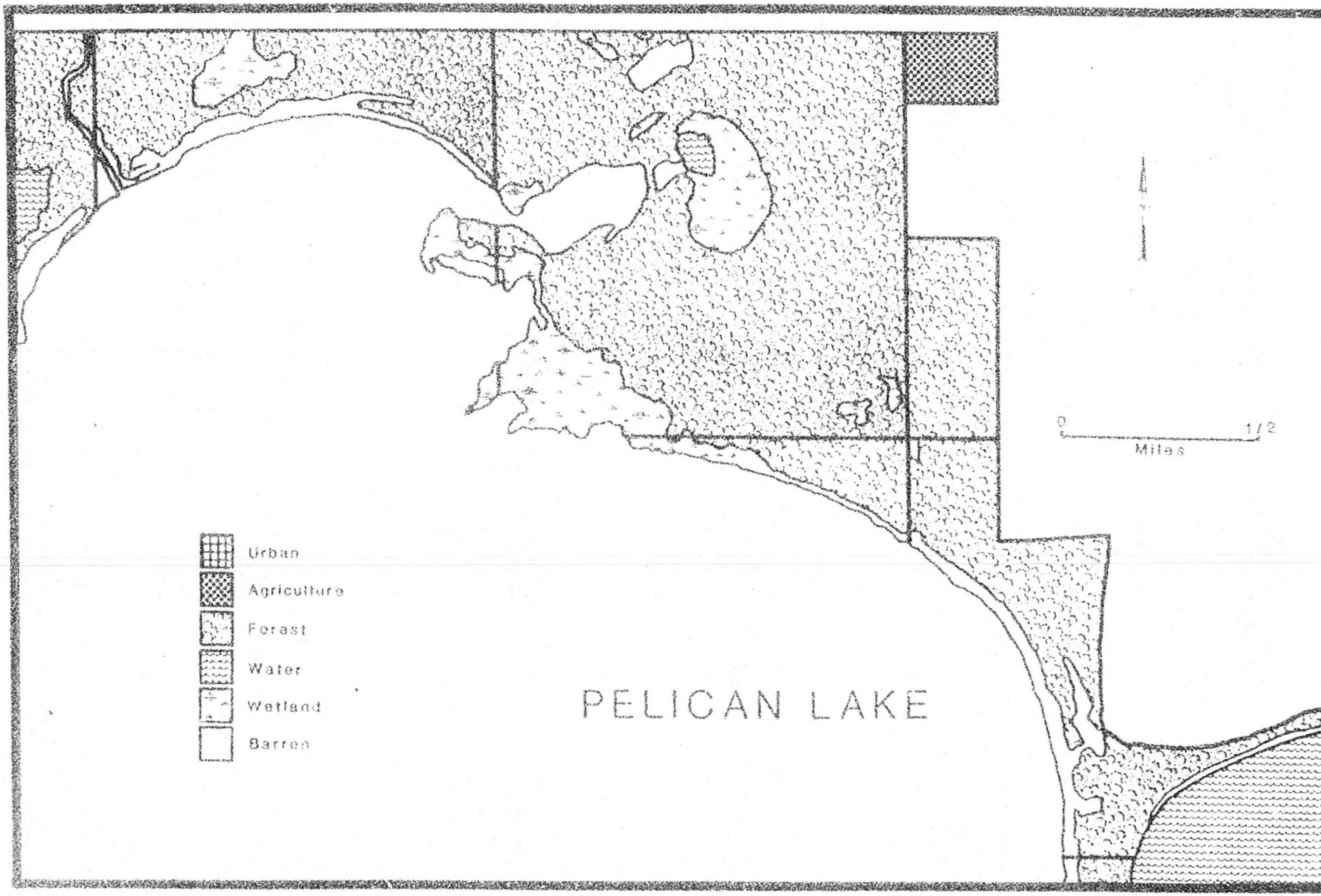


Figure 15: Plate 4 of 1960 Land Use/Cover Map.

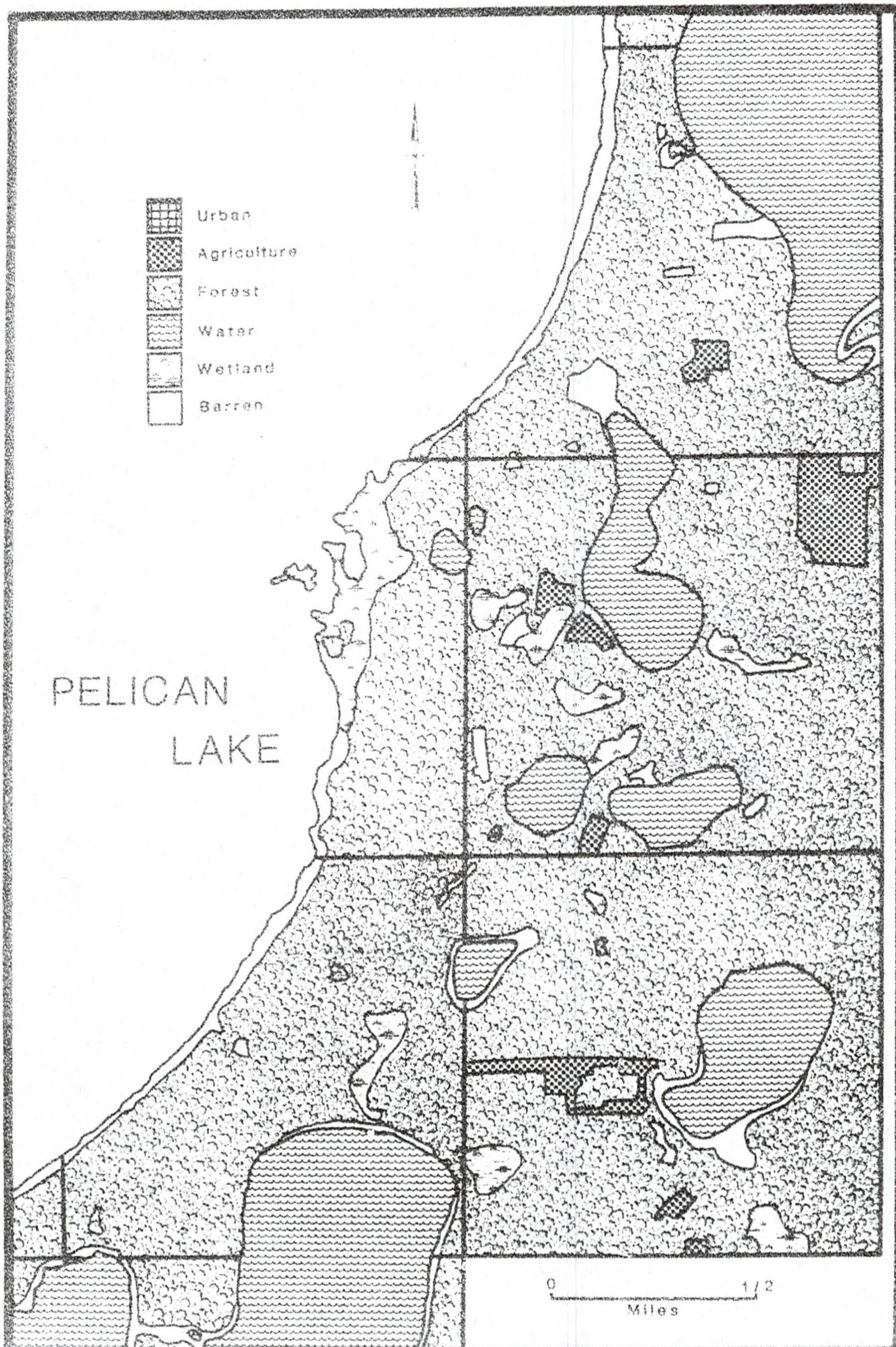


Figure 16: Plate 5 of 1960 Land Use/Cover Map.

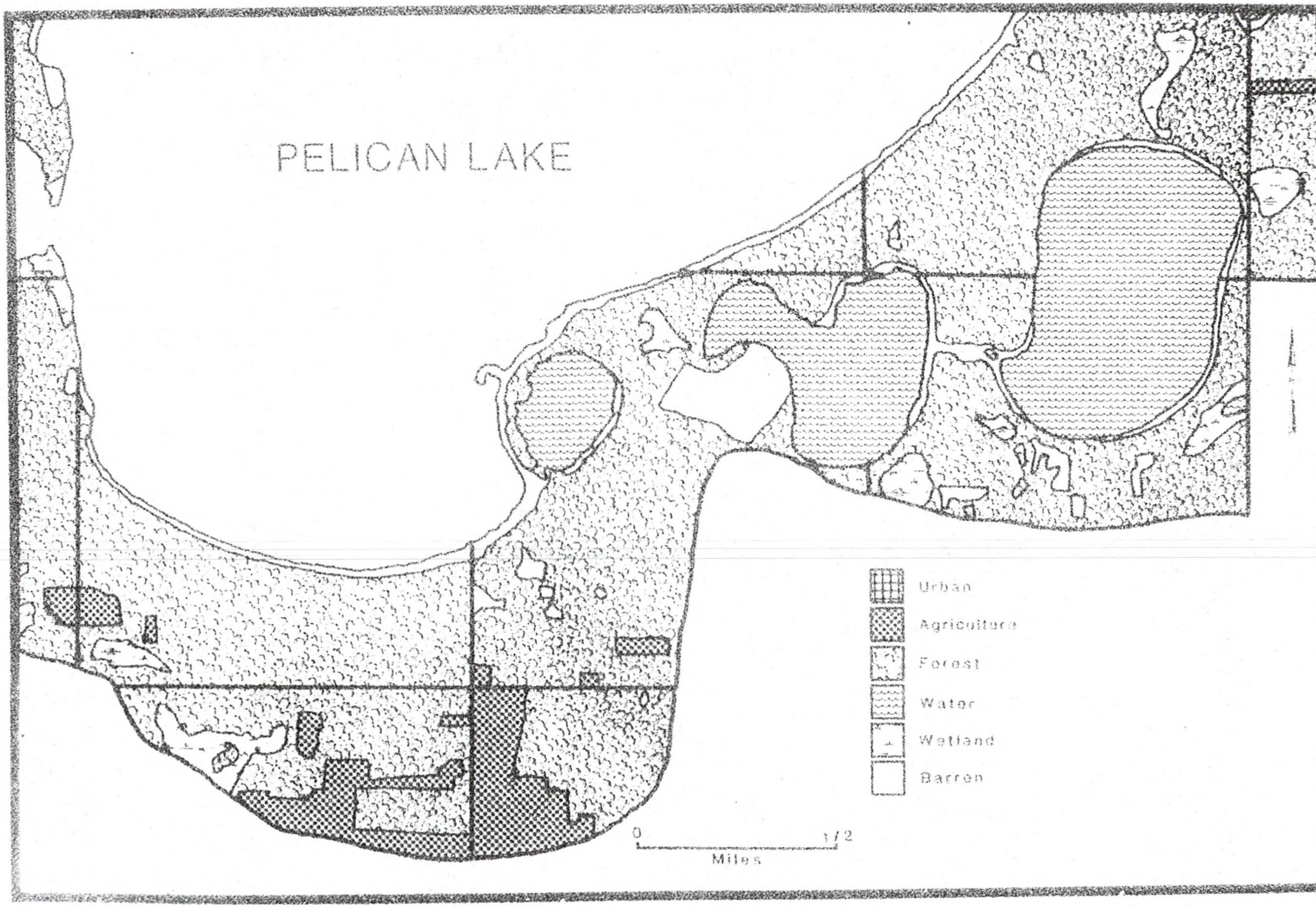


Figure 17: Plate 6 of 1960 Land Use/Cover Map.

1969 Map

Except for minor alterations, Pelican Lake's shape and size remained virtually unchanged between 1960 and 1969 (Figures 18-23). On the northern end of the watershed a channel was dug to connect a small lake to Pelican Lake (Figure 18). Another minor change occurred in the Breezy Point area where another channel was dug to accomodate boat owners who resided in condominiums not directly on Pelican Lake (Figure 19).

A number of conclusions can be reached after analyzing Pelican Lake's watershed in 1969, and include:

1) forested acres remained the dominant land cover, but its acreage diminished slightly during the previous nine years (Figures 18, 19, and 20). Data for the two years indicates a decline of about one hundred acres in the watershed.

2) agricultural acreage remained at levels similar to those of 1960, and continued to exist primarily in the northwest and southern portions (Figures 18 and 23).

3) land classified as urban increased in the Breezy Point area (Figures 18 and 19), primarily as development spread along the shoreline in both directions. The addition of nine holes to the original golf course also was a reason for the increase in acreage.

4) beach along the shoreline of Pelican Lake remained virtually unchanged, but the total land classified as

barren increased by about one-hundred-and-fifty acres since 1960. A major reason for this was the construction of power lines near and along the western boundary of the watershed which brought about clear-cutting of forested acres and resulted in the strip of barren land apparent in Figures 19 and 20.

5) a rather subtle change which might not be readily noticed, but nevertheless is quite apparent when analyzing land use acreage data, is the decline in water acreage other than Pelican Lake. This occurred primarily as emergent vegetation engulfed many of the small bodies of water. There had been an initial increase in water throughout the watershed after construction of the diversion ditch in 1939. In subsequent years, however, small, shallow bodies of water relinquished parts of their surface area to encroaching vegetation. This led to a decline in water acreage and, eventually, wetland acres. Examples of this phenomenon are evident in Figures 22 and 23.

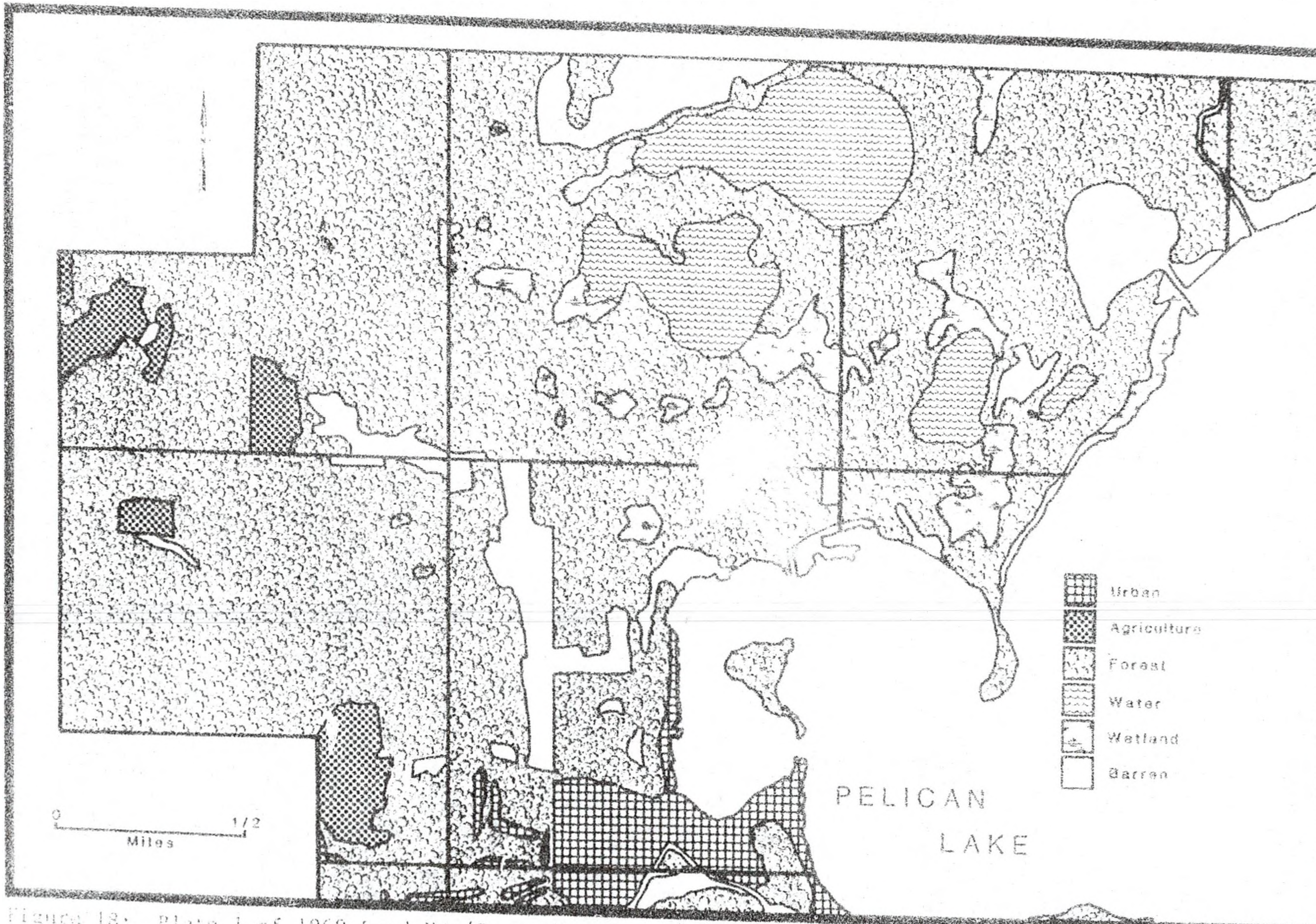


Figure 18: Plate 1 of 1969 Land Use/Cover Map.

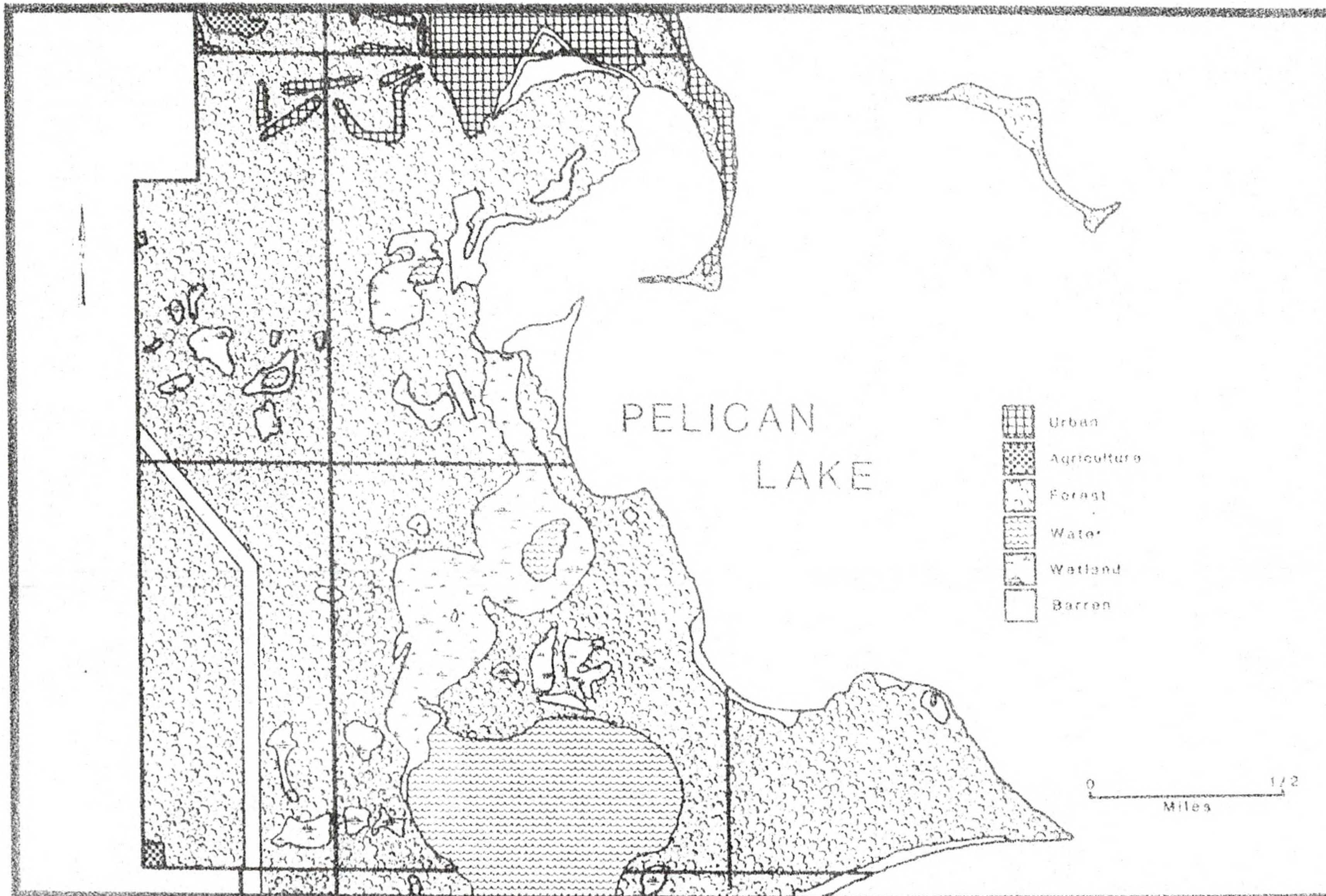


Figure 19: Plate 2 of 1969 Land Use/Cover Map.

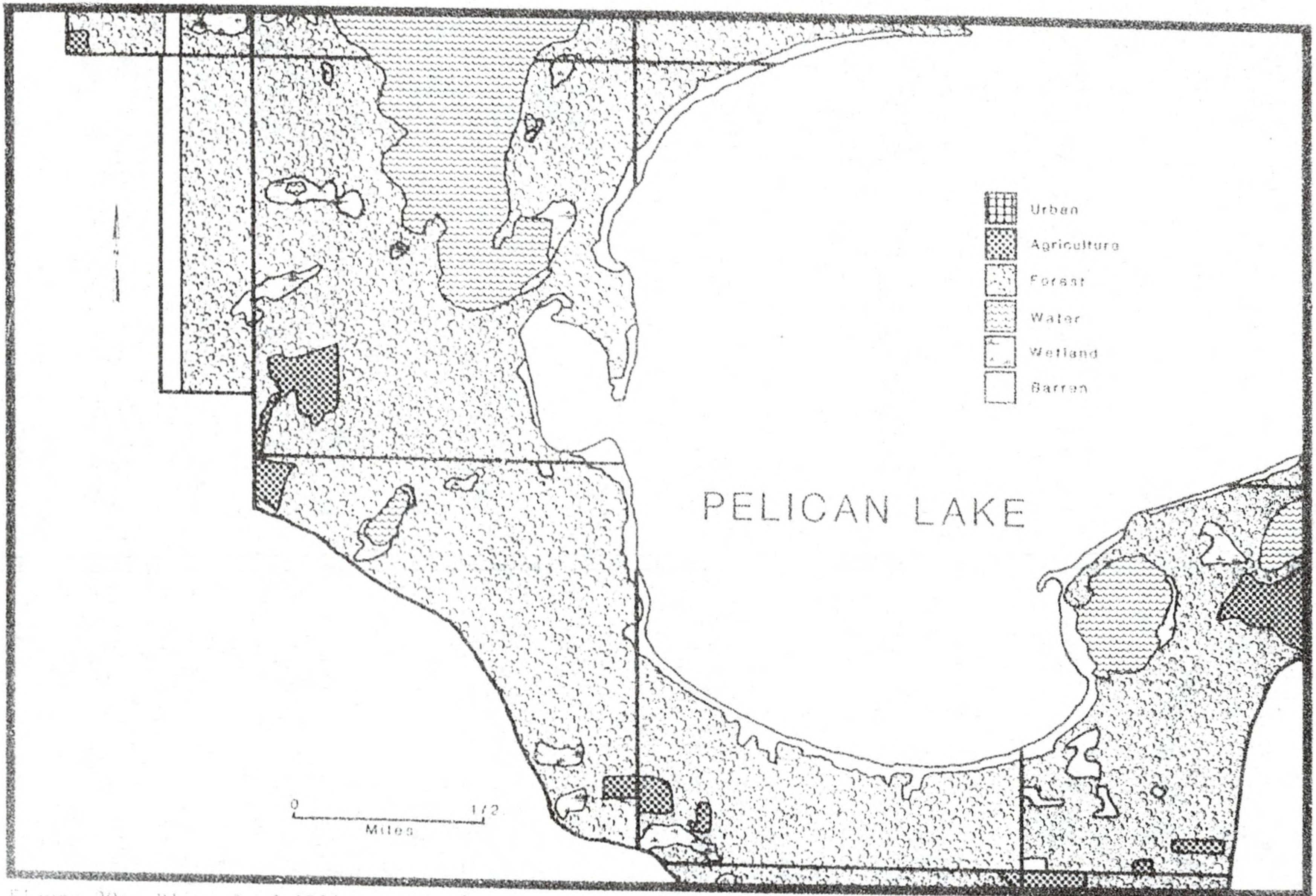


Figure 20: Plate 3 of 1969 Land Use/Cover Map.

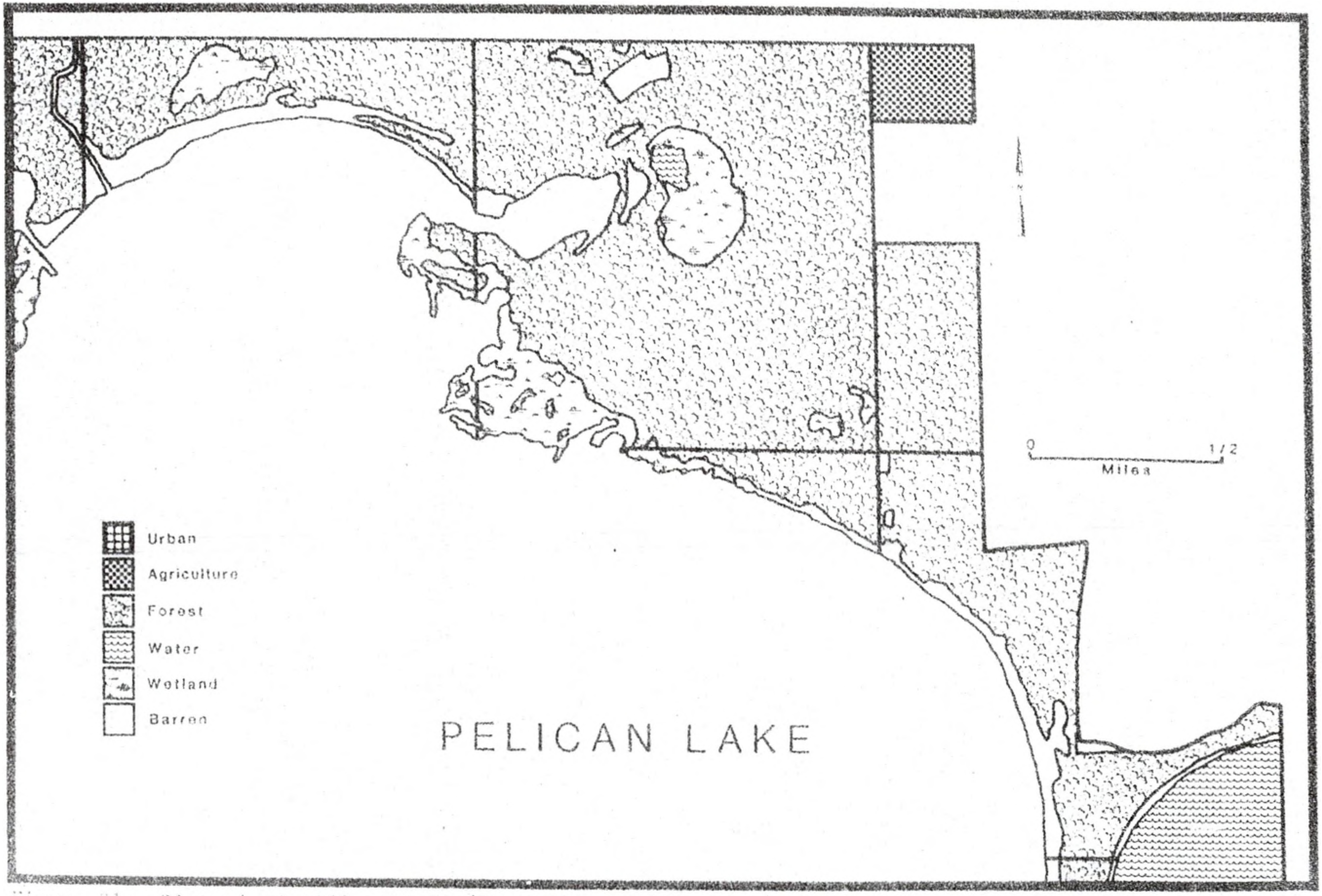


Figure 21: Plate 4 of 1969 Land Use/Cover Map.

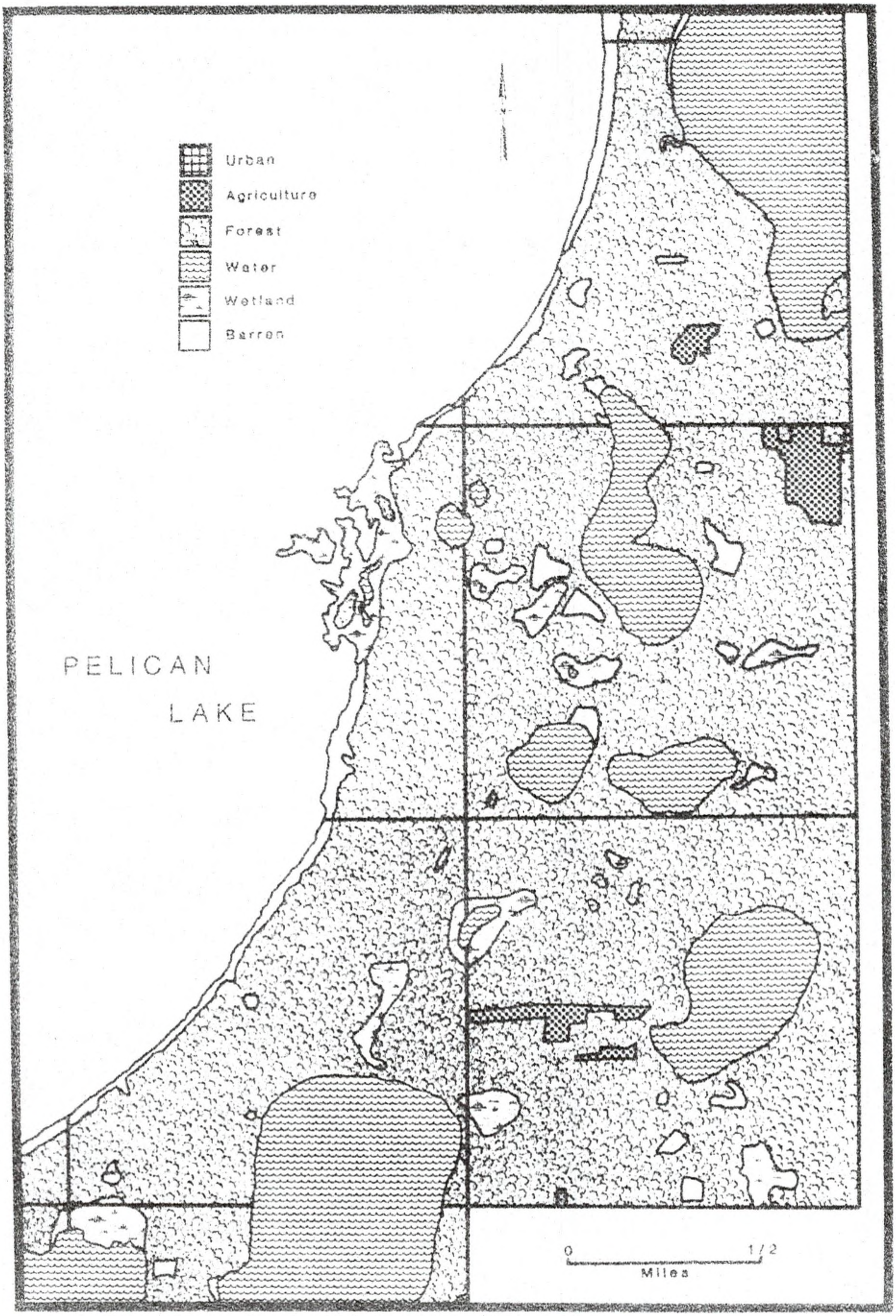


Figure 22: Plate 5 of 1969 Land Use/Cover Map.

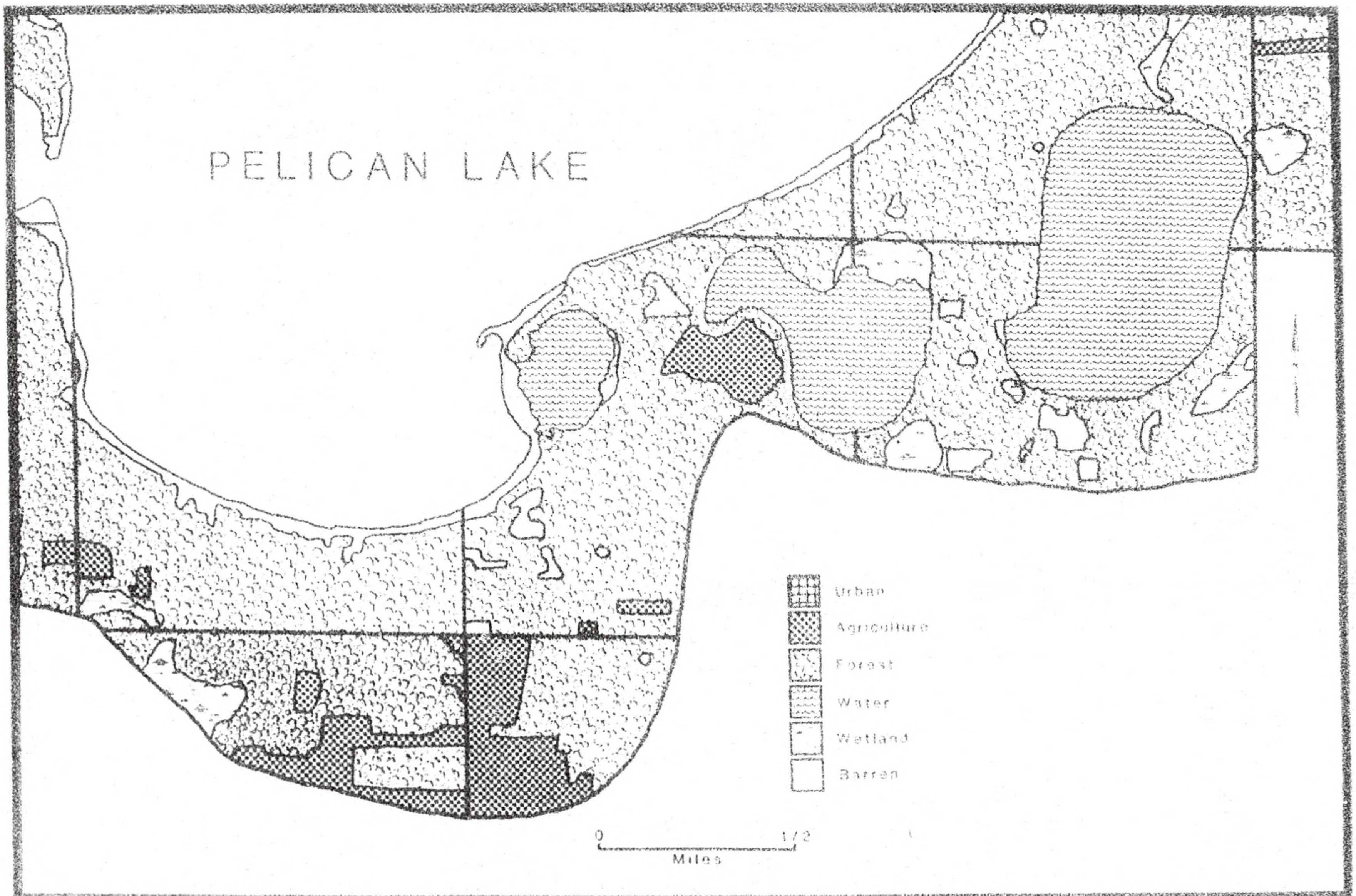


Figure 21: Plate 6 of 1969 Land Use/Cover Map.

1978 Map

Very few changes in size and shape of Pelican Lake occurred in the nine years prior to 1978 (Figures 24-29). Changes within the watershed continued to occur, however, and include the following:

1) an increase in forested land occurred between 1969 and 1978, although it was not strikingly obvious because of the dominance of forest in both years. One area where it was noticed, however, was in the northwest corner of the watershed where a rather large area of previously barren land was naturally reforested (Figure 24).

2) agricultural area continued to decline as areas were abandoned or left as fallow and reclassified as barren (Figures 28 and 29). The northwest and southern portions of the watershed remained the principal areas where agriculture could be found (Figures 24 and 29).

3) Breezy Point showed a substantial increase in land classified as urban, primarily due to the addition of a small airport and sewage facility (Figures 24 and 25).

4) total barren land remained unchanged for the most part -- while certain agricultural areas were turned into land classified as barren, other areas, such as the airport, were converted from barren to urban.

5) the effects of emergent vegetation along the perimeters of water bodies resulted in a decline of water acreage, and the subsequent increase in wetland acreage.

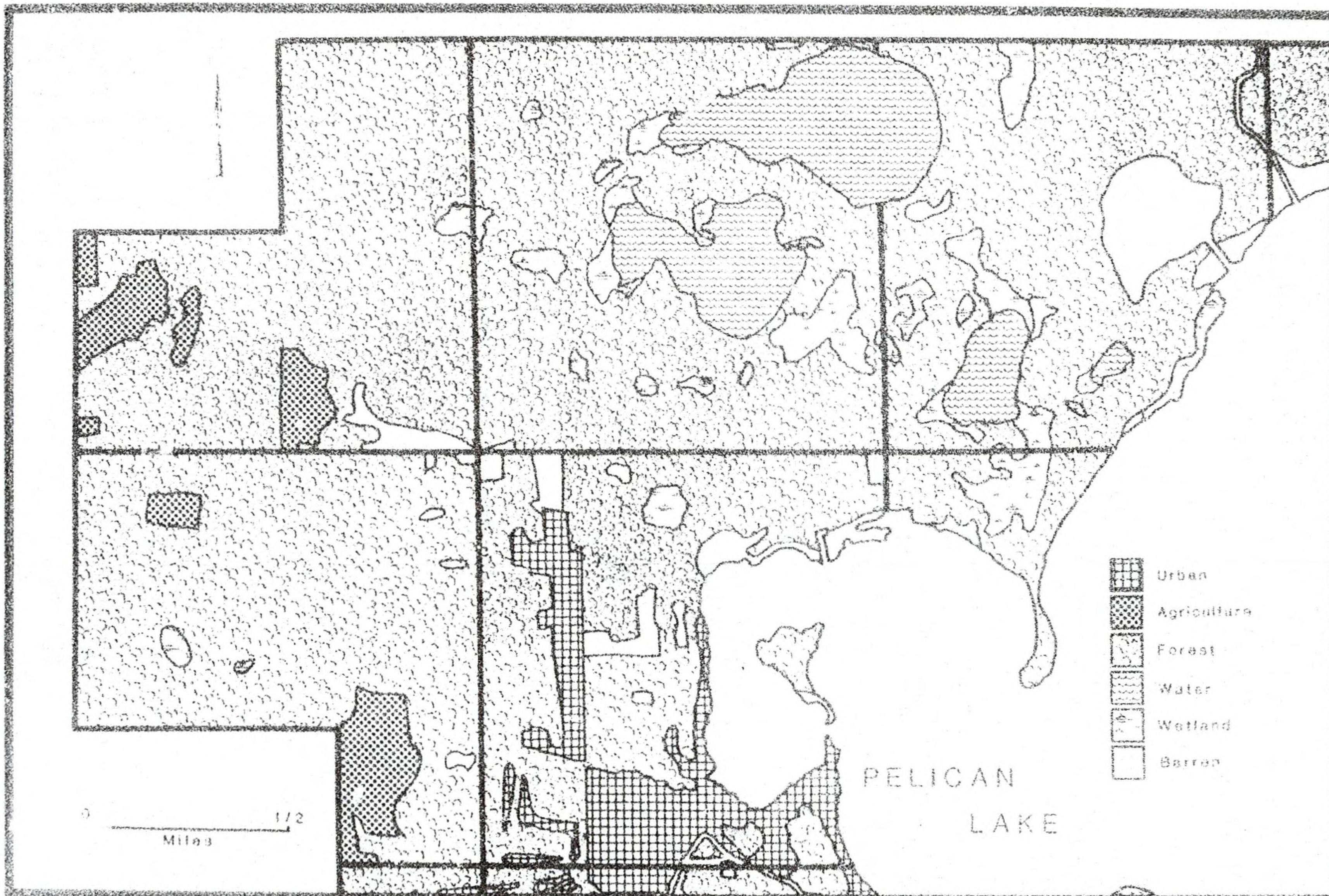


Figure 24: Plate 1 of 1978 Land Use/Cover Map.

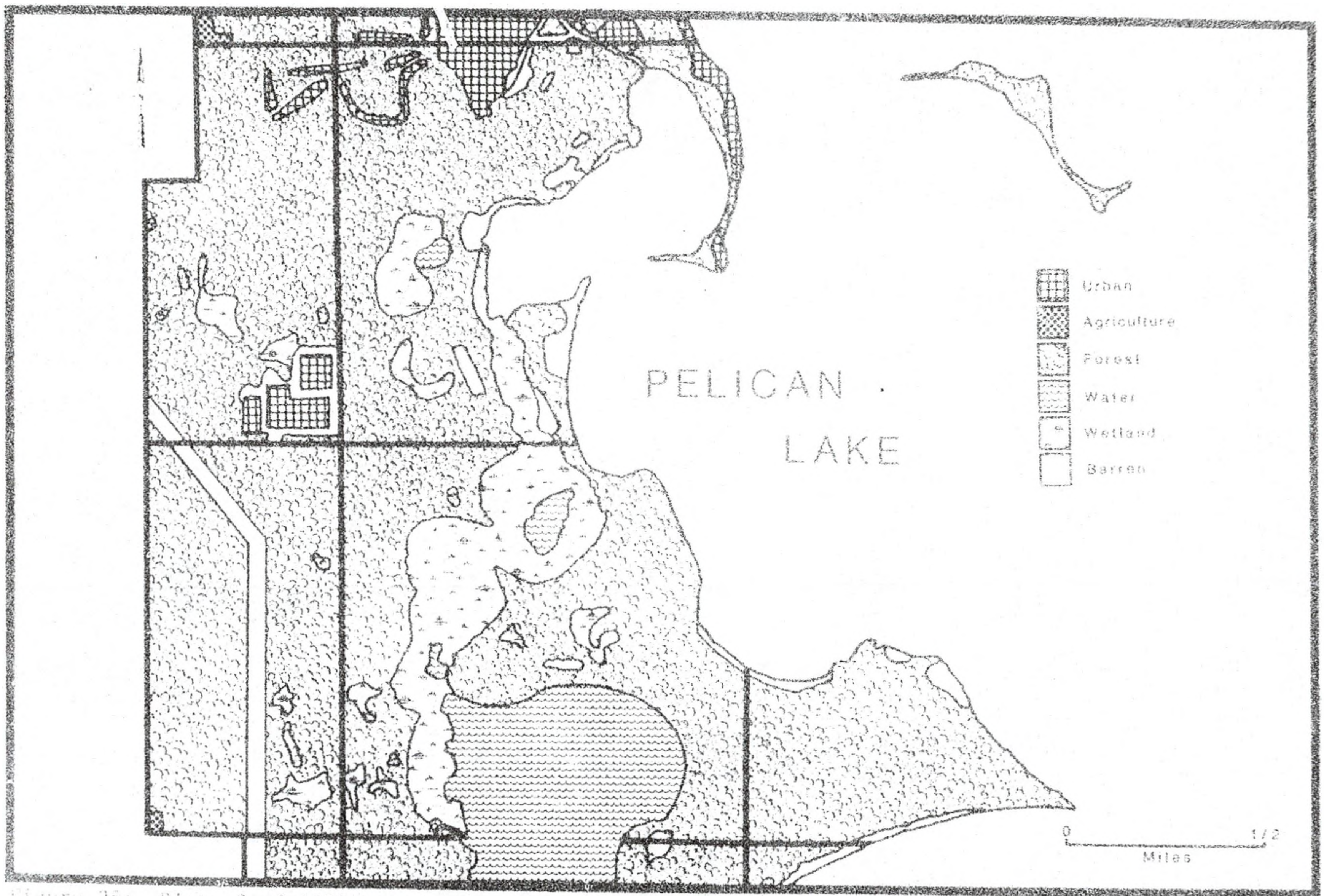


Figure 25: Plate 2 of 1978 Land Use/Cover Map.

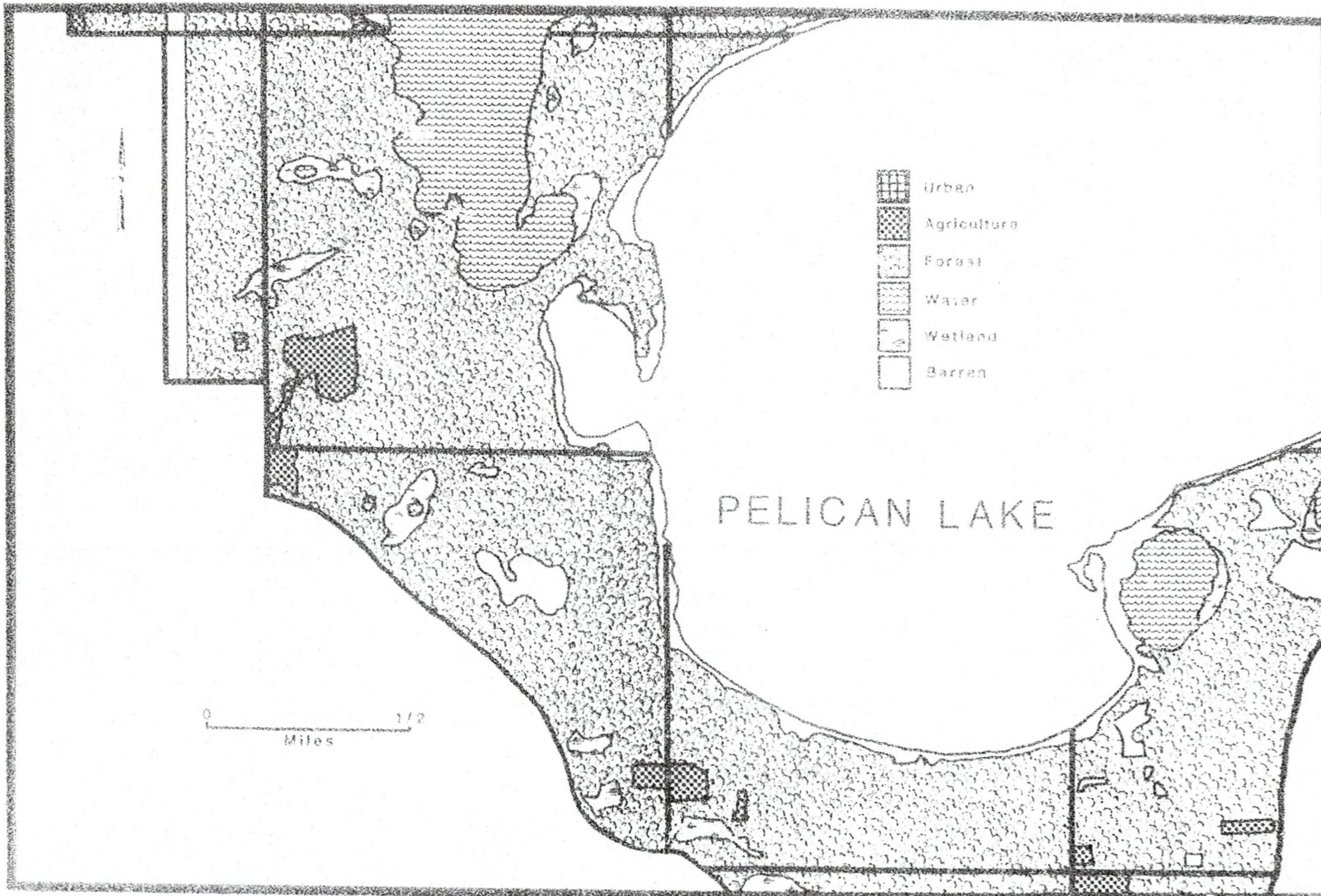


Figure 26: Plate 3 of 1978 Land Use/Cover Map.

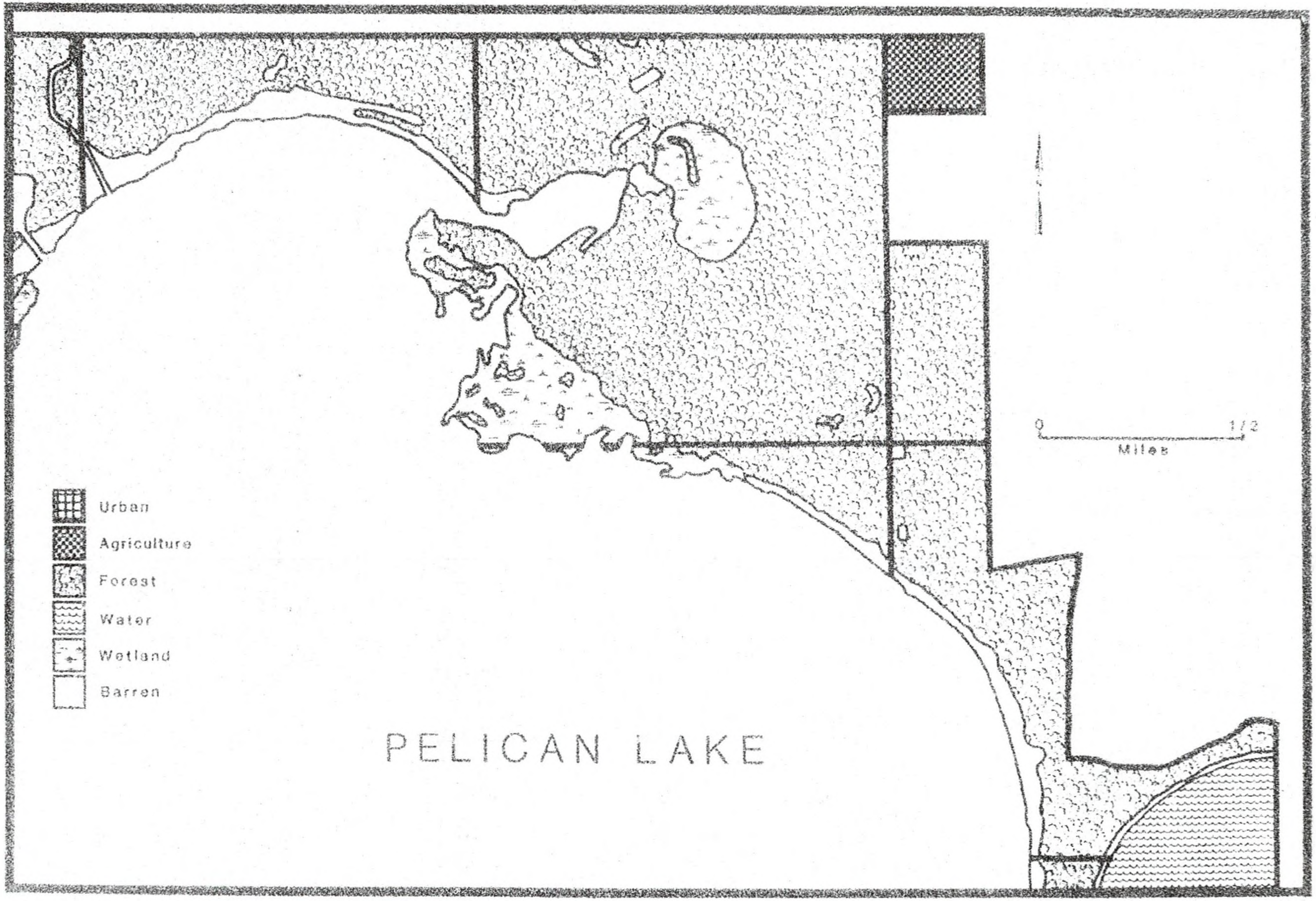


Figure 27: Plate 4 of 1978 Land Use/Cover Map.

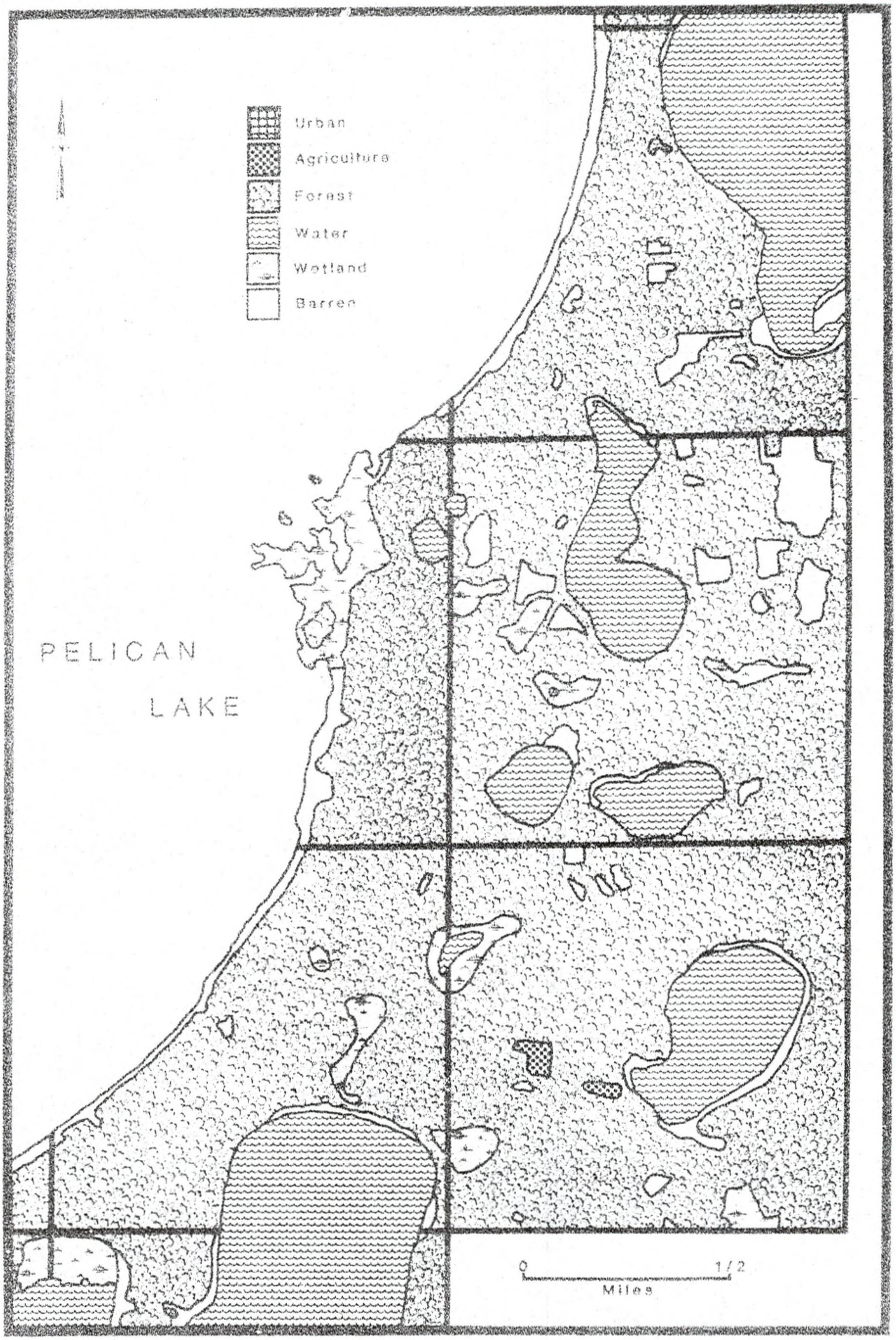
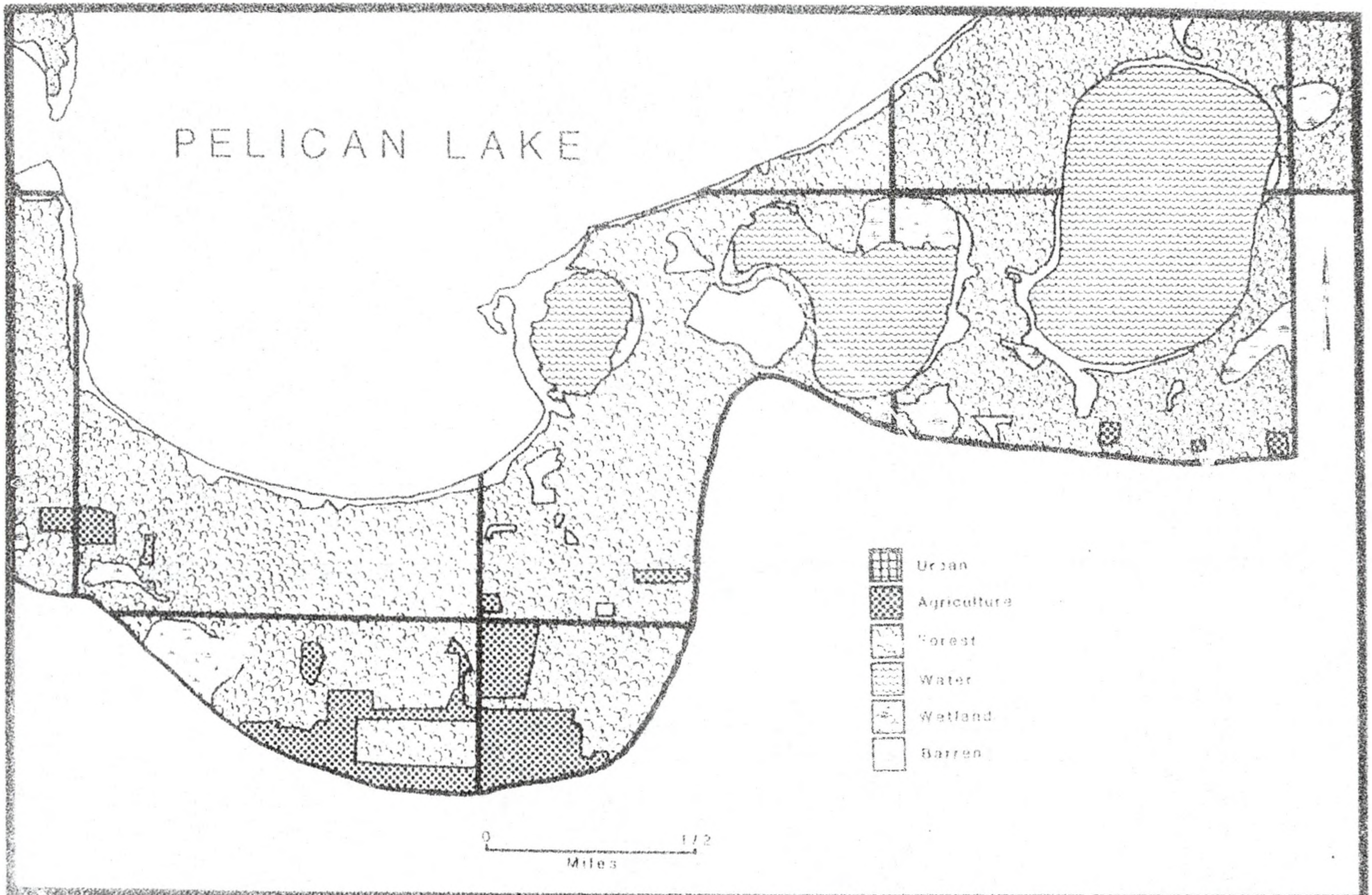


Figure 28: Plate 5 of 1978 Land Use/Cover Map.



[illegible]: Plate 6 of 1978 Land Use/Cover Map.

LAND USE/COVER CHANGES

Agriculture

The greatest number of acres in agricultural land within the study area was identified and calculated from the 1939 photography and has decreased steadily through the years to about half of its 1939 total (Figure 30). The primary reason for the decrease in land classified as agricultural was the recognition of the economic reality that the land was better suited for other purposes. Because of sandy soil, and the majority of the watershed consisting of forest, water, and wetland, agriculture is not a viable primary economic activity in this area. Agricultural land, which presently consists of two percent of the total land within the watershed, is used primarily as cropland and pasture.

Forest

The area classified as forest was at its lowest calculated level in 1939 as a result of the cutting of great numbers of trees in the years prior (Figure 31). Reduced timber harvest pressure and increased concern of lake home owners (i.e. formation of groups such as Crow Wing Environment Protection Association) led to an increase in forest acreage during the 1960s and 1970s. Northwest Paper Company continues to own portions of forest-covered land within the study area and variations in forest acreage will occur as the mill decides when to harvest. Forested land presently accounts for almost seventy-five percent of the land area in

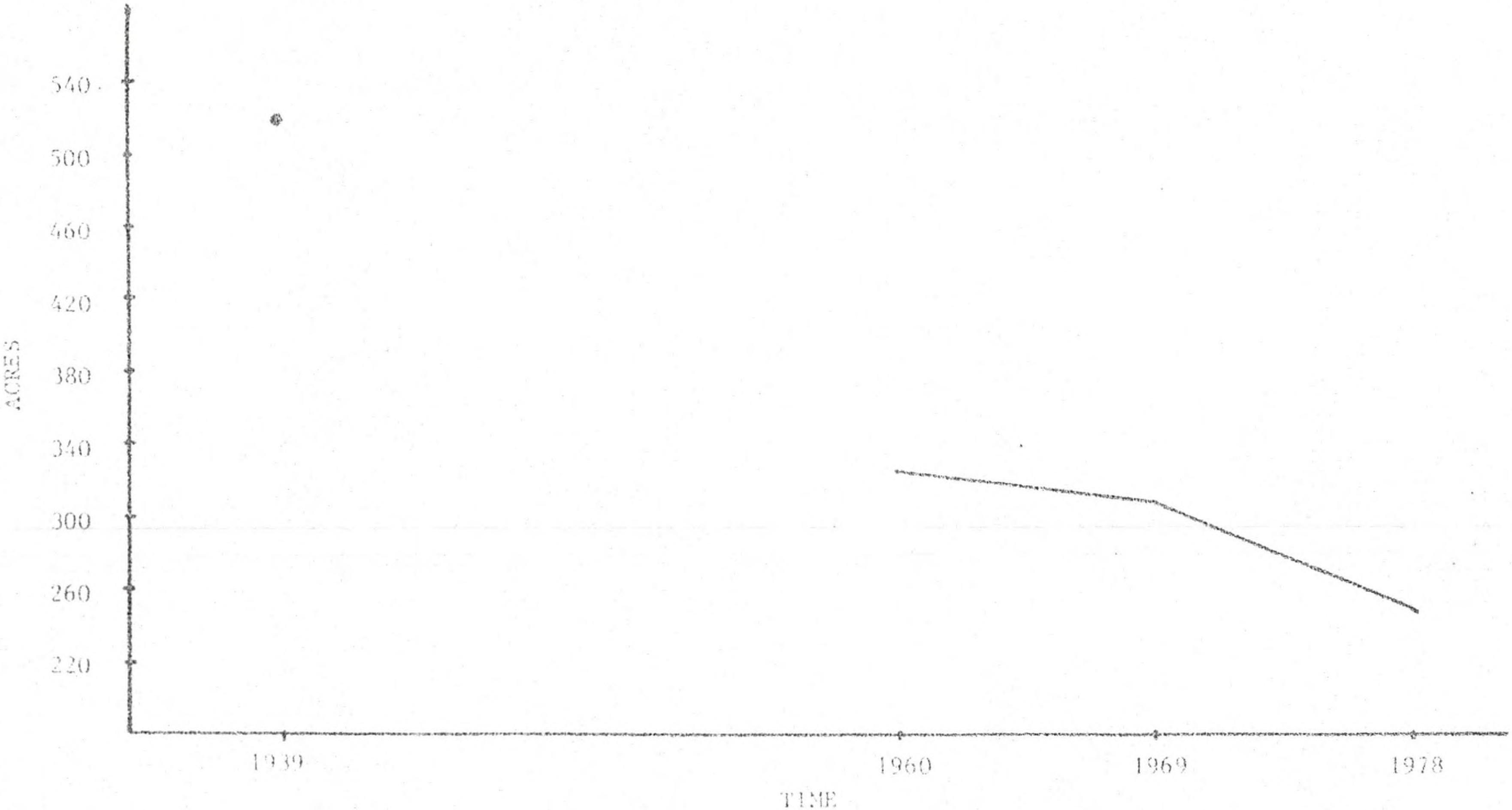


Figure 30: Time Series Graph Depicting Study Area Change in Agricultural Acres.

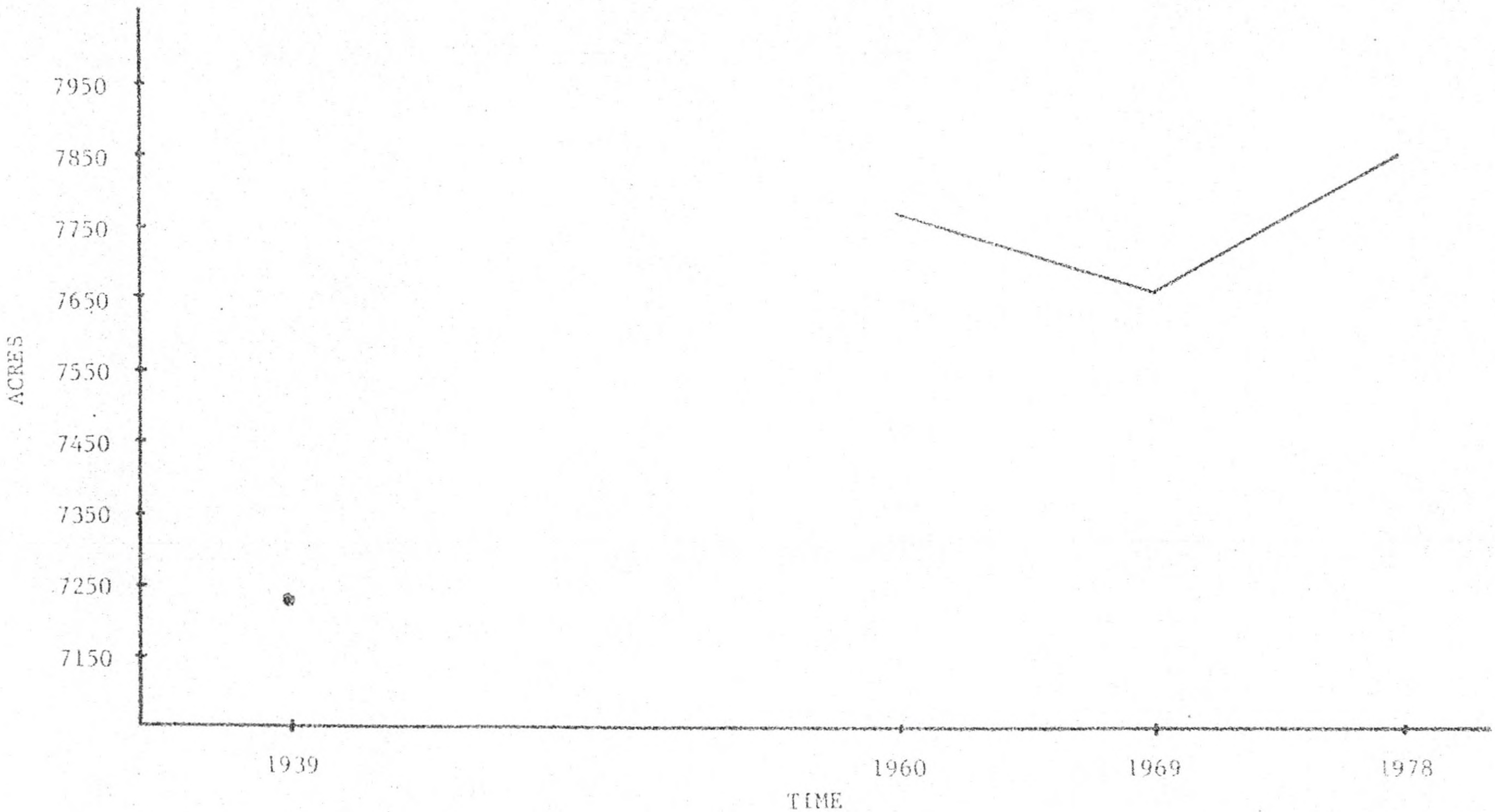


Figure 31: Time Series Graph Depicting Study Area Change in Forest Acres.

the watershed, and is by far the major land cover within the region.

Water

Total calculated area classified as water, excluding Pelican Lake, increased sharply between 1939 and 1960 (Figure 32). Two principle reasons for this are the construction of a diversion ditch between Ossawinnamakee Lake and Pelican Lake, and an increase in precipitation in northern Minnesota following the dust-bowl drought of the 1930s. The diversion ditch allowed more water into Pelican Lake and, subsequently, the surrounding area as the water table rose. Decline in acres of water since 1960 could best be explained by the effects of emergent vegetation filling in smaller lakes, ponds, and wetlands surrounding Pelican Lake. Also, that four of the five years prior to 1978 were years where yearly precipitation failed to reach its average is a major factor in low water acreage in 1978 (Figure 33); 1976 remains as the single lowest yearly precipitation total in Brainerd's history -- only 13.16 inches of precipitation (Appendix D). Pelican Lake's water surface accounts for forty-four percent of the entire study area, while open water other than Pelican Lake composes approximately eleven percent of the total land area.

The same basic factors that are responsible for for changes in water acreage elsewhere in the watershed are also responsible for changes in acreage of Pelican Lake (Figure

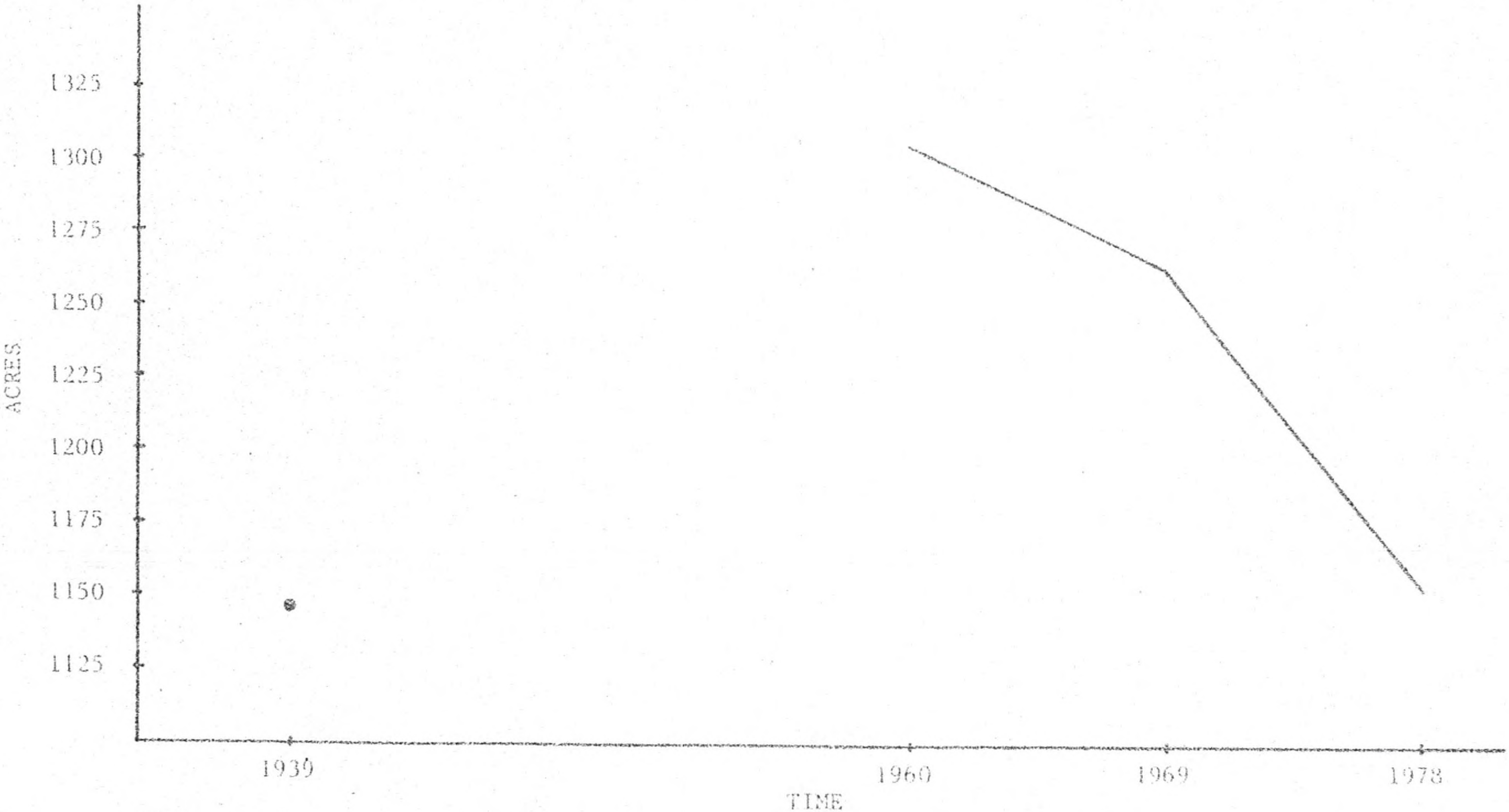


Figure 32: Time Series Graph Depicting Study Area Change in Water Acres other than Pelican Lake.

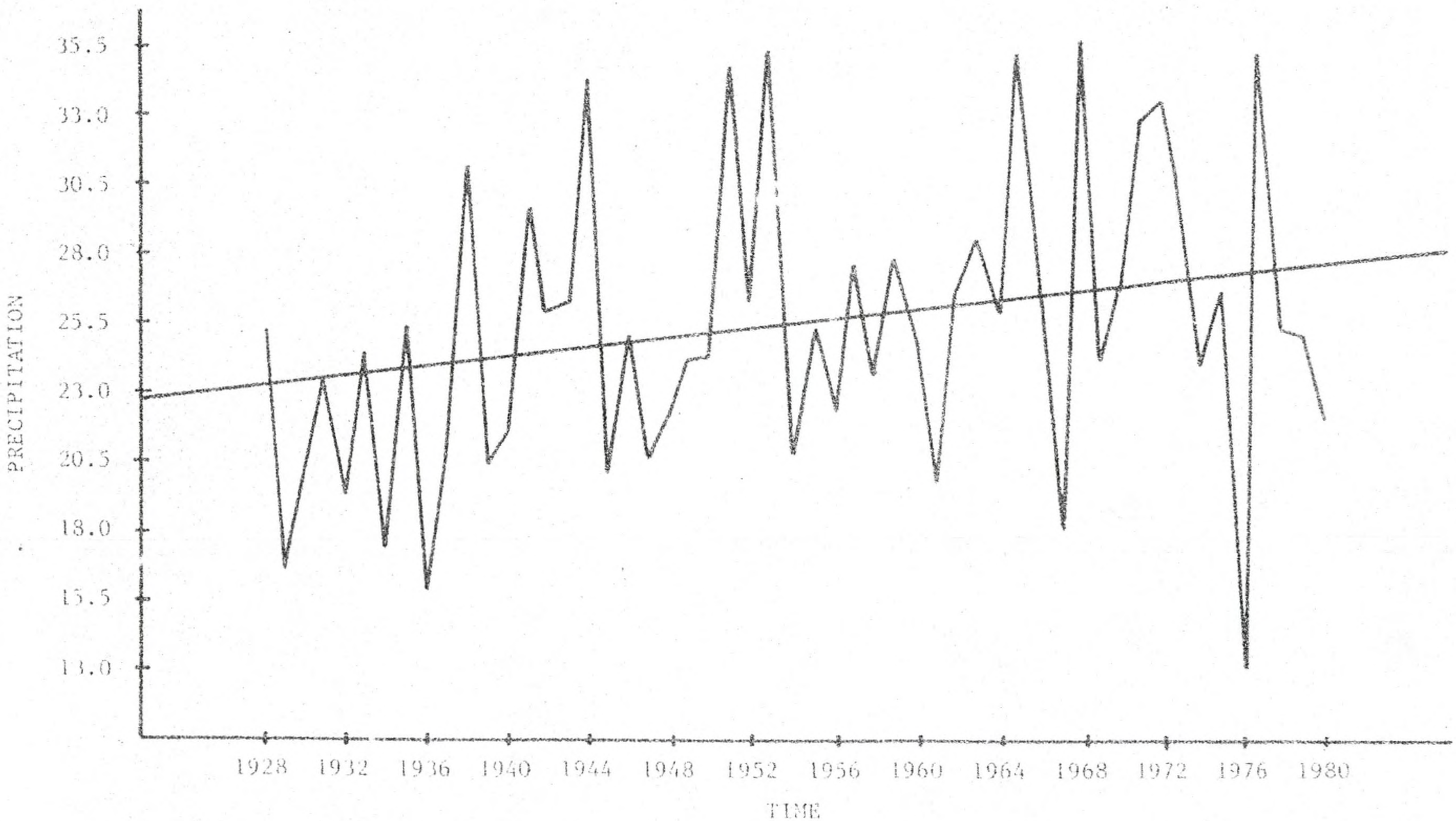


Figure 33: Total Annual Precipitation at Brainerd, Minnesota, 1928-1980.

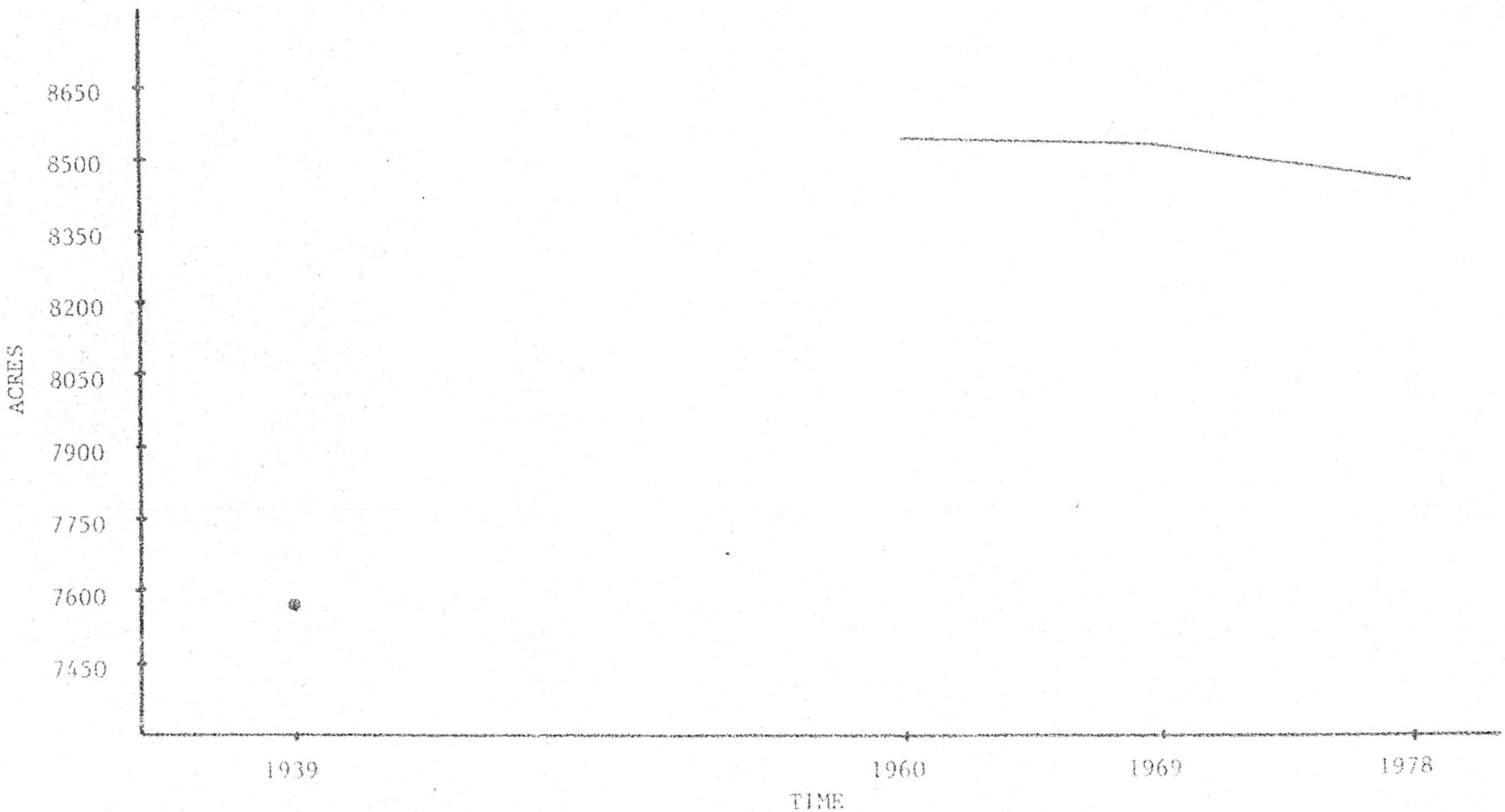


Figure 34: Time Series Graph Depicting Study Area Change in Pelican Lake Acres.

34). However, these factors do not have the same impact on Pelican Lake because of its large size. Acreage totals of the lake for the years 1960, 1969, and 1978 remained fairly consistent, with the greatest difference occurring between 1969 and 1978. Again, the low yearly precipitation values prior to photographic coverage in 1978 best explain the slight decline in lake size.

Wetland

Much of the area which was wetland in 1939 became bodies of water such as ponds after the diversion ditch was constructed, thus a significant decrease in wetland acreage on the 1960 photographs was observed (Figure 35). This coincides with the increase in water throughout the area during this same period. As small bodies of water were being overwhelmed by infringing vegetation, wetland acreage stabilized and even increased, as evidenced by the total calculated from 1978 photos. Encompassing about six percent of the total area, wetlands comprise the third highest land cover classified within the study area.

Barren

Barren land in this study includes areas such as beaches, sandy areas other than beaches, and transitional areas mentioned earlier. The single most important factor leading to the large acreage classified as barren land in 1939 was the large expanse of sandy areas and beaches present due to a low Pelican Lake level (Figure 36). As lake levels elevated

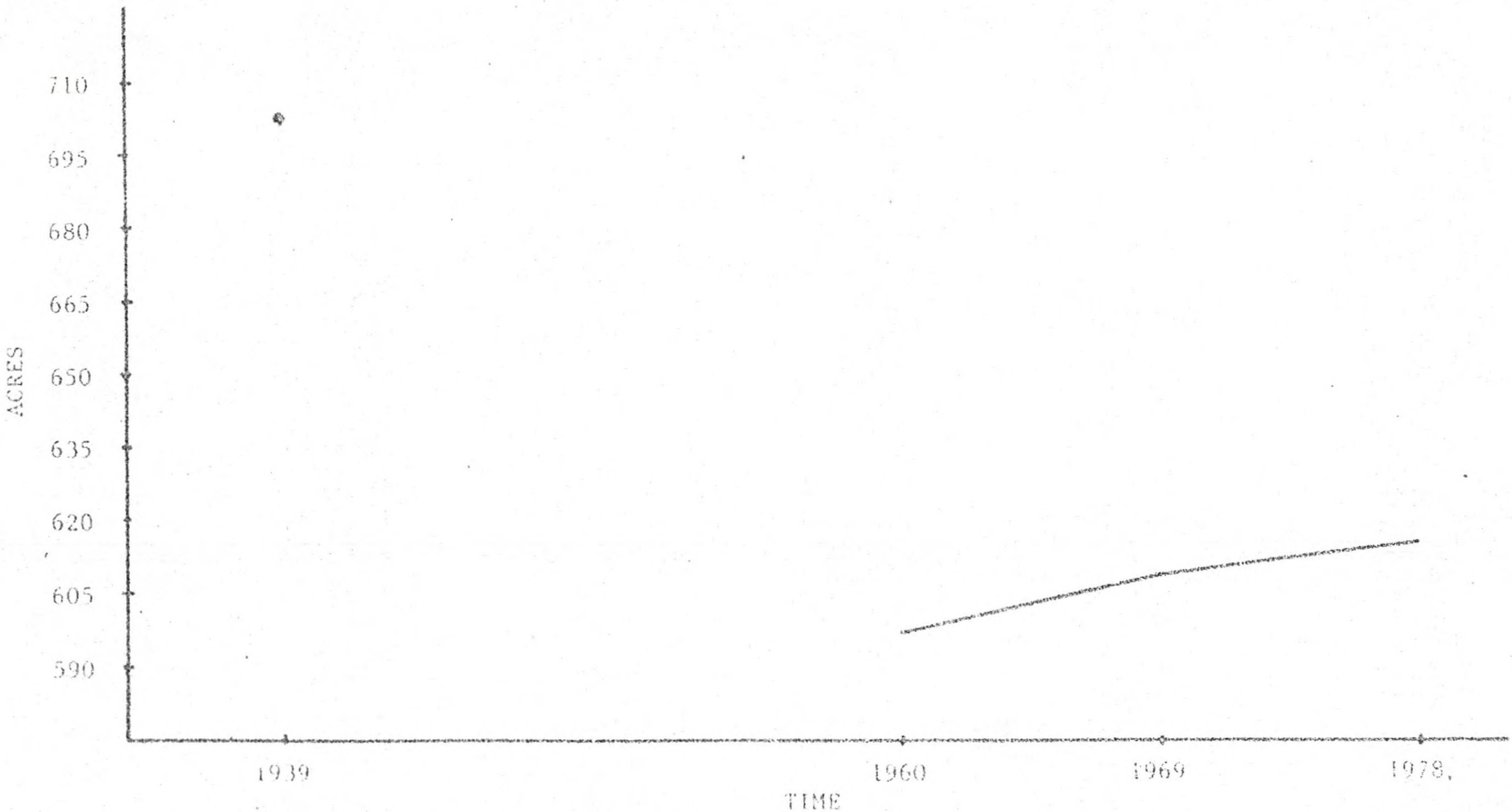


Figure 35: Time Series Graph Depicting Study Area Change in Wetland Acres.

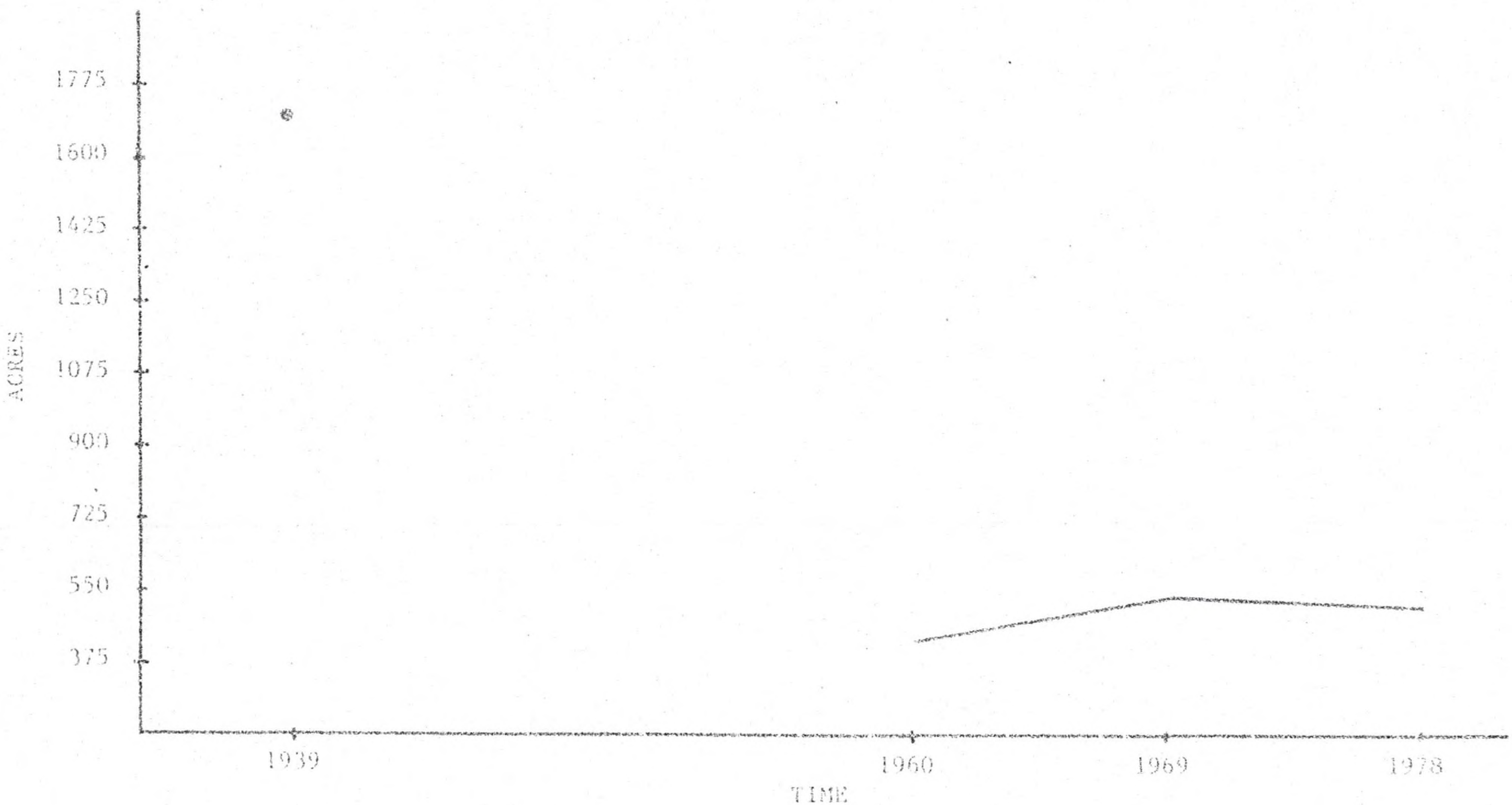


Figure 36: Time Series Graph Depicting Study Area Change in Barren Acres.

through the years, the beach deposits were covered by water. Little shore erosion occurred as a result of the increase in water level because of the gentle gradient of relief along the water; acres of significant relief lie at some distance from Pelican Lake. Minor fluctuations in barren land acreage from 1960 to 1978 are best explained by changes in transitional areas away from the lakeshore. Barren land presently accounts for approximately five percent of the total land area.

RECREATIONAL DEVELOPMENT

Recreational home development on Pelican Lake has increased dramatically over the past 54 years (Figure 37). In terms of number of homes, this increase had been rather steady until the 1960s, when a tremendous increase in dwellings was noted. More homes were built in the 1960s than had previously existed on the lake.

Little home or site development occurred during the 1930s primarily because of the great economic depression. Land values failed to increase and, in many instances, plummeted. Number of homes rose significantly in the 1940s and 1950s, however; an indication of things to come. The 1960s brought another type of recreational development to Pelican Lake -- the condominium. During this time, 156 condominiums units were constructed on Pelican Lake, all within the village limits of Breezy Point. Another thirty-four units were add-

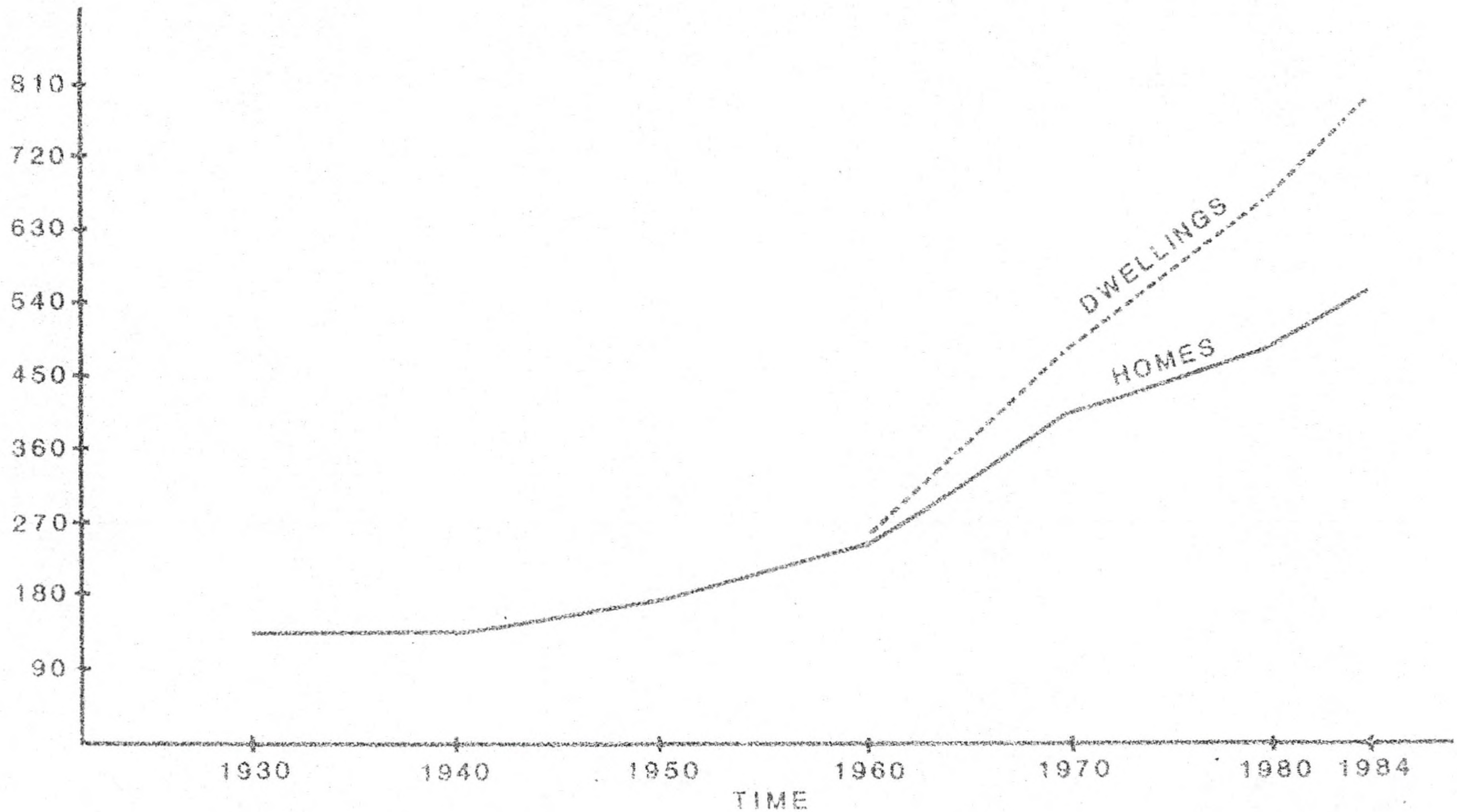


Figure 37: Homes and Dwellings at Pelican Lake plotted against Time.

ed in the 1970s with an additional fifty-six appearing between 1980 and 1984. This unique recreational area currently finds itself in the midst of a dramatic upswing which could surpass the development increases of the 1960s and 1970s.

Development on Pelican Lake, 1930-1984

Very few homes were present on the shores of Pelican Lake in 1930; a total of forty-four were located around the entire lake (Figure 38). In only two areas (four sections) were there clusters of development worth noting: the west side of the lake (the location of Breezy Point), and the southernmost two sections. Excluding the homes within those four sections, only eleven recreational homes existed on Pelican Lake.

Pelican Lake, as a recreational area, remained relatively undeveloped in 1940; an additional seven homes had been built in the preceding ten years. The same four sections on the west and south shores continued to have the majority of housing sites; seventy-five percent of the homes on Pelican Lake could be found in these four sections (Figure 39).

The first significant increase in development on Pelican Lake could be observed in 1950 (Figure 40). The following interpretations can be made from the data and maps:

1) the west and south sides of Pelican Lake continued to be the most developed areas surrounding the lake.

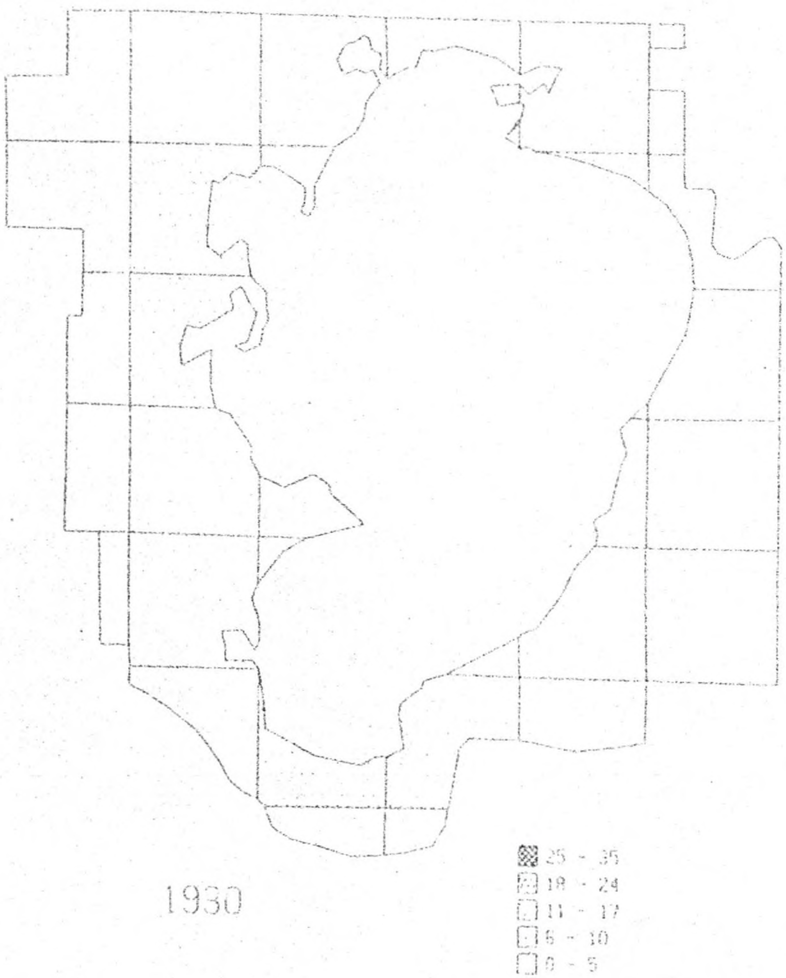


Figure 38: CALFORM Map Depicting Development at Pelican Lake by Section, 1930.

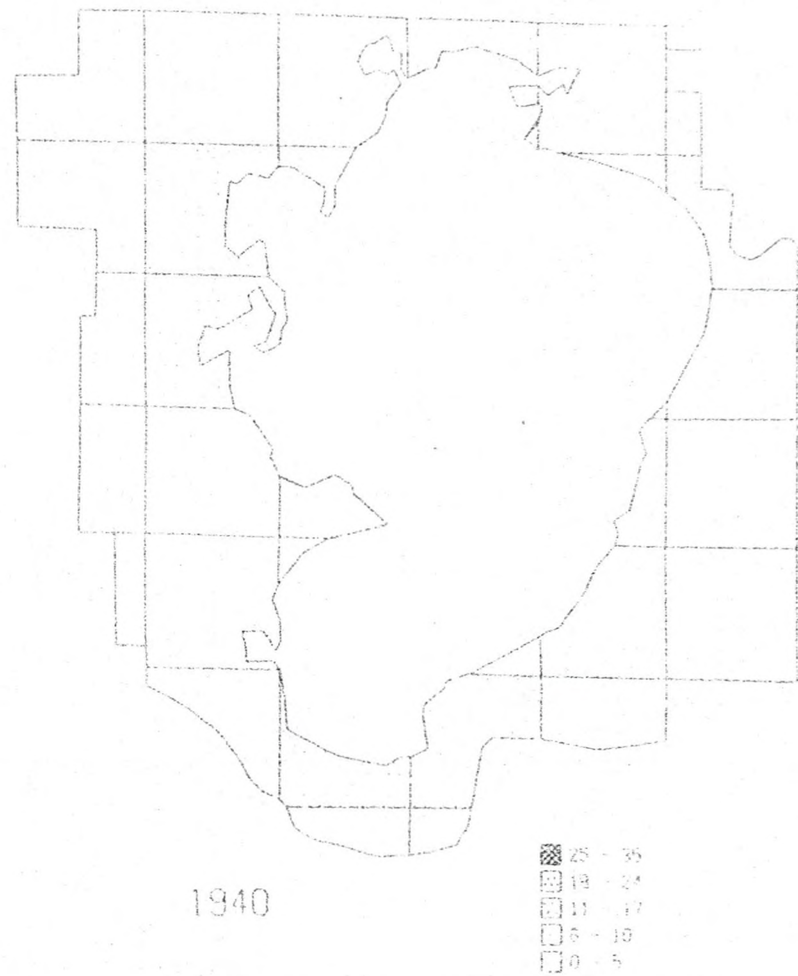


Figure 39: CALFORM Map Depicting Development at Pelican Lake by Section, 1940.

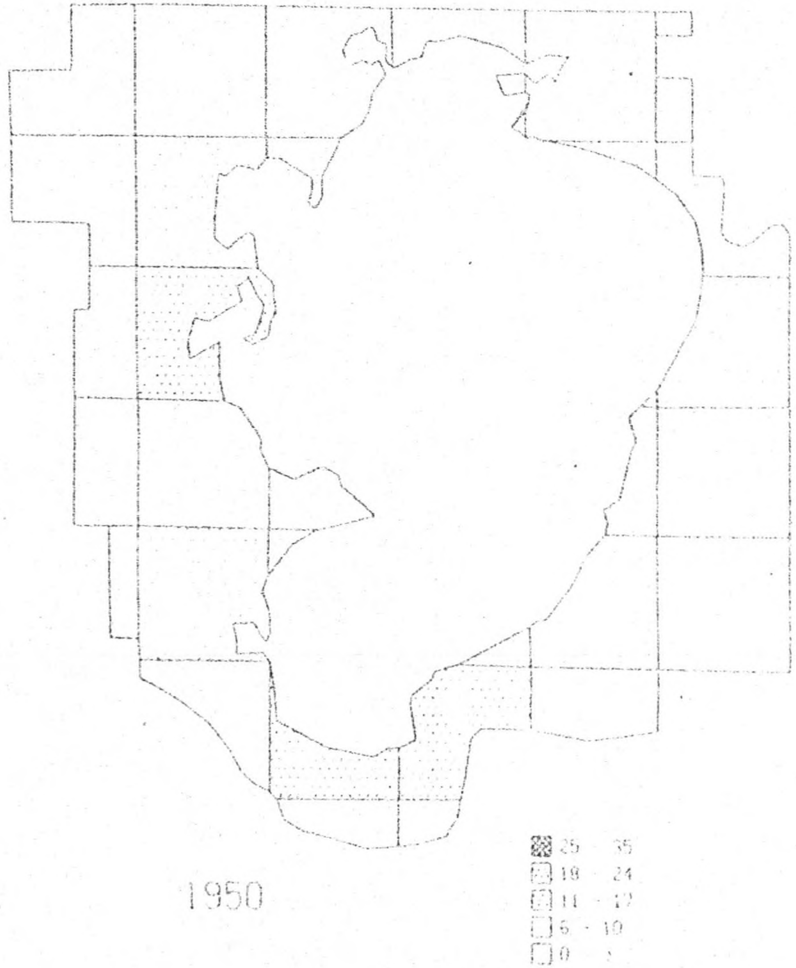


Figure 40: CALFORM Map Depicting Development at Pelican Lake by Section, 1950.

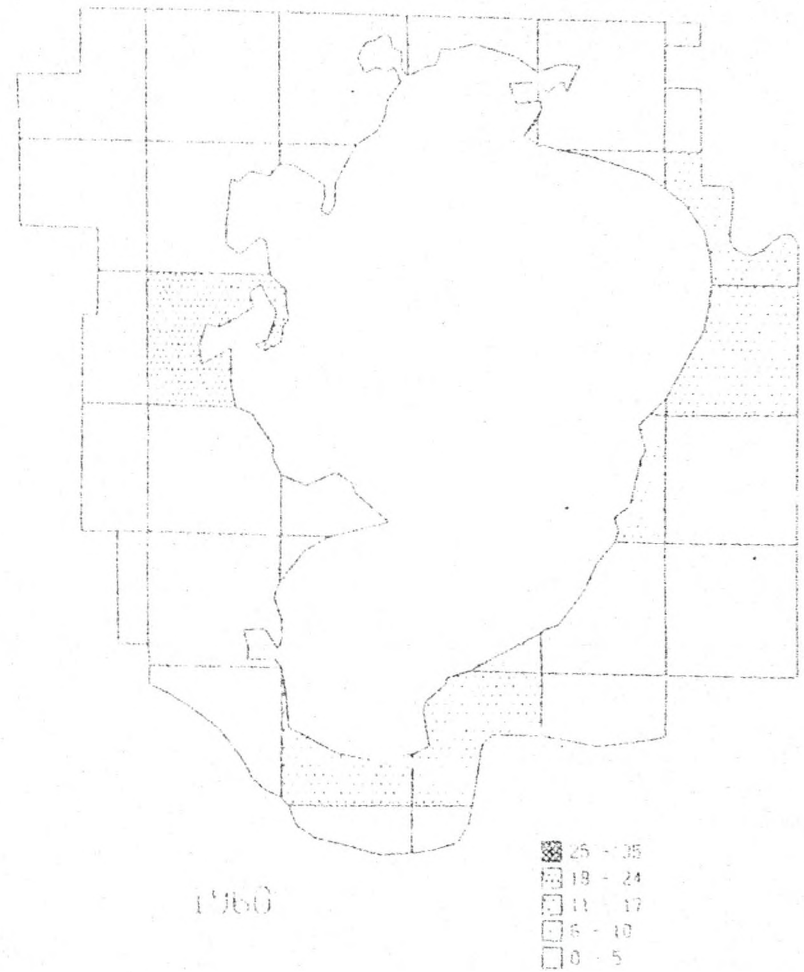


Figure 41: CALFORM Map Depicting Development at Pelican Lake by Section, 1960.

2) two additional sections had increased to 6-10 homes apiece, as development appeared to branch out for the first time in the developmental history of the lake.

3) three sections had increased to 11-17 homes apiece.

4) the southern two sections became the most developed area, relacing the western two sections, which included Breezy Point.

An even more dramatic increase in development occurred between 1950 and 1960 (Figure 41). Observations of recreational development reveal:

1) four additional sections (east, south, and north) had increased to 6-10 homes per section.

2) five sections included 11-17 homes apiece.

3) one section (Breezy Point) contained over 18 homes.

4) ten sections numbered at least 6 homes.

5) three distinct areas appeared to be major concentrations of development -- the west, south, and east portions of the shoreline.

6) the appearance of a section in the north containing over 6 homes.

The most dramatic increase in development on Pelican Lake occurred during the 1960s (Figure 42). Major findings show:

1) a section of Breezy Point contained over 102 dwellings.

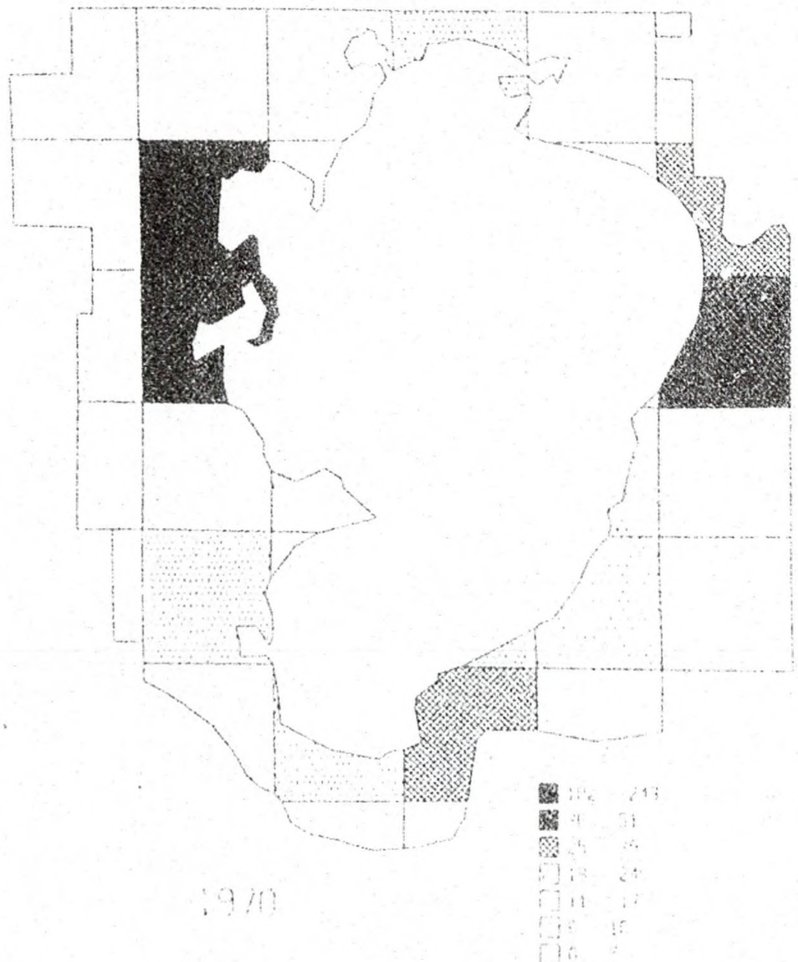


Figure 42: CALFORM Map Depicting Development at Pelican Lake by Section, 1970.

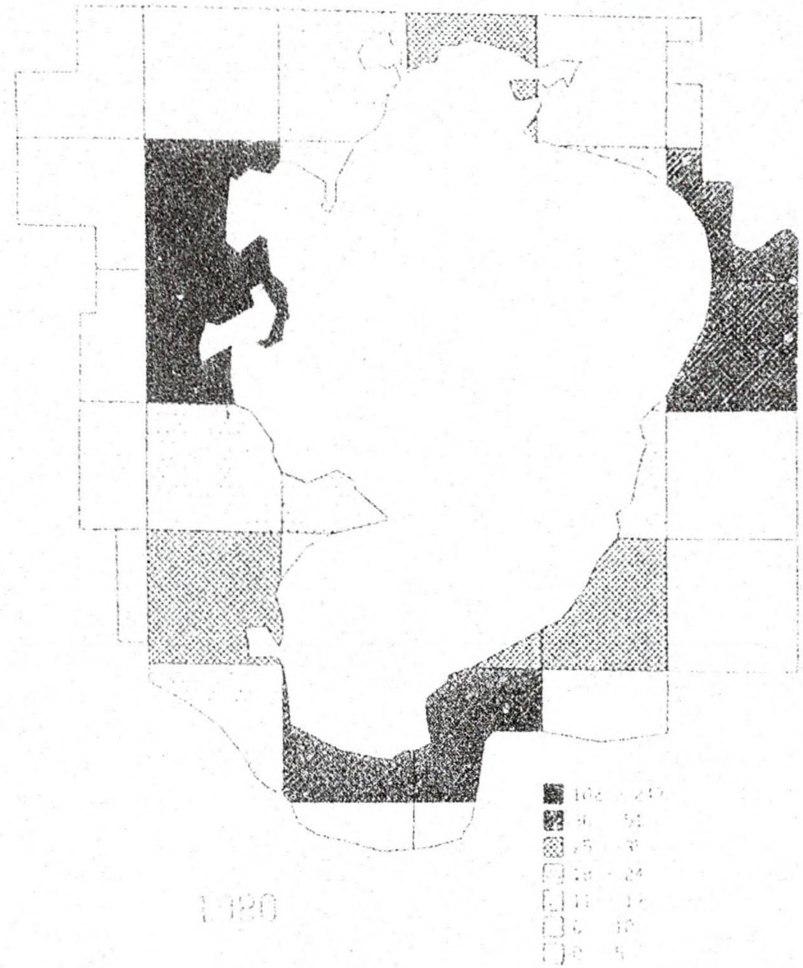


Figure 43: CALFORM Map Depicting Development at Pelican Lake by Section, 1980.

2) the western shore of Pelican Lake resumed its statistical position as the most populated area.

3) the eastern and southern shores were the next highest developed areas.

4) only four sections with 5 or less homes remained.

5) this year marked the last in the sequence of maps in which a section included no homes (section 13 of Pelican Township).

6) condominiums appeared in sections 16 and 21 of Pelican Township (Breezy Point).

Development continued to increase through the 1970s. The following conclusions can be made by analyzing the 1980 map (Figure 43):

1) two sections of Breezy Point included at least 102 dwellings apiece.

2) the western shore remained the most populated, followed by the eastern and southern shores.

3) nearly every section bordering Pelican Lake experienced a significant increase during the previous ten years.

Development between 1980 and 1984 increased at a rate never experienced prior to this time at Pelican Lake. Projected growth in the 1980s indicates the largest number of new dwellings being constructed for any ten-year period to date. Breezy Point accounts for the great majority of this increase, followed by the northern and eastern shores (Figure 44). Major findings include:

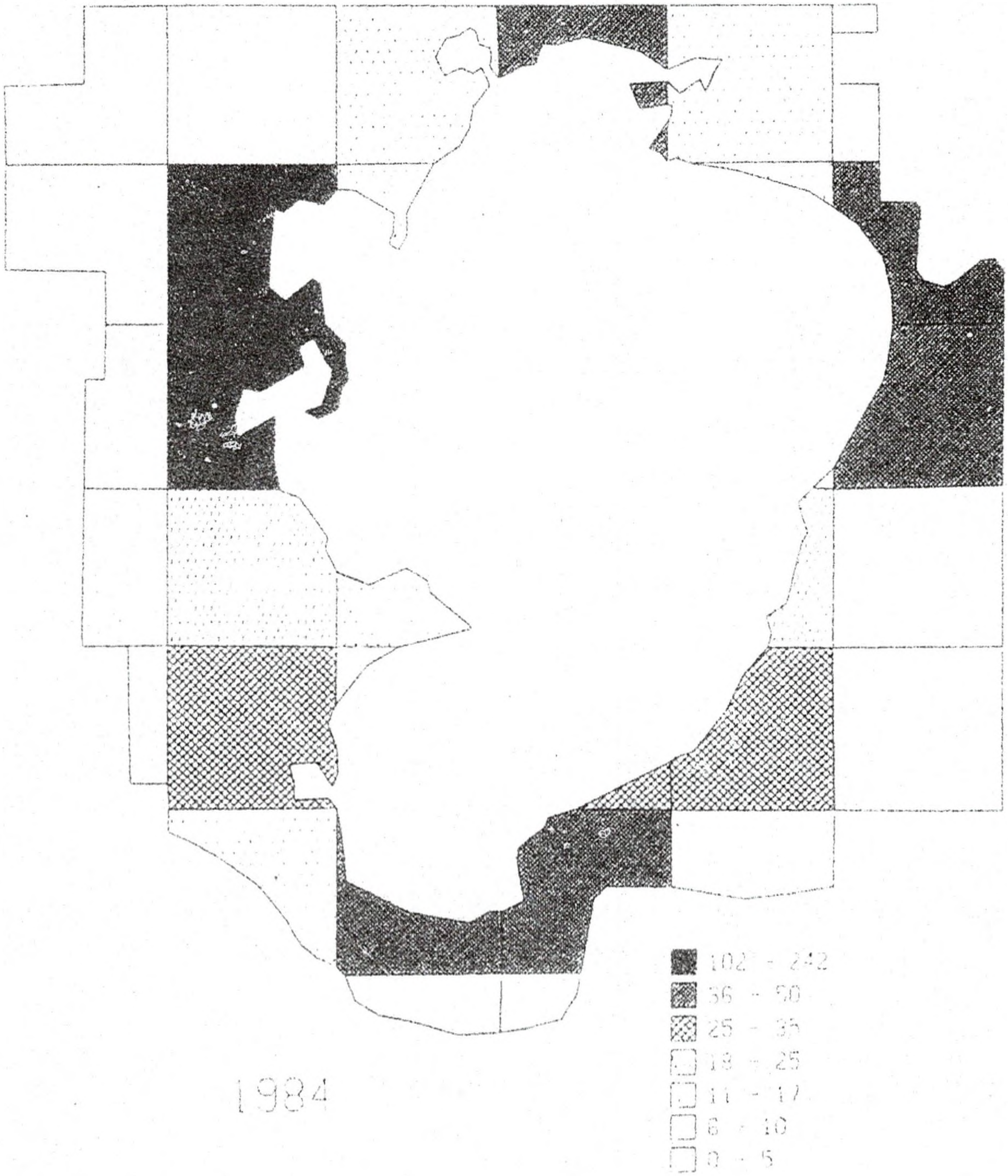


Figure 44: CALFORM Map Depicting Development at Pelican Lake by Section, 1984.

1) only two sections (24 and 34 of Pelican Township) include five or less homes apiece, largely because most of these sections lie within Pelican Lake.

2) the southern and eastern shores continue to be the next-highest developed areas, much the same as 1960-80.

3) a section of the north shore (section 11 of Pelican Township) appears to be the fourth most dominant area in terms of population. This is the culmination of a steady increase within this section which began in 1960.

Although development has grown tremendously in the fifty years prior to 1984, Pelican Lake does not appear to have a problem of overcrowding because of its large size (Table 4). This becomes readily apparent when looking at the number of homes per acre of water in Pelican Lake (.065). Even when taking condominiums at Breezy Point into consideration, the number of dwellings per acre of Pelican Lake remains low (.094). As stated earlier, using Borchert's (1970) potential crowding classification for Minnesota lakes, Pelican Lake is considered to have negligible crowding potential.

TABLE 4

DEVELOPMENTAL DENSITY OF PELICAN LAKE

	1930	1940	1950	1960	1970	1980	1984
Homes	44	51	87	158	320	474	550
Dwellings	44	51	87	158	476	664	796
Miles of Lakeshore	22.7	23.3	24.2	24.8	25.2	25.0	25.0
Acres of Water Surface	6811	7577	8534	8534	8529	8470	8470
Homes per Mile of Lakeshore Ratio	1.9	2.2	3.6	6.4	12.7	19.0	22.0
Dwellings per Mile of Lake-shore Ratio	1.9	2.2	3.6	6.4	18.9	26.6	31.8
Homes per Acre of Water Ratio	.006	.007	.010	.019	.038	.056	.065
Dwellings per Acre of Water Ratio	.006	.007	.010	.019	.056	.078	.094

RESORTS

The number of resorts on Pelican Lake has fluctuated throughout the past 54 years (Table 5). Factors such as additional personal income, increased leisure time, and the need for recreational experiences have played a major role in determining the number of resorts on the lake at any one time. In 1930, Breezy Point was the only resort on Pelican Lake, having been built eight years earlier. It was not until the 1940s that another resort was built on the lake. Three additional resorts were constructed during the 1950s and 1960s, making a total of eight on Pelican Lake, the most operating at any one time. This number decreased to six in 1980, and five in 1984. This pattern of declining resorts follows a trend Minnesota has been experiencing since the 1970s ("Number of Resorts..." October 31, 1983).

Table 5

HOMES, DWELLINGS, AND RESORTS ON PELICAN LAKE
1930 - 1984

	1930	1940	1950	1960	1970	1980	1984
Homes	44	51	87	158	320	474	550
Condominium Units					156	190	246
Dwellings (Homes and Condominium Units)	44	51	87	158	476	664	796
Resorts	1	1	2	5	8	6	5

BREEZY POINT

As shown by the maps depicting location of development surrounding Pelican Lake (Figures 38-44), Breezy Point has accounted for a major portion of all development throughout the time period studied. As long ago as 1930, Breezy Point comprised 48% of the total number of homes on Pelican Lake. Development grew faster on the rest of the lake than at Breezy Point during the next three decades as new homes and resorts appeared. Its percentage of total development fell to 41%, 30%, and 22% in 1940, 1950, and 1960, respectively. By 1970, aided by the introduction of condominiums, Breezy Point accounted for a full 47% of the total development present on Pelican Lake. While Breezy Point continued to grow at a rapid pace during the following ten years, the other areas on the lake increased as well, and Breezy Point's share of total development decreased to 44%. By the beginning of 1984, revived by new vacation concepts such as time-sharing, Breezy Point had resumed its 48% share of total development on Pelican Lake.

PEARSON CORRELATION MATRIX

Homes

Strength of association between shoreline and number of homes on Pelican Lake (R=.71, P=.001) suggests that the longer the shoreline, the greater the number of homes within a given land area (Table 6). The great majority of persons

TABLE 6

CORRELATION MATRIX GENERATED BY PEARSONS CORRELATION ROUTINE (HOMES)

	FOREST	PELICAN	WATER	WETLAND	BARREN	RELIEF	SHORE	DEPTH	DISTANCE	HOMES
FOREST	1.00000 0.0000	-0.93546 0.0001	0.63754 0.0059	0.46015 0.0770	0.14503 0.5786	0.50022 0.0409	0.37103 0.1426	-0.42658 0.0877	-0.37590 0.1370	0.28256 0.2718
PELICAN		1.00000 0.0000	-0.69412 0.0020	-0.60124 0.0107	-0.30348 0.2363	-0.62367 0.0075	-0.47425 0.0554	0.56409 0.0183	0.39991 0.1117	-0.36234 0.1529
WATER			1.00000 0.0000	0.57031 0.0168	-0.23192 0.3705	0.28676 0.2655	0.15030 0.5637	-0.28178 0.2732	-0.56608 0.0178	0.47884 0.0518
WETLAND				1.00000 0.0000	-0.09272 0.7234	0.56919 0.0171	0.19677 0.4491	-0.49523 0.0432	-0.55398 0.0210	0.18626 0.4751
BARREN					1.00000 0.0000	0.06609 0.8010	0.34696 0.1725	-0.28494 0.2676	0.37132 0.1423	-0.07585 0.7723
RELIEF						1.00000 0.0000	0.61511 0.0086	-0.58858 0.0129	-0.46912 0.0575	0.38829 0.1235
SHORE							1.00000 0.0000	-0.36464 0.1501	-0.37326 0.1400	0.71381 0.0013
DEPTH								1.00000 0.0000	0.21519 0.4068	-0.12963 0.6199
DISTANCE									1.00000 0.0000	-0.52525 0.0304
HOMES										1.00000 0.0000

wanting to live near a lake demand property that borders the lake, rather than property located at a distance from water. If there is more shoreline in a particular section, there is more area that can be developed for lake homes.

The next strongest correlation between homes and another variable occurred with distance from shoreline to an improved road (R= -.53, P= .03). Because of the negative correlation, this analysis implies that the number of homes found within a section decreases as distance to an improved road increases. Greater access to lakeshore would seem to be a significant factor in the location of homes on Pelican Lake; this evidence concurs with Borchert's (1970) study which showed accessibility to be a major factor in consideration of lakeshore home location.

The correlation coefficient yielded for homes and acres of water other than Pelican Lake (R=.48, P=.05) implies that a greater number of homes appear in those sections which contain a larger portion of water. This correlation may best be explained by the large number of lakes and ponds found scattered throughout the watershed. Homes lying on the shores of lakes other than Pelican Lake are not included in this study and, therefore, would not be a factor in this analysis.

Dwellings

Strength of the degree of association between relief and number of dwellings (R=.73, P=.001) suggests that the greater the relief found in a section, the greater the number of dwellings (Table 7). This evidence concurs with Borchert's (1970) and Orning's (1976) findings concerning physical characteristics, such as relief and scenery, being of major consideration in second home locations. The addition to the model of condominiums at Breezy Point and its presence in an area of high relief increases this degree of association.

A high level of significance continues to exist between the length of shoreline and number of dwellings (R=.51, P=.04), suggesting that the longer the shoreline, the greater the number of dwellings.

STEPWISE REGRESSION

Stepwise Regression procedure chooses the most significant of the independent variables for inclusion in the multiple regression model. First, a selection process finds the single variable model which produces the largest R-square value (coefficient of determination). An F-statistic is calculated for each of the remaining variables, reflecting the contribution that each variable would make to the model if it were included. The variable with the largest F-statistic and a level of significance greater than the specified significance probability (P=.10) is then added to

TABLE 7

CORRELATION MATRIX GENERATED BY PEARSONS CORRELATION ROUTINE (DWELLINGS)

	FOREST	PELICAN	WATER	WETLAND	BARREN	RELIEF	SHORE	DEPTH	DISTANCE	DWELLING
FOREST	1.00000 0.0000	-0.93546 0.0001	0.63754 0.0039	0.44015 0.0770	0.15505 0.5786	0.50022 0.0409	0.37103 0.1426	-0.42555 0.0877	-0.37590 0.1370	0.22269 0.3903
PELICAN		1.00000 0.0000	-0.69412 0.0020	-0.60125 0.0107	-0.30348 0.2363	-0.62367 0.0075	-0.47425 0.0544	0.56509 0.0183	0.39991 0.1117	-0.31534 0.2205
WATER			1.00000 0.0000	0.57631 0.0168	-0.23192 0.3702	0.28676 0.2645	0.15070 0.5637	-0.28378 0.2732	-0.56608 0.0173	0.05588 0.8412
WETLAND				1.00000 0.0000	-0.09252 0.7234	0.56919 0.0171	0.19677 0.4491	-0.59523 0.0542	-0.55398 0.0210	0.04452 0.8653
BARREN					1.00000 0.0000	0.06609 0.8010	0.35698 0.1775	-0.28493 0.2676	0.37132 0.1423	0.08711 0.7395
RELIEF						1.00000 0.0000	0.61513 0.0086	-0.58858 0.0129	-0.50912 0.0575	0.72592 0.0010
SHORE							1.00000 0.0000	-0.36464 0.1501	-0.37326 0.1400	0.50538 0.0585
DEPTH								1.00000 0.0000	0.21519 0.4068	-0.26135 0.3109
DISTANCE									1.00000 0.0000	[illegible] [illegible]
DWELLING										1.00000 0.0000

the model. F-statistics are again calculated for those variables which remain outside the model and this process is repeated until no variable produces a significant F-statistic. The stepwise selection technique then calculates partial F-statistics for variables already included in the model. A variable is deleted if it does not produce a partial F-statistic at the specified significance level for staying in the model. The process continues until no variable meets conditions for inclusion or when the variable to be added has just been deleted (SAS Institute Inc., 1982). Tables 8 and 9 list the variables selected by the stepwise procedure.

TABLE 8

VARIABLES SELECTED BY THE STEPWISE PROCEDURE
(DEPENDENT VARIABLE = HOMES)

VARIABLE	R-SQUARE	F-STATISTIC	PROB GT F
Length of Shoreline	.51	15.58	.0013
Acres of Water	.65	13.03	.0006
Acres of Pelican Lake	.77	14.52	.0002

TABLE 9

VARIABLES SELECTED BY THE STEPWISE PROCEDURE
(DEPENDENT VARIABLE = DWELLINGS)

VARIABLE	R-SQUARE	F-STATISTIC	PROB GT F
Relief	.53	16.71	.001
Acres of Wetland	.73	18.74	.0001

the model. F-statistics are again calculated for those variables which remain outside the model and this process is repeated until no variable produces a significant F-statistic. The stepwise selection technique then calculates partial F-statistics for variables already included in the model. A variable is deleted if it does not produce a partial F-statistic at the specified significance level for staying in the model. The process continues until no variable meets conditions for inclusion or when the variable to be added has just been deleted (SAS Institute Inc., 1982). Tables 8 and 9 list the variables selected by the stepwise procedure.

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(DEPENDENT VARIABLE = DWELLINGS)

VARIABLE	R-SQUARE	F-STATISTIC	PROB GT F
Relief	.53	16.71	.001
Acres of Wetland	.73	18.74	.0001

Homes

Of the nine variables used in this analysis, the length of shoreline explains the largest percentage of variation in number of lakeshore homes in each section on Pelican Lake. As determined in the Pearson's Correlation Matrix (Table 6), this variable has the largest R-value when correlated with number of homes; thus its inclusion as the most important variable in the model. Acres in water other than Pelican Lake is selected for the model when the stepwise procedure is repeated. Together with length of shoreline, the model explains 65% of the variation in number of homes. Though distance to nearest improved road is correlated more significantly with homes (R= -.53) than acres of water (R=.48), it is apparent from the stepwise selection process that the combination of shoreline length and acres of water explains a larger proportion of the location of lakeshore homes. The final variable selected for inclusion in the model is acres within Pelican Lake itself. It is important to realize the correlation that exists between homes and acres in Pelican Lake is a negative one; that is, the greater the percentage of a section's area lying in Pelican Lake, the fewer the number of homes to be expected. The reason for this would be that there is less area to be developed, thus less homes. When combined, the effect of the three variables explains 77% of the variation in homesites.

Dwellings

Of the nine variables used in this analysis, the amount of relief explains the largest percentage of variation in the number of lakeshore dwellings on Pelican Lake. The R-value of relief when correlated with number of dwellings increases compared to that of relief vs. homes because of the influence of Breezy Point. Significant relief in Breezy Point's two sections combined with the large number of dwellings raises the significance of relief's R-value. When the stepwise procedure is repeated, acres in wetland is selected for the model. It should be noted that a very weak correlation exists between wetland and number of dwellings; every other variable, in fact, has a more significant correlation with number of dwellings than does wetland (Table 7). It should also be noted that it is a positive correlation which exists between wetland and number of dwellings. But again, a significant amount of wetland exists in a section which contains almost 250 dwellings, obscuring the significance of other variables. Combination of relief and wetland explain 73% of the variation in location of lakeshore dwellings on Pelican Lake.

Figures 45-48 illustrate the best relationships found between the nine independent variables and the number of homes/dwellings.

Multivariate models constructed for both homes and dwellings are as follows:

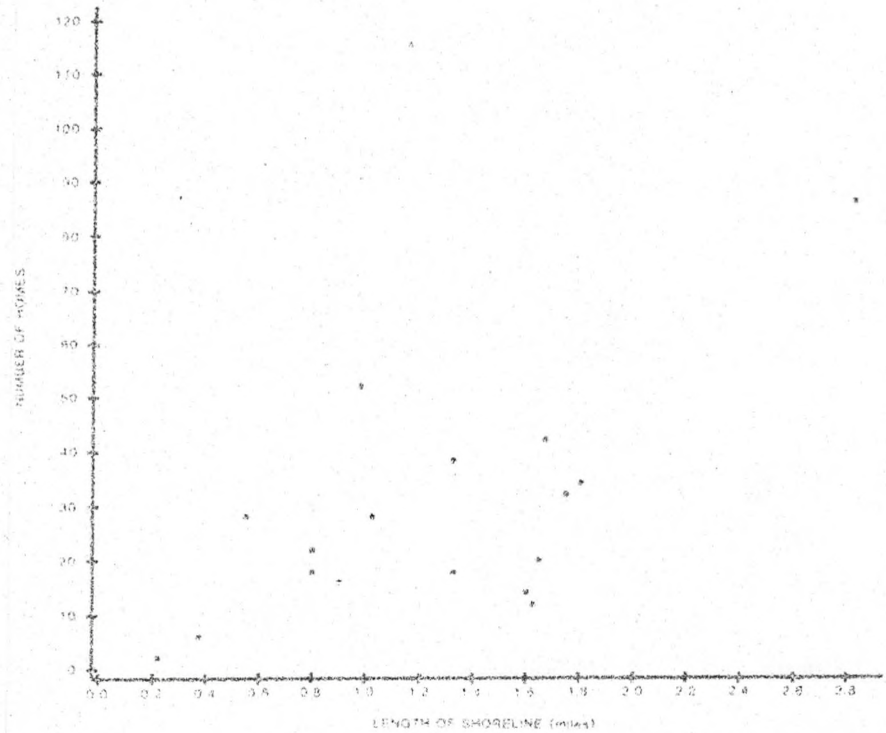

Figure 45: Scattergram Depicting the Relationship between Length of Shoreline and Number of Homes.

Figure 46: Scattergram Depicting the Relationship between Distance to Road and Number of Homes.

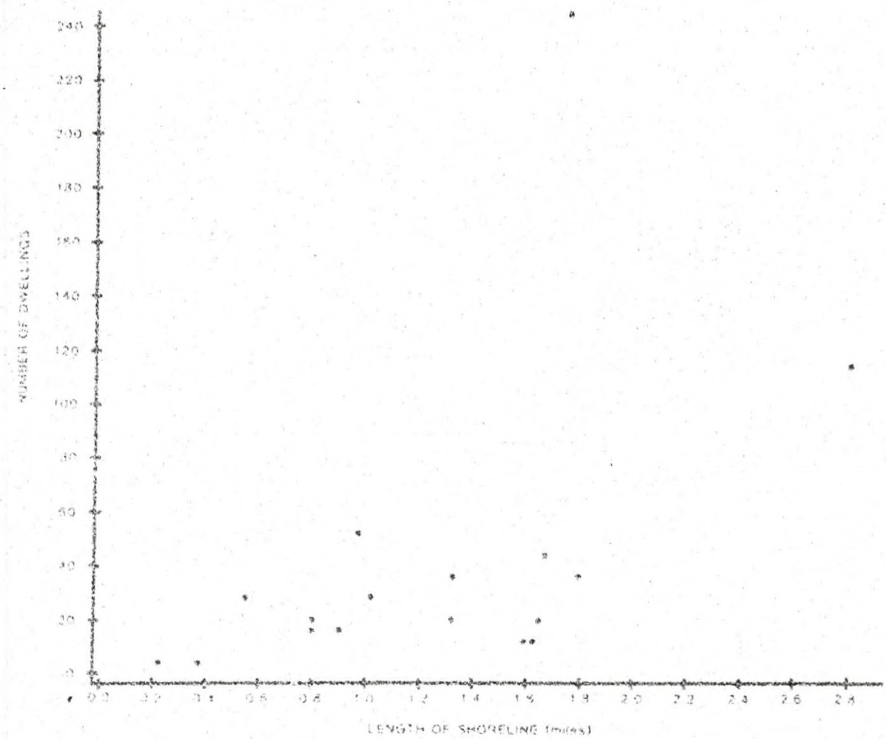

Figure 47: Scattergram Depicting the Relationship between Length of Shoreline and Number of Dwellings.

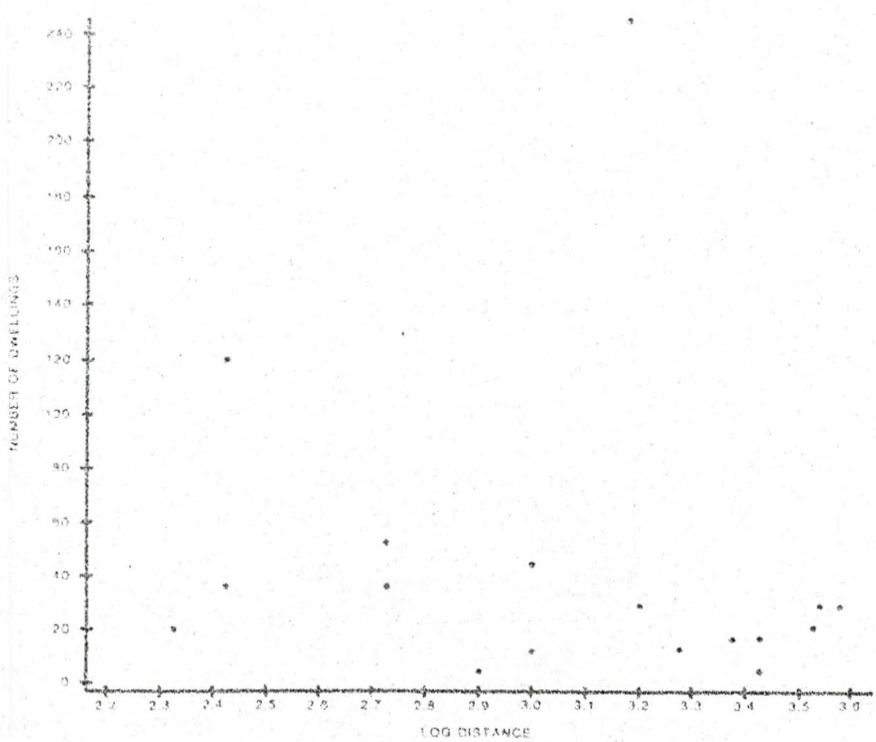

Figure 48: Scattergram Depicting the Relationship between Distance to Road and Number of Dwellings.

Homes: $Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3$

where:

Y is the predicted location of lakehomes,

b is the slope of the regression line,

x_1 represents length of shoreline,

x_2 represents acres of water other than Pelican Lake, and

x_3 represents acres in Pelican Lake.

A large portion of the lakehome locations can thus be predicted when the slope and actual values are inserted for each of the three variables in the equation:

$$Y = -30.16 + (25.43)x_1 + (.27)x_2 + (.05)x_3.$$

Dwellings: $Y = b_0 + b_1x_1 + b_2x_2$

where:

Y is the predicted location of lakeshore dwellings,

b is the slope of the regression line,

x_1 represents the relief, and

x_2 represents acres of wetland.

A large portion of the lakeshore dwelling locations can thus be predicted when the slope and actual values are inserted for each of the two variables in the equation:

$$Y = -23.24 + (2.43)x_1 + (-.68)x_2.$$

GENERAL LINEAR MODEL

In order to determine the percentages of variation in lakeshore home/dwelling location that the remaining variables (i.e., those not included in the stepwise model) explain, a general linear multiple regression was run for both homes and dwellings. In the case of homes, an R-square value of .83 indicates that the combination of all variables explains 83% of the variation in lakeshore home location surrounding Pelican Lake. Thus, the six variables not included in the stepwise model contribute only an additional 6% explanation to the model.

In the case of number of dwellings, an R-square value of .92 indicates that the combination of all variables explains 92% of the variation in lakeshore dwelling location. In this instance, the seven variables not included in the stepwise model contribute an additional 19% explanation to the model.

CONCLUSION

SUMMARY OF RESULTS

Eleven variables were initially analyzed in order to determine if there was any relationship between various land use and physical characteristics of Pelican Lake and its watershed, and the location of homes/dwellings surrounding the lake. Prior to the correlation and regression procedures, it was determined that the variables, urban and agricultural acres, would need to be excluded from the analysis. There has been much recreational development taking place in the two sections of Breezy Point included in this study during the past fifty years. Reasons for individuals wanting to build in this area include: 1) easy access to utilities such as electricity, water, and sewage; 2) service availability, such as shopping and dining; 3) recreational facilities, such as golf, tennis, a marina to store and rent boats, and an airport; 4) close proximity to others, for those that appreciate this rather than isolation, and; 5) price investment -- resale availability is likely to increase as a result of the amenities mentioned above. The strong degree of association that exists between urban acres and location of lakeshore homes/dwellings tends to obscure any relationships which may exist between the remaining variables and number of homes/dwellings. A similar circumstance occurs when including agricultural acres in the Breezy Point area, and the lack of agricultural land in most of the remaining sections. As a result, urban and agriculture were omitted from the correlation and regression models.

Of the remaining nine variables, five were determined to be significant in determining lakeshore home/dwelling location on Pelican Lake: 1) length of shoreline; 2) distance to nearest improved road; 3) amount of relief; 4) acres of water other than Pelican Lake, and; 5) acres in Pelican Lake. Length of shoreline proved to be the leading indicator in the number of homes/dwellings in each section bordering Pelican Lake, with the remaining four variables having various degrees of association with number of homes/dwellings. Breezy Point's influence on the analysis continued to be apparent with such variables as relief, whose correlation coefficient rose significantly when including condominium units in the model.

Of the land use/cover data obtained from the aerial photographs, only acres of that land covered by water and acres in Pelican Lake were determined to be of significance in location of lakeshore homes/dwellings. Forest acreage understandably had little significance because of its dominance throughout the watershed. Wetland had little significance, except when combined with the amount of relief in the regression model analyzing dwellings. Wetland's correlation with number of homes/dwellings is a positive one, primarily influenced by the Breezy Point area, which contains a significant amount of wetland acreage. Principal wetland areas lie at a distance from Pelican Lake; very few wetland areas border on the lake itself. Therefore, the positive correlation between wetland acres and number of homes/dwellings is likely not indicative of what is actually occurring at Pelican Lake. Barren land would seem to have negligible influence on the locations of lakeshore homes/dwellings. The barren area bordering Pelican Lake in 1939 was fairly uniform, resulting in an insignificant correlation coefficient.

As a result of this analysis, two major conclusions can be reached: 1) development has been, and continues to be, increasing very rapidly in the Breezy Point area of Pelican Lake. Reasons for persons desiring to locate in this area have been previously mentioned, and; 2) development has been spreading out around the lake since the 1940s with one apparent factor being of significance in determination of lakeshore home/dwelling location; this being distance to nearest improved road. Access appears to be of major concern in an area such as this which is heavily wooded with few roads. Length of shoreline and acres of a section in Pelican Lake are not true factors of desirability: 1) the longer the shoreline, the more area that can be developed, thus more homes, and; 2) the greater the amount of a section in Pelican Lake, the less land area within that section, thus fewer homes. Though agriculture was omitted from the correlation and regression routines, it may have played a major role in determining the location of lakeshore homes/ dwellings to some extent. When studying the 1939 land use maps of the Pelican Lake watershed (Figures 6-11), it is apparent that agriculture was primarily located in the Breezy Point area and along the southern perimeter of the watershed. These areas coincide with those of heaviest development (Figures 38-44). Persons may have developed in areas of more agriculture because farmers maintained good access to their fields, thus prospective owners had greater access to Pelican Lake. The remaining aspects of land use and physical characteristics have negligible associations with locations of lakeshore homes/dwellings because they are relatively uniform throughout the watershed; few abberations exist.

FUTURE RESEARCH

Research similar to this study could be conducted throughout the state of Minnesota in order to better predict those areas which have the potential to be developed more rapidly than others. Knowledge such as this could be used to prepare an area's residents and landowners for the development and make the transition from undeveloped to developed less troublesome. A number of lakes from various areas of the state could be included in a model in order to better understand building patterns in lakeshore environments. In that way, a number of additional variables could be analyzed, such as soil types, depth to water table, vegetation type, etc.

Aerial photography is an excellent tool for studies such as this. Other forms of remote sensing could also be used in the assessment of physical characteristics and land use and their impact on development.

Water quality studies concerning Pelican Lake are not practical at this time due to a lack of groundwater information pertaining to this area. Until groundwater data is made available, a determination of recreational development's affects on water quality at Pelican Lake can not be made.

Recreational development is something which will continue to expand on specific lakes in Minnesota as variables, such as disposable income, leisure time, and population continue to increase. To ensure that future land use allocation and resource plans meet the needs of the public, a resource information system using data from studies like this needs to be developed. If people who make decisions about land and resources have better access to the proper information, they are likely to make better decisions.

APPENDICES

Appendix A

DEVELOPMENT ON PELICAN LAKE BY SECTION 1930-1984

(Crow Wing County Auditor, Brainerd, MN)

TABLE 10

DEVELOPMENT ON PELICAN LAKE BY SECTION

Section	1930	1940	1950	1960	1970	1980	1984
Pelican Township (T136N R28W)							
10	0	0	0	1	8	12	15
11	0	0	1	7	19	33	42
12	0	0	0	0	2	6	11
13	0	0	0	0	0	12	17
15	1	1	2	3	9	16	18
16	10	10	10	10	169	176	243
21	10	10	14	22	48	103	120
24	0	0	0	1	1	2	2
25	0	0	0	13	15	15	20
27	1	1	3	4	7	12	13
28	0	0	0	3	8	15	21
33	0	1	6	9	21	33	34
34	0	1	3	5	4	5	5
35	3	3	4	7	20	25	27
36	0	0	0	4	16	26	27
Mission Township (T136N R27W)							
18	4	4	4	13	27	37	40
19	2	2	8	17	37	48	51
Lake Edward Township (T135N R28W)							
2	6	9	15	17	32	41	42
3	7	9	17	17	23	36	37
4	0	0	0	5	10	11	11

Appendix B

AERIAL PHOTOGRAPHY STATISTICS

TABLE 11

AERIAL PHOTOGRAPHY STATISTICS (1930, 1960)

Date	Scale	Photo Number	DNR Area Office
9/20/39	1:21,120	BXT-2-53	Brainerd
		BXT-2-54	Pequot Lakes
		BXT-2-56	Pequot Lakes
		BXT-2-57	Pequot Lakes
		BXT-2-71	Pequot Lakes
		BXT-2-73	Pequot Lakes
		BXT-2-104	Pequot Lakes
		BXT-5-106	Brainerd
		BXT-5-108	Pequot Lakes
7/22/60	1:16,600	CRW-6-48	Pequot Lakes
		CRW-6-49	Pequot Lakes
		CRW-6-50	Pequot Lakes
		CRW-6-51	Pequot Lakes
		CRW-6-52	Pequot Lakes
		CRW-5-135	Pequot Lakes
		CRW-5-136	Pequot Lakes
		CRW-5-137	Pequot Lakes
		CRW-5-138	Pequot Lakes
		CRW-5-139	Pequot Lakes
		CRW-5-197	Pequot Lakes
		CRW-5-198	Pequot Lakes
		CRW-5-199	Pequot Lakes
		CRW-5-200	Pequot Lakes
		CRW-5-201	Pequot Lakes
		CRW-5-202	Pequot Lakes

Note: All photographs were black and white paper prints portraying a north-south flight direction.

TABLE 12

AERIAL PHOTOGRAPHY STATISTICS (1969, 1978)

Date	Scale	Photo Number	DNR Area Office
8/16/69	1:15,967	CROW-W-2-70	Pequot Lakes
		CROW-W-2-71	Pequot Lakes
		CROW-W-2-72	Pequot Lakes
		CROW-W-2-73	Pequot Lakes
		CROW-W-2-74	Pequot Lakes
		CROW-W-2-106	Pequot Lakes
		CROW-W-2-107	Pequot Lakes
		CROW-W-2-108	Pequot Lakes
		CROW-W-2-109	Pequot Lakes
		CROW-W-2-110	Pequot Lakes
		CROW-W-2-179	Pequot Lakes
		CROW-W-2-180	Pequot Lakes
		CROW-W-2-181	Pequot Lakes
		CROW-W-2-182	Pequot Lakes
		CROW-W-2-183	Pequot Lakes
		CROW-W-2-184	Pequot Lakes
8/4/78	1:15,840	CRW-2-31	Pequot Lakes
		CRW-2-32	Pequot Lakes
		CRW-2-34	Pequot Lakes
		CRW-2-35	Pequot Lakes
		CRW-2-36	Pequot Lakes
		CRW-2-71	Pequot Lakes
		CRW-2-72	Pequot Lakes
		CRW-2-73	Pequot Lakes
		CRW-2-73A	Pequot Lakes
		CRW-2-74	Pequot Lakes
		CRW-2-74A	Pequot Lakes
		CRW-2-179	Pequot Lakes
		CRW-2-180	Brainerd
		CRW-2-181	Brainerd

Note: All photographs were black and white paper prints portraying a north-south flight direction.

Appendix C

SECTIONAL LAND-USE DATA, 1939- 78

(Obtained From Aerial Photography)

TABLE 13

PELICAN LAKE WATERSHED LAND USE DATA (IN ACRES), 1939

Sec.	Urb.	Ag.	For.	Pel. Lake	Other Water	Wet.	Bar.
Pelican Township (T136N R28W)							
8	0	61	414	0	0	4	12
9	0	21	444	0	114	45	16
10	0	22	311	49	83	58	116
11	0	0	146	375	0	13	106
12	0	9	408	0	16	65	142
13	0	0	36	514	0	4	86
14	0	0	0	630	0	0	10
15	0	17	39	551	1	0	32
16	70	53	270	126	1	14	106
17	0	40	459	0	0	0	1
20	0	0	272	0	0	7	3
21	64	0	211	116	103	86	60
22	0	0	9	588	0	0	43
23	0	0	0	640	0	0	0
24	0	0	1	628	0	0	11
25	0	0	128	244	4	0	264
26	0	0	0	640	0	0	0
27	0	0	123	435	0	0	82
28	0	0	281	33	130	178	18
29	0	0	278	0	1	9	24
32	0	0	128	0	0	4	2
33	0	27	416	38	98	36	25
34	0	0	13	608	0	0	19
35	0	0	38	581	0	0	21
36	0	0	367	105	88	9	71
Mission Township (T136N R27W)							
7	0	31	77	0	0	0	0
18	0	0	161	114	54	0	45
19	0	11	302	139	152	0	36
30	0	58	413	0	92	20	57
31	0	27	518	0	55	38	2
Lake Edward Township (T135N R28W)							
1	0	0	210	0	103	40	22
2	0	35	141	30	51	44	201
3	0	0	211	392	0	3	32
4	0	8	283	1	0	12	16
10	0	43	63	0	0	11	65
11	0	52	61	0	0	0	0

TABLE 14

PELICAN LAKE WATERSHED LAND USE DATA (IN ACRES), 1960

Sec.	Urb.	Ag.	For.	Pel. Lake	Other Water	Wet.	Bar.
Pelican Township (T136N R28W)							
8	0	56	428	0	0	7	0
9	0	0	447	0	142	51	0
10	0	0	404	67	104	31	34
11	0	0	137	451	1	26	25
12	0	0	486	52	0	93	9
13	0	0	36	593	0	8	3
14	0	0	640	0	0	0	0
15	0	0	45	563	0	17	15
16	76	0	312	187	0	6	59
17	0	42	445	0	0	5	8
20	0	1	266	0	0	14	2
21	21	0	278	270	4	43	24
22	0	0	16	624	0	0	0
23	0	0	0	640	0	0	0
24	0	0	4	634	0	1	1
25	0	0	149	439	5	40	7
26	0	0	0	640	0	0	0
27	0	0	166	468	0	0	6
28	0	0	329	57	154	98	2
29	0	2	301	0	0	9	0
32	0	0	130	0	0	4	0
33	0	19	404	67	119	23	8
34	0	0	9	626	0	0	6
35	0	0	28	606	0	0	6
36	0	0	347	161	95	13	24
Mission Township (T136N R27W)							
7	0	32	77	0	0	0	0
18	0	0	142	129	70	0	33
19	0	5	278	145	175	0	37
30	0	40	461	0	104	28	7
31	0	19	509	0	75	17	20
Lake Edward Township (T135N R28W)							
1	0	0	182	0	148	20	25
2	0	6	273	58	101	8	56
3	0	6	200	415	0	6	11
4	0	11	284	2	8	12	3
10	0	40	125	0	0	17	0
11	0	47	66	0	0	0	0

TABLE 15

PELICAN LAKE WATERSHED LAND USE DATA (IN ACRES), 1969

Sec.	Urb.	Ag.	For.	Pel. Lake	Other Water	Wet.	Bar.
Pelican Township (T136N R28W)							
8	0	46	426	0	0	2	17
9	0	0	407	0	145	49	39
10	0	0	406	106	70	44	14
11	0	0	138	444	1	21	36
12	0	0	489	44	8	85	14
13	0	0	38	592	0	5	5
14	0	0	640	0	0	0	0
15	0	0	55	562	0	14	9
16	85	0	322	147	1	5	80
17	0	43	447	0	0	2	8
20	6	1	255	0	2	16	2
21	46	0	291	233	2	35	33
22	0	0	15	625	0	0	0
23	0	0	0	640	0	0	0
24	0	0	1	636	0	2	1
25	0	0	140	446	5	36	13
26	0	0	0	640	0	0	0
27	0	0	173	457	0	0	10
28	0	0	318	40	151	126	5
29	0	2	270	0	0	11	29
32	0	0	105	0	0	3	26
33	0	17	411	56	122	20	14
34	0	0	16	615	0	0	9
35	0	0	26	608	0	0	6
36	0	0	316	188	104	14	18
Mission Township (T136N R27W)							
7	0	26	82	0	0	0	0
18	0	0	136	145	59	0	34
19	0	4	291	166	154	0	25
30	0	22	465	0	113	21	19
31	0	13	515	0	79	27	6
Lake Edward Township (T135 R28W)							
1	0	0	179	0	151	30	15
2	0	30	270	77	91	8	26
3	0	6	184	418	0	6	24
4	0	9	285	3	6	10	7
10	0	42	124	0	0	16	0
11	0	48	65	0	0	0	0

TABLE 16

PELICAN LAKE WATERSHED LAND USE DATA (IN ACRES), 1978

Sec.	Urb.	Ag.	For.	Pel. Lake	Other Water	Wet.	Bar.
Pelican Township (T136N R28W)							
8	0	49	429	0	0	4	9
9	0	0	453	0	132	50	5
10	0	0	423	104	58	43	12
11	0	0	151	438	0	15	36
12	0	0	504	34	3	91	8
13	0	0	41	584	0	9	6
14	0	0	0	640	0	0	0
15	0	0	55	566	0	16	3
16	119	0	305	176	0	6	34
17	4	43	446	0	0	4	3
20	21	1	241	0	0	5	14
21	31	0	291	253	6	41	18
22	0	0	15	625	0	C	0
23	0	0	0	640	0	0	0
24	0	0	4	635	0	0	1
25	0	0	152	434	5	39	10
26	0	0	0	640	0	0	0
27	0	0	160	470	0	0	10
28	0	0	324	55	130	127	4
29	0	1	278	0	0	8	25
32	0	0	111	0	0	2	21
33	0	15	405	57	120	21	22
34	0	0	13	621	0	0	6
35	0	0	23	612	0	0	5
36	0	0	359	161	88	14	18
Mission Township (T136N R27W)							
7	0	29	79	0	0	0	0
18	0	0	203	107	40	0	24
19	0	0	299	144	162	0	35
30	0	0	464	0	103	21	52
31	0	6	519	0	73	22	20
Lake Edward Township (T135N R28W)							
1	0	3	174	0	141	32	25
2	0	4	264	70	93	10	61
3	0	6	207	402	0	5	18
4	0	8	277	2	0	14	19
10	0	43	122	0	0	17	0
11	0	47	66	0	0	0	0

Appendix D

PRECIPITATION DATA 1912-1980

(MN Department of Natural Resources,

Division of Waters, State Climatology Office)

TABLE 17

PRECIPITATION 1912-1980 (Brainerd, MN)

Year	Precipitation (inches)	Year	Precipitation (inches)
1912	25.84	1947	20.55
1913	25.04	1948	22.22
1914	26.06	1949	24.33
1915	29.13	1950	24.71
1916	29.65	1951	34.66
1917	17.36	1952	26.52
1918	18.20	1953	35.39
1919	26.74	1954	21.09
1920	23.93	1955	25.36
1921	23.26	1956	22.57
1922	22.40	1957	27.63
1923	19.74	1958	23.94
1924	27.27	1959	27.90
1925	19.05	1960	24.58
1926	25.56	1961	19.81
1927	20.72	1962	26.34
1928	25.31	1963	28.79
1929	16.63	1964	26.16
1930	19.80	1965	34.99
1931	23.76	1966	27.13
1932	19.54	1967	18.56
1933	24.53	1968	35.78
1934	17.46	1969	24.33
1935	25.49	1970	26.74
1936	15.81	1971	32.94
1937	21.09	1972	33.54
1938	31.34	1973	30.71
1939	20.59	1974	24.38
1940	21.48	1975	27.61
1941	29.49	1976	13.16
1942	26.29	1977	35.19
1943	26.65	1978	25.39
1944	34.29	1979	24.96
1945	20.26	1980	22.19
1946	25.08		

REFERENCES

American Land Development Association. The Land Industry Survey, 1973. Washington, D.C.: Government Printing Office, 1973.

American Society of Planning Officials. Waterfronts: Planning for Resort and Residential Uses. Washington, D.C.: Government Printing Office, 1959.

American Society of Planning Officials. Subdividing Rural America. Washington, D.C.: Government Printing Office, 1976.

Anderson, J.R.; Hardy, E.E.; Roach, J.T.; and Witmer, R.E. A Land Use and Land Cover Classification System for Use with Remote Sensor Data. U.S. Geological Society Professional Paper 964, Washington, D.C.: Government Printing Office, 1976.

Borchert, John R. Minnesota's Lakeshore: Resources, Development, Policy Needs. Parts I and II. Minneapolis: University of Minnesota Press, 1970.

Brockman, C. Frank and Merriam, Lawrence C. Jr. Recreational Use of Wild Lands. New York: McGraw-Hill Company, 1979.

Clayton, Lee and Moran, Stephen R. "Chronology of Late Wisconsinan Glaciation in Middle North America." Quaternary Science Reviews 1 (1982): 55-82.

Cole, Gerald A. Textbook of Limnology. St. Louis: C.V. Mosby Company, 1975.

Davis, Kenneth P. Land Use. New York: McGraw-Hill Company, 1976.

Epperson, Arlin F. Private and Commercial Recreation: A Text and Reference. New York: John Wiley and Sons, 1977.

Fabos, Julius Gy. "An Analysis of Environmental Quality Ranking Systems." In Proceedings of Recreation Symposium. Syracuse, New York: USDA Forest Service, 1971.

Fabos, Julius Gy. Planning the Total Landscape: A Guide to Intelligent Land Use. Boulder, Colorado: Westview Press, 1979.

Gunn, C.A. "Public-Pivate Interface." In Land and Leisure: Concepts and Methods in Outdoor Recreation. Edited by Van Doren, Carlton S.; Priddle, George B.; and Lewis, John E.. Chicago: Maaroufa Press, Inc., 1979: 145-147.

Hammond, R. and McCullagh, P.S. Quantitative Techniques in Geography. Oxford: Clarendon Press, 1978.

Harrell, Lyle E. "Tour of Subdivisions in Lassen and Madera Counties." Oregon, 1971. (Mimeographed.)

Hart, John Fraser. The Look of the Land. Englewood Cliffs, New Jersey: Prentice-Hall, 1975.

Hart, John Fraser. "Population Change in the Upper Great Lake States." Annals of the Association of American Geographers 74 (June 1984): 221-243.

Hodges, Ernest J. "Private Enterprise Reacts to Recreation Demands." In Issues in Outdoor Recreation. Edited by Jensen, Clayne R. and Thorstenson, Clark T.. Minneapolis, Minnesota: Burgess Publishing Company, 1977: 145-147.

Jensen, Clayne R. Outdoor Recreation in America: Trends, Problems, and Opportunities. Minneapolis, Minnesota: Burgess Publishing Company, 1977.

Johannsen, Chris J. and Barney, Terry W. "Land Use Change and Concerns in Missouri." In Innovations in Land Use Management. Edited by Dando, William A. and Johnson, Gary E.. Grand Forks, North Dakota: University of North Dakota Press, 1976: 71-77.

Knudson, Douglas M. Outdoor Recreation. New York: Macmillan Publishing Company, 1980.

Koppen, Wladimir and Geiger, R. Klima der Erde. Darmstadt, Germany: Justus Perthes, 1954.

Laboratory for Computer Graphics and Spatial Analysis. SYMVU Manual. Cambridge, Massachusetts: Harvard University Press, 1975.

Latham, Craig A. and White, Denis. CALFORM Manual. Cambridge, Massachusetts: Laboratory for Computer Graphics and Spatial Analysis, Harvard University, 1978.

"Leisure Boom: Biggest Ever and Still Growing." U.S. News and World Report, April 17, 1972, pp. 42-45.

Luekenon, Roy. Crow Wing County Auditor's Office, Brainerd, Minnesota. Personal Communication, 20 June 1984.

Marsh, William M. Environmental Analysis for Land Use and Site Planning. New York: McGraw-Hill Company, 1978.

Martin, Wendall H. "Remote Land: Development or Exploitation." Urban Land 30 (1971): 4-10.

Minnesota Department of Natural Resources. "Lake Survey Summary - Pelican Lake." Brainerd, Minnesota, 1943. (Mimeographed.)

Minnesota Department of Natural Resources. "Lake Survey Summary - Pelican Lake." Brainerd, Minnesota, 1977. (Mimeographed.)

Minnesota Department of Natural Resources. "Lake Survey Summary - Pelican Lake." Brainerd, Minnesota, 1983. (Mimeographed.)

National Oceanic and Atmospheric Administration. Climates of the States Vol. II - Western States. Port Washington, New York: Water Information Center, Inc., 1974.

Nelson, Bruce Kenneth. Minnesota Treasure Maps. Rosemount, Minnesota: Treasure Publishing Company, 1982.

"Number of Resorts in Itasca County Down, Study Says." Minneapolis Tribune, 31 October 1983, sec. 2, p. 1.

Oakes, E.L. and Bidwell, L.E. Water Resources of the Mississippi Headwaters Watershed North Central Minnesota. U.S. Geological Survey, Hydrologic Investigations Atlas-278, Washington, D.C.: Government Printing Office, 1968.

Ojakangas, Richard W. and Matsch, Charles L. Minnesota's Geology. Minneapolis, Minnesota: University of Minnesota Press, 1982.

Orning, George William. "The Use of a Land Information System for Land Allocation Decisions." In Innovations in Land Use Management. Edited by Dando, William A. and Johnson, Gary E.. Grand Forks, North Dakota: University of North Dakota Press, 1976: 25-34.

Parsons, James J. "Slicing Up Open Space: Subdivisions Without Homes in Northern California." Erdkunde 36 (1972): 1-8.

Platt, Rutherford H. "Backwoods Urban Growth: The Recreation Land Development Boom." Proceedings, Association of American Geographers 5 (1973): 225-229.

"Politics of Water: The Struggle over Lake Pulaski." Minneapolis Tribune, 10 September 1984, sec. 1, p. 1.

SAS Institute Inc. SAS User's Guide: Statistics, 1982 Edition. Cary, North Carolina: SAS Institute Inc., 1982.

Snyder, Robert. "Vacation Homes, Economic Development, and Local Government Policy in Rural Minnesota." Minnesota Agricultural Economist (June 1969): 1-4.

Snyder, Robert and Adams, Duane. "Seasonal Recreational Properties in Minnesota." Farm Business Notes 495 (1967): 1-3.

Stroud, Hubert B. "Environmental Problems Associated with Large Recreational Subdivisions." Professional Geographer 35 (1983): 303-313.

Thirty Lakes Watershed District. "Regulations of the Thirty Lakes Watershed District." Brainerd, Minnesota, 1972. (Mimeographed.)

Thorsen, Brian J.; Cooper, Rollin B.; Stanifoeth, Sydney D.; and Christiansen, Rudolph A. Wisconsin Second Home Ownership: Wisconsin Residents. Madison, Wisconsin: University of Wisconsin Press, 1973.

"Time-Sharing Reviving Venerable Breezy Point." Minneapolis Tribune, 26 February 1984, sec.4, p. 1.

Tombaugh, Larry W. "Factors Influencing Vacation Home Locations." Journal of Leisure Research 2 (1970): 54-63.

University of Minnesota, Department of Soil Science. Minnesota Soil Atlas, Brainerd Sheet. Minneapolis, Minnesota: University of Minnesota Press, 1969.

Urban Land Institute. Residential Development Handbook. Washington, D.C.: Government Printing Office, 1978.

U.S. Bureau of the Census. Census of Housing: Characteristics of Housing Units: Vol. 1, Part 25, Minnesota. Washington, D.C.: Government Printing Office, 1970.

U.S. Bureau of the Census. Census of Housing: Characteristics of Housing Units: Vol. 1, Part 25, Minnesota. Washington, D.C.: Government Printing Office, 1980.

U.S. Bureau of the Census. Statistical Abstract of the United States: 1984. Washington, D.C.: Government Printing Office, 1983.

U.S. Department of Housing and Urban Development, Office of Interstate Land Sales Registration. "Recreational Subdivisions." Washington, D.C., 1973. (Mimeographed.)

U.S. Department of the Interior, Bureau of Outdoor Recreation. Outdoor Recreation, A Legacy for America: A Summary of Outdoor Recreation in America 1972-1978. Washington, D.C.: Government Printing Office, 1973.

Wheeler, Douglas P. "Private Involvement in Outdoor Recreation." In Issues in Outdoor Recreation. Edited by Jensen, Clayne R. and Thorstenson, Clark T.. Minneapolis, Minnesota: Burgess Publishing Company, 1977.

Zelinsky, Wilbur. "Changes in the Geographic Patterns of Rural Population in the United States." The Geographical Review 52 (October 1962): 492-524.

Zumberge, James H. The Lakes of Minnesota: Their Origin and Classification. Minneapolis, Minnesota: University of Minnesota Press, 1952.