METHOD FOR PREDICTING WATER DEMAND FOR CROP USES IN NEW JERSEY IN 1990, 2000, 2010, AND 2020, AND FOR ESTIMATING WATER USE FOR LIVESTOCK AND SELECTED SECTORS OF THE FOOD-PROCESSING INDUSTRY IN NEW JERSEY IN 1987

By Rick M. Clawges and Elizabeth O. Titus

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BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Robert M. Hirsch, Acting Director

For additional information
write to:

District Chief
U.S. Geological Survey
Mountain View Office Park
810 Bear Tavern Road
Suite 206
West Trenton, NJ 08628

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CONVERSION FACTORS AND ABBREVIATIONS

CONVERSION FACTORS

Multiply	By	To obtain
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
acre	0.4047	hectare
gallons (gal)	0.003785	cubic meter
gallons per acre (gal/acre)	0.009353	cubic meter per hectare
acre-inch per acre per year (acre-in./acre)/yr	254.1	cubic meter per hectare per year
acre-foot (acre-ft)	1,233	cubic meter
acre-inch (acre-in.)	102.75	cubic meter
million gallons (Mgal)	3,785	cubic meter
billion gallons (x 10^9 gal)	3,785,000	cubic meter
million gallons per day (Mgal/d)	0.04381	cubic meter per second
pound (lb)	0.4536	kilogram
degree Fahrenheit	°C = 5/9 (°F - 32)	degree Celsius

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ABSTRACT

This report presents the results of a study to predict water demand for crop uses in New Jersey in 1990, 2000, 2010, and 2020. In addition, water use for livestock and selected sectors of the New Jersey food-processing industry in 1987 was estimated. Predictions and estimates of agricultural water demand are necessary because water supplies in New Jersey must be allocated among competing users, particularly in summer, when demand by all users is great.

Predictions of water demand for field-grown crops, cranberries, and container-grown nursery crops were made for 1990, 2000, 2010, and 2020 by multiplying the predicted number of irrigated acres in each crop group by estimated irrigation amounts. Different methods were used to estimate irrigation amounts for each of the three crop groups. Irrigated acreage was predicted by using historical irrigated-acreage data, and harvested acreage was predicted by using a statistical model relating population to the number of harvested acres.

The number of harvested acres in New Jersey was predicted to decrease from about 537,000 acres in 1990 to about 412,000 acres in 2020. Counties with the largest predicted decrease in harvested acreage (more than 10,000 acres) were Burlington, Gloucester, Hunterdon, Middlesex, Monmouth, and Sussex. Projected population increases for these counties during the prediction period are large. Irrigated acreage in New Jersey is predicted to decrease about 7 percent from 1990 through 2020. At the county level, irrigated acreage is predicted to decrease in all but three New Jersey counties (Salem, Cumberland, and Union).

A Thornthwaite daily water-balance model was used to calculate optimum irrigation amounts for field-grown crops in each of the 20 New Jersey counties that contain farmland. Optimum-annual and -monthly irrigation amounts were calculated for three climatological scenarios: wet year, average year, and drought year.

For 1990, water demand for field-grown crops was predicted to be 4.53×10^9 gal (gallons) for the wet-year scenario, 10.60×10^9 gal for the average-year scenario, and 16.82×10^9 gal for the drought-year scenario. For 2020, water demand for field-grown crops was predicted to be 4.10×10^9 gal for the wet-year scenario, 9.54×10^9 gal for the average-year scenario, and 15.07×10^9 gal for the drought-year scenario. This represents a 9-percent decrease in predicted water demand for field-grown crops from 1990 to 2020 for the wet year scenario, and a 10-percent decrease for the average- and drought-year scenarios. Prediction results indicate that the method for predicting water demand for field-grown crops is sensitive to changes in the climatological input data.

Predictions of water demand for cranberries and container-grown nursery crops also were made for 1990, 2000, 2010, and 2020. Predictions for the three climatological scenarios were made for water demand for container-grown nursery crops, but not for cranberry water demand, because water demand for cranberries varies little in response to climatological factors.

Water demand for cranberries was predicted by multiplying predicted harvested cranberry acreages by an estimated use of 4 acre-ft. This use estimate was obtained from interviews with members of the New Jersey agricultural community.

Water demand for cranberries was predicted to be 4.43×10^9 gal in all four prediction years. This water use is largely non-consumptive and occurs in the three Coastal Plain counties of Atlantic, Burlington, and Ocean. Burlington County alone accounts for more than 90 percent of cranberry water demand in the State.

Water demand for container-grown nursery crops was estimated by multiplying the predicted number of acres of container-grown nursery crops by an estimate of actual water use for container-grown nursery crops. The estimate of actual water use was made by using the data on water use reported to the New Jersey Department of Environmental Protection and Energy by farmers. For 1990, water demand for container-grown nursery crops was predicted to be 1.89×10^9 gal for the wet-year scenario, 2.27×10^9 gal for the average-year scenario, and 2.64×10^9 gal for the drought-year scenario. For 2020, water demand for container-grown nursery crops was predicted to be 2.60×10^9 gal for the wet-year scenario, 3.11×10^9 gal for the average-year scenario, and 3.63×10^9 gal for the drought-year scenario.

Water use by livestock was estimated to be 0.78×10^9 gal in 1987. Water use by livestock was estimated by animal type and for milk processing and feeder pig production. Of the animal types considered, cattle and horses were estimated to use the most water. Water use by selected sectors of the food-processing industry in New Jersey was estimated to be 3.75×10^9 gal in 1987. Water demand for livestock and food-processing was not predicted because demand in these sectors depends on many factors--national, regional, and local--that are too variable to predict.

INTRODUCTION

Increased competition for water resources in New Jersey has resulted in severe water-storage shortages during drought periods. Predictions of water demand by type of use are needed to develop sound water-management plans that can mitigate the effect of reduced supplies during drought. Agricultural water use is one use that must be evaluated to identify long-term needs.

The New Jersey Department of Environmental Protection and Energy (NJDEPE) is responsible for allocating water among competing users in the State. The New Jersey Department of Agriculture (NJDA) is responsible for advising the NJDEPE about future water needs of farmers. In order to develop both short- and long-term estimates of demand for agricultural water, the NJDA formed the Agricultural Water Advisory Committee in 1987. The Committee includes representatives of the NJDEPE, the NJDA, Rutgers University, the Delaware River Basin Commission, the U.S. Soil Conservation Service, and the U.S. Geological Survey (USGS). In order to provide information needed for allocation of water resources in New Jersey, the USGS, in cooperation with the NJDA, conducted a study to estimate the quantity of water that might be used by New Jersey farmers in the future.

Purpose and Scope

This report describes a method for predicting long-term water demand for all crop uses in New Jersey in 1990, 2000, 2010, and 2020, and for estimating water demand for livestock and selected sectors of the food-processing industry in New Jersey in 1987. Predictions and estimates are made for all agricultural areas in New Jersey.

Approach

This study involved the development of methods for predicting water demand for crop uses in New Jersey in 1990, 2000, 2010, and 2020 and for estimating the amount of water used for livestock and selected sectors of the food-processing industry in New Jersey in 1987. The sectors of the food-processing industry for which estimates of water use were made are (1) meat products, (2) preserved fruits and vegetables, and (3) miscellaneous food and like products.

Predictions of water demand for crop uses were made specifically for 1990, 2000, 2010, and 2020 because population forecast data used to predict harvested acreage and water demand for crop uses were available for those years. Predictions for years between 1990 and 2020, for example 1994, can be calculated by interpolation.

Separate methods were developed to predict water demand for three distinct crop groups: (1) field-grown crops, (2) cranberries, and (3) container-grown nursery crops. Separate methods also were developed for estimating water use for livestock and selected sectors of the food-processing industry. Methods were not developed to predict water demand for livestock and selected sectors of the food-processing industry because demand in these sectors depends on many factors--national, regional, and local--that are too variable to predict.

The prediction of water demand for crop uses in New Jersey required three main steps. First, a statistical model was developed to predict the number of harvested acres in a minor civil division (MCD) on the basis of the projected population density in the MCD. Second, the predicted number of irrigated acres was determined from the number of predicted harvested acres by using information derived from the analysis of irrigated-acreage data and from interviews with members of the New Jersey agricultural community. Third, predictions of water demand for each crop group were made by multiplying the predicted number of irrigated acres for each crop group by the estimated irrigation amounts determined for that crop group.

A Thornthwaite daily water-balance model (Mather, 1978) was used to calculate optimum irrigation amounts for field-grown crops in 1990, 2000, 2010, and 2020. This model required data on climate, water-holding capacity of soil, and water requirements by crop type. In order to obtain a range of predictions of water demand for field-grown crops, optimum irrigation amounts were calculated for three climatological scenarios: (1) wet year, (2) average year, and (3) drought year.

Predictions of water demand for cranberries in 1990, 2000, 2010, and 2020 were made by multiplying the predicted number of harvested cranberry acres by an estimate of water demand per acre of cranberries. Predictions of water demand for container-grown nursery crops were made by multiplying the predicted acreage by an estimate of actual water usage per acre in 1989 by container-grown nursery crops. Actual water use was estimated by verifying reported water use during a field study conducted by the USGS in 1989. Water demand for container-grown nursery crops was estimated for the wet-year, average-year, and drought-year scenarios.

Estimates of water use for livestock in 1987 were calculated by multiplying numbers of animals and production numbers in 1987 by coefficients of water use per animal or type of production. Water use for selected sectors of the food-processing industry in 1987 was estimated by multiplying the number of employees in each sector by the estimated rate of water use per employee.

Description of the Study Area

New Jersey is a mid-Atlantic state and has a humid, temperate climate. Average annual precipitation during 1931-80 was 45.26 inches (Ludlum, 1983, p. 249). New Jersey is divided into 21 counties composed of 567 MCD's (pl. 1). Two major urban centers are adjacent to New Jersey--New York City, New York, directly to the east of north-central New Jersey, and Philadelphia, Pennsylvania, directly to the west of south-central New Jersey (fig. 1). A mixture of commercial, industrial, residential, and agricultural land uses is present throughout New Jersey.

Physiography and Land Use

Physiographically, New Jersey can be divided into two areas--northern and southern--by the Fall Line. In the north are the Piedmont, Highland, and Valley and Ridge Provinces, where rocky and finely textured soil types predominate. In the south is the Coastal Plain Province, with predominantly sandy and sandy-loam soil types. Figure 1 shows the four physiographic provinces in New Jersey and the Pinelands region.

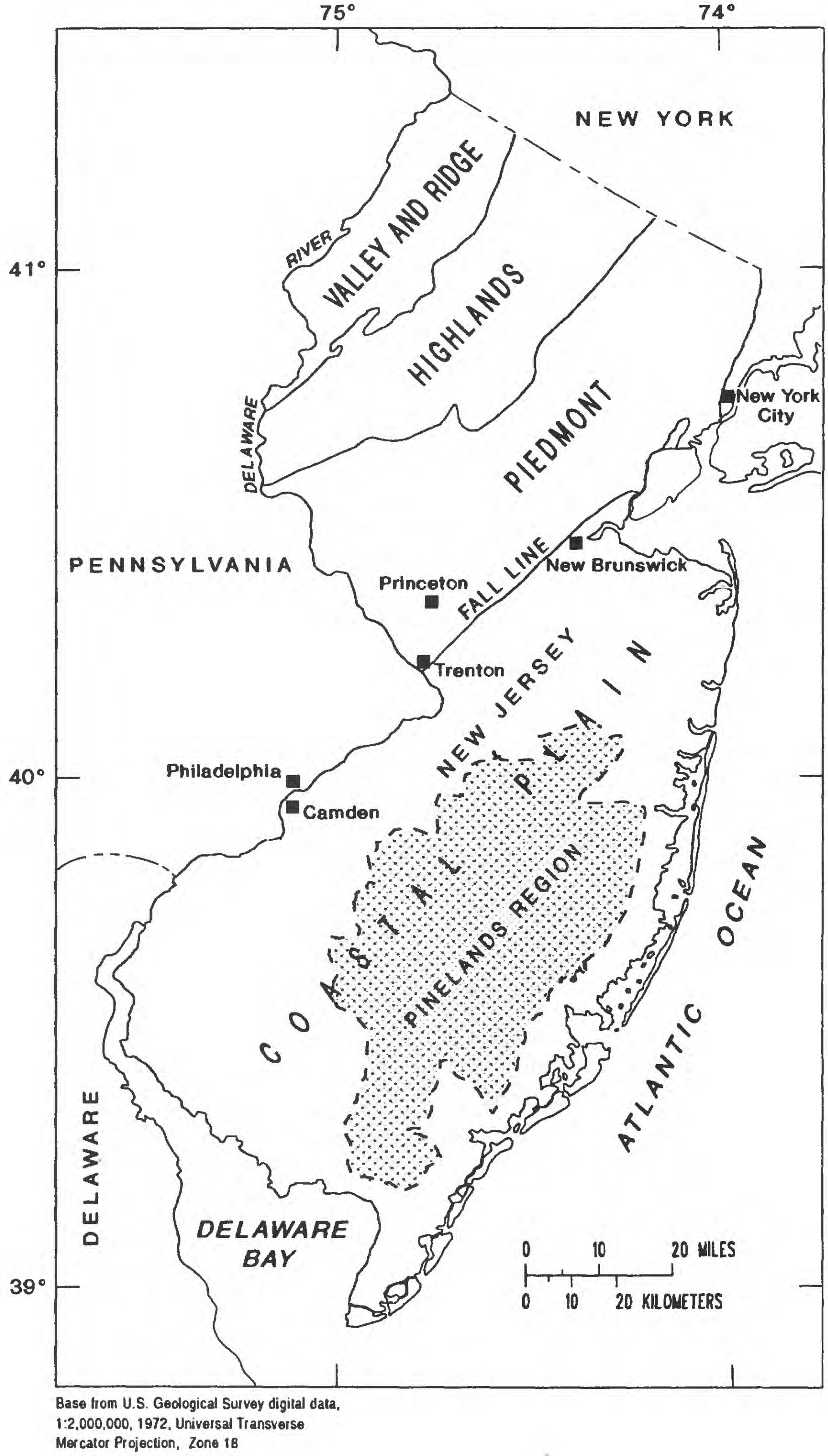


Figure 1.--Location of study area.

The area north of the Fall Line includes 10 counties composed of 274 MCD's. The northeastern part of New Jersey borders New York City and is dominated by commercial, industrial, and residential land uses, with little land devoted to agriculture. The northwestern part of New Jersey is rocky, hilly, and mostly rural; agriculture is a major land use, consisting mainly of farms on which livestock are raised and field crops are grown. Field crops grown in New Jersey include corn for grain, sorghum for grain, wheat, barley, oats, rye, soybeans, white potatoes, sweet potatoes, corn for silage, sorghum for silage, and hay (U.S. Bureau of the Census, 1989, p. 212-217). Some of the land in northwestern New Jersey, much of it parkland, is forested.

Eleven counties and 293 MCD's lie on or south of the Fall Line in the Atlantic Coastal Plain. The cities of Camden and Trenton and the rapidly developing corridor between Princeton and New Brunswick also occupy this area. The beachfront is developed along the coast from Monmouth County to Cape May County. Outside the developed areas, however, are large rural areas that are used extensively for agriculture. The New Jersey Pinelands occupies a large area in the center of the Coastal Plain region (fig. 1). Development in the Pinelands is restricted to protect ground-water-recharge areas in the Coastal Plain. Marshland is present along the coast of the Atlantic Ocean and Delaware Bay. Development in some of these coastal areas also is restricted.

Population

New Jersey has experienced rapid population growth as a result of industrialization and urbanization. Before 1920, population growth was primarily in or near industrial areas. From 1900 through 1920, the most densely populated counties were the industrial counties of Hudson, Union, Camden, Passaic, and Essex. Population trends changed during the 1930's, when migration from some urban areas occurred (New Jersey Department of Labor, 1984, p. ii-iii). Table 1 shows New Jersey population by county from 1930 through 1980 at 10-year intervals (New Jersey Department of Labor, 1984, p. 13), and provisional estimates of population in 1988 (New Jersey Department of Labor, 1989, p. 11).

Increased immigration from abroad and the post-World War II "baby boom" accelerated national population-growth rates in the 1940's and 1950's. Heavy migration into New Jersey from other states increased the 1950-60 population-growth rate per decade to 25.5 percent and the 1960-70 population-growth rate per decade to 18.2 percent. Much of this migration was directed into areas surrounding the major job centers of New York and Philadelphia. The non-metropolitan counties of Ocean, Monmouth, and Sussex also experienced relatively large population gains (New Jersey Department of Labor, 1984, p. iii).

Population growth in New Jersey during 1970-80 departed from historical trends. New Jersey experienced only a 2.7-percent population-growth rate per decade from 1970 to 1980, a rate that was far below the national rate of 11.4 percent and that was the lowest recorded rate for the State since the first census was taken in 1790 (New Jersey Department of Labor, 1984, p. iii-iv). Population growth shifted from the industrialized urban areas to rural, suburban, and coastal counties, resulting in rapid growth rates for Cape May, Ocean, Hunterdon, and Sussex Counties during this period.

Table 1.--Resident population of New Jersey counties, 1930-80 and 1988

[Data from the New Jersey Department of Labor, 1984, 1989]

County	Population						
	1930	1940	1950	1960	1970	1980	1988
Atlantic	124,823	124,066	132,399	160,880	175,043	194,119	212,900
Bergen	364,977	409,646	539,139	780,255	897,148	845,385	827,100
Burlington	93,541	97,013	135,910	224,499	323,132	362,542	397,000
Camden	252,312	255,727	300,743	392,035	456,291	471,650	500,600
Cape May	29,486	28,919	37,131	48,555	59,554	82,266	95,900
Cumberland	69,895	73,184	88,597	106,850	121,374	132,866	138,400
Essex	833,513	837,340	905,949	923,545	932,526	851,116	838,500
Gloucester	70,802	72,219	91,727	134,840	172,681	199,917	218,800
Hudson	690,730	652,040	647,437	610,734	607,839	556,972	541,000
Hunterdon	34,728	36,766	42,736	54,107	69,718	87,361	100,500
Mercer	187,143	197,318	229,781	266,392	304,116	307,863	331,700
Middlesex	212,208	217,077	264,872	433,856	583,813	595,893	653,200
Monmouth	147,209	161,238	225,327	334,401	461,849	503,173	559,700
Morris	110,445	125,372	164,371	261,620	383,454	407,630	420,600
Ocean	33,069	37,706	56,622	108,241	208,471	346,038	413,000
Passaic	302,129	309,353	337,093	406,618	460,782	447,585	463,400
Salem	36,834	42,274	49,508	58,711	60,346	64,676	66,300
Somerset	65,132	74,390	99,052	143,913	198,372	203,129	227,300
Sussex	27,830	29,632	34,423	49,255	77,528	116,119	126,600
Union	305,209	328,344	398,138	504,255	543,116	504,094	499,700
Warren	49,319	50,181	54,374	63,220	73,960	84,429	89,000
Total	4,041,334	4,160,165	4,835,329	6,066,782	7,171,112	7,365,011	7,721,000

Population growth in suburban, rural, and coastal areas continued during the 1980's. During 1980-88, population by percentage increased most in the Counties of Ocean (19.4 percent), Cape May (16.6 percent), Hunterdon (15.0 percent), Somerset (11.9 percent), and Monmouth (11.2 percent). In terms of the number of people, the largest gains were in Ocean, Middlesex, Monmouth, Burlington, and Camden Counties. The counties which lost population during this period were urban-industrial--Hudson, Bergen, Essex, and Union. Many of the people leaving these counties relocated in rural and suburban counties.

Agriculture in New Jersey

Although total farmland has been decreasing in New Jersey for more than 30 years, irrigated land has been increasing (table 2). During 1954-87, nearly 50 percent of agricultural land in New Jersey was converted to other uses (U.S. Bureau of the Census, 1989, p. 7). Irrigated land, on the other hand, increased slightly more than 54 percent during this period. Although land-use data for 1954 and 1987 indicate an overall increase in irrigated land, the number of irrigated acres varies from census year to census year, possibly because of climate variability. Figure 2 is a map of agricultural land in New Jersey in 1973 derived from aerial photographs (Anderson and others, 1976).

Table 2.--Farmed and irrigated acreage in New Jersey, 1954-87

[Data from U.S. Bureau of the Census, 1989]

Year	Farmed acreage[1] (acres)	Irrigated acreage (acres)
1954	1,665,241	58,912
1959	1,379,002	73,873
1964	1,155,597	96,433
1969	1,035,678	71,967
1974	961,395	89,321
1978	987,309	77,159
1982	916,331	83,049
1987	894,426	91,208

[1] Farmed acreage includes irrigated acreage.

In 1984, 119 of the 274 MCD's in northern New Jersey contained no harvested farmland (New Jersey Division of Taxation, 1984). Seventy-seven MCD's contained harvested land that was not irrigated (J.R. Gibson, New Jersey Agricultural Statistics Service, written commun., 1987), and the remaining 78 MCD's contained irrigated farmland, which accounted for less than 5 percent of the irrigated cropland statewide. Field crops, such as hay and grain corn, which are largely non-irrigated, are the major crops in the northern part of the State. Some berries and vegetables that require irrigation are grown.

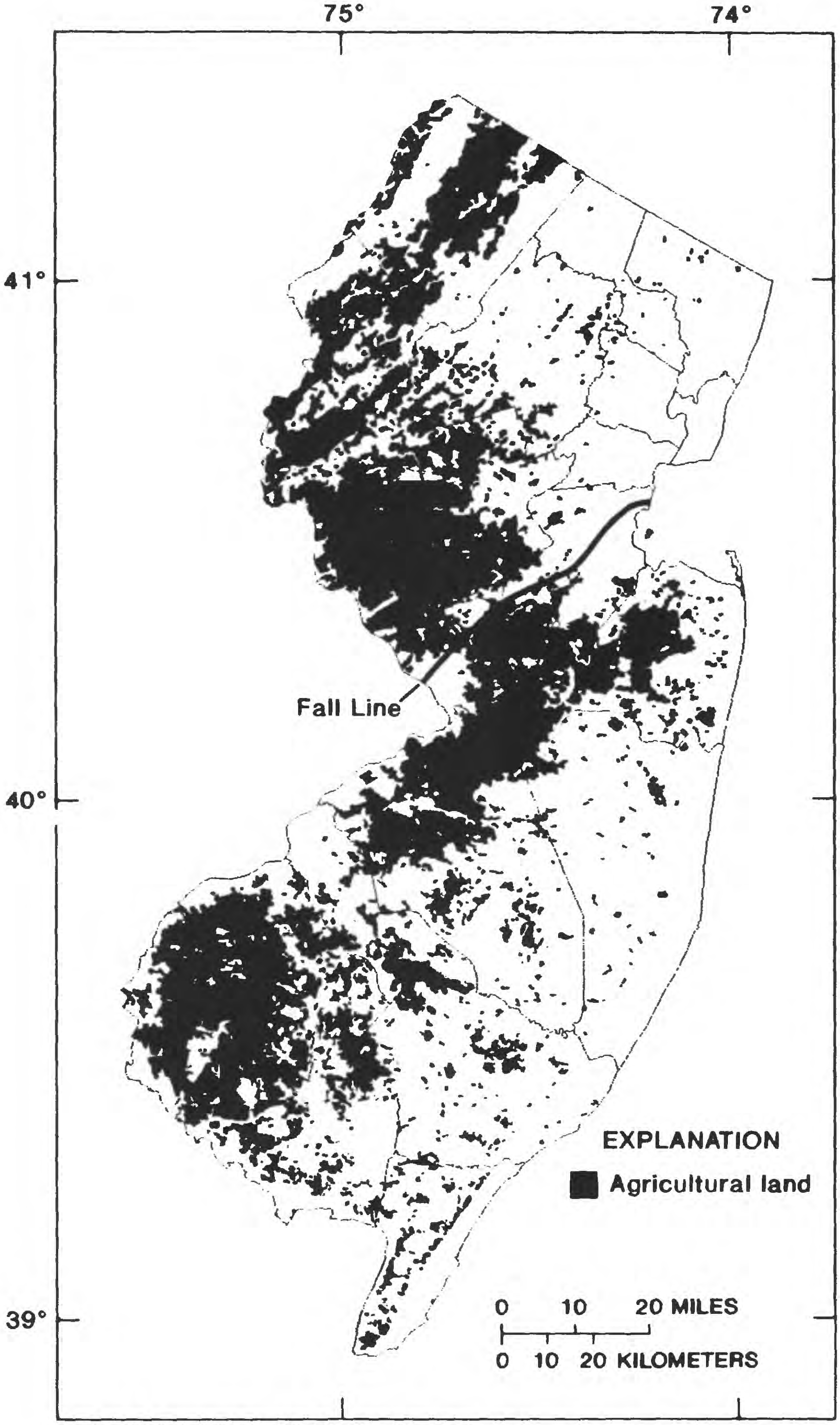
Vegetables grown in New Jersey include asparagus, lima beans, snap beans, beets, broccoli, brussels sprouts, chinese cabbage, head cabbage, cantaloupes, carrots, cauliflower, celery, chicory, collards, cucumbers, eggplant, endive, escarole, kale, lettuce and romaine, mustard greens, dry onions, green onions, okra, parsley, green peas, hot peppers, sweet peppers, pumpkins, radishes, rhubarb, shallots, spinach, squash, sweet corn, tomatoes, turnips, turnip greens, and watermelons (U.S. Bureau of the Census, 1989, p. 218-227). Nursery and sod farms in the area also require irrigation. Overall, however, the water demand for crops grown north of the Fall Line accounts for a small fraction of irrigation-water demand in the State. In 1988, for example, agricultural water demand reported by farmers to the NJDEPE for counties north of the Fall Line accounted for less than 2 percent of the reported total for New Jersey (J.A. Locke, New Jersey Department of Environmental Protection and Energy, written commun., 1989).

In 1984, 129 MCD's in southern New Jersey contained no harvested farmland (New Jersey Division of Taxation, 1984), but more than 95 percent of New Jersey's irrigated cropland was located in this region (J.R. Gibson, New Jersey Agricultural Statistics Service, written commun., 1987). Irrigated crops, including vegetables, fruits, sod, nursery crops, and some field crops, are concentrated in the southern region.

Most types of crops, whether they are grown in the northern or southern part of New Jersey, are irrigated. Generally, however, not all acreage planted with a particular crop type is irrigated. Vegetables have a high water content and are sensitive to dry periods. Orchard crops are more deeply rooted and can withstand longer dry periods than vegetables, but they also need to be irrigated from time to time for healthy fruit development and for frost protection. Cranberries require water for cooling in the summer, for harvesting in the fall, and for frost protection in the winter. Container-grown nursery crops require frequent irrigation. Field-grown nursery crops, other berries, and field crops also can benefit from irrigation.

New Jersey farmers use a variety of irrigation equipment depending on the crop type, the size of the area under irrigation, soils, slopes, expense, and other factors. Traveling guns and hand-moved lateral-pipe systems are popular on vegetable and field-crop farms where large areas can be irrigated with a movable system. Center-pivot irrigation systems also are used to spray large areas. Permanent and solid-set irrigation systems are used on farms with crops, such as container-grown nursery crops, blueberries, and cranberries, that do not require overland equipment for harvesting. These types of spray-irrigation systems generally are rated at about 75-percent efficiency (U.S. Soil Conservation Service, 1983, p. 6.8). Surface systems used on cranberry farms to move water from one bog to another for harvesting and frost protection generally are rated at about 50-percent efficiency (Smajstrla and others, 1988, p. 15). Trickle irrigation is becoming increasingly popular for irrigation of row crops. This system is rated at about 80- to 90- percent efficiency (Smajstrla and others, 1988, p. 15), but is capital-intensive.

In addition to irrigation and harvesting of crops, water is used by New Jersey farmers for raising and maintenance of livestock and by the food-processing industry for various purposes. Pasture grass is used for livestock grazing and to provide hay for wintertime feeding; however, only a small percentage of pasture grass in New Jersey is irrigated.



Base from U.S. Geological Survey, 1:24,000 quadrangles, Agricultural land from U.S. Geological Survey digital data, 1:250,000, 1986, Universal Transverse Mercator projection, Zone 18

Figure 2.--Agricultural land in New Jersey, 1973.

New Jersey farmers use both ground- and surface-water sources. Ground water[1] is obtained from a number of aquifers throughout the State. Surface water is obtained from rivers and streams, as well as from natural and dug reservoirs and ponds. Farmers sometimes pump water from wells into holding ponds for future use. In 1987, surface-water sources accounted for more than 80 percent of total reported agricultural water use in New Jersey, according to the U.S. Geological Survey's Site-Specific Water-Use Data System (SSWUDS), a computerized data base containing water-withdrawal data. Water-withdrawal data in the SSWUDS data base is provided to the USGS by the NJDEPE as part of the Cooperative Water-Use Program between the two agencies.

The extent of New Jersey agriculture has changed since the 1940's. Accelerated suburban development after World War II was accompanied by the construction of highways and single-family homes. Houses have been built and other infrastructural development has occurred in formerly agricultural areas as part of the suburbanization process.

Suburbanization involves the direct conversion of farmland and vacant land near an urban center to housing, commercial, and transportation use. Postwar population growth and suburbanization have caused severe declines in both farmland acreage and farming operations in most sectors of New Jersey agriculture. Therefore, State, county, and local officials have instituted farmland-preservation strategies, such as the purchase of development rights, agricultural zoning, and preferential tax assessment for farms. These strategies have been implemented only recently in New Jersey, most of them in the 1980's. Although farmland-preservation strategies protect specific agricultural areas, results of statewide analysis of farmland acreage indicates no change in the overall trend in declining farmland. Figure 3 shows the farmed acreage in New Jersey from 1972 through 1987. From 1972 through 1981, farmed acreage was nearly constant. Since 1981, when the Farmland Preservation Program was instituted in New Jersey, farmed acreage has declined sharply. This trend is likely to continue if trends in suburbanization continue.

Previous Investigations

Some predictions of agricultural water demand for New Jersey have been documented in previous studies. The North Atlantic Regional Water Resources Study Coordinating Committee (1972) developed a model to predict agricultural water demand for 21 areas (which included New Jersey) within six subregions in the northeastern United States for 1964, 1980, 2000, and 2020. The total number of acres on which vegetables, fruits, and potatoes were grown was projected by fitting an exponential curve to acreages of these crops obtained from 1949, 1954, 1959, and 1964 censuses and extending the exponential equation to 2020. It was assumed that all of the projected crop acres would be irrigated by 2020 and that no shortage of water would occur to limit irrigation. A modified Blaney-Criddle method (Blaney and Criddle, 1950) was used to compute the monthly and seasonal consumptive-use requirements for the crops studied.

[1] In this report, underlined terms are defined in the Glossary.

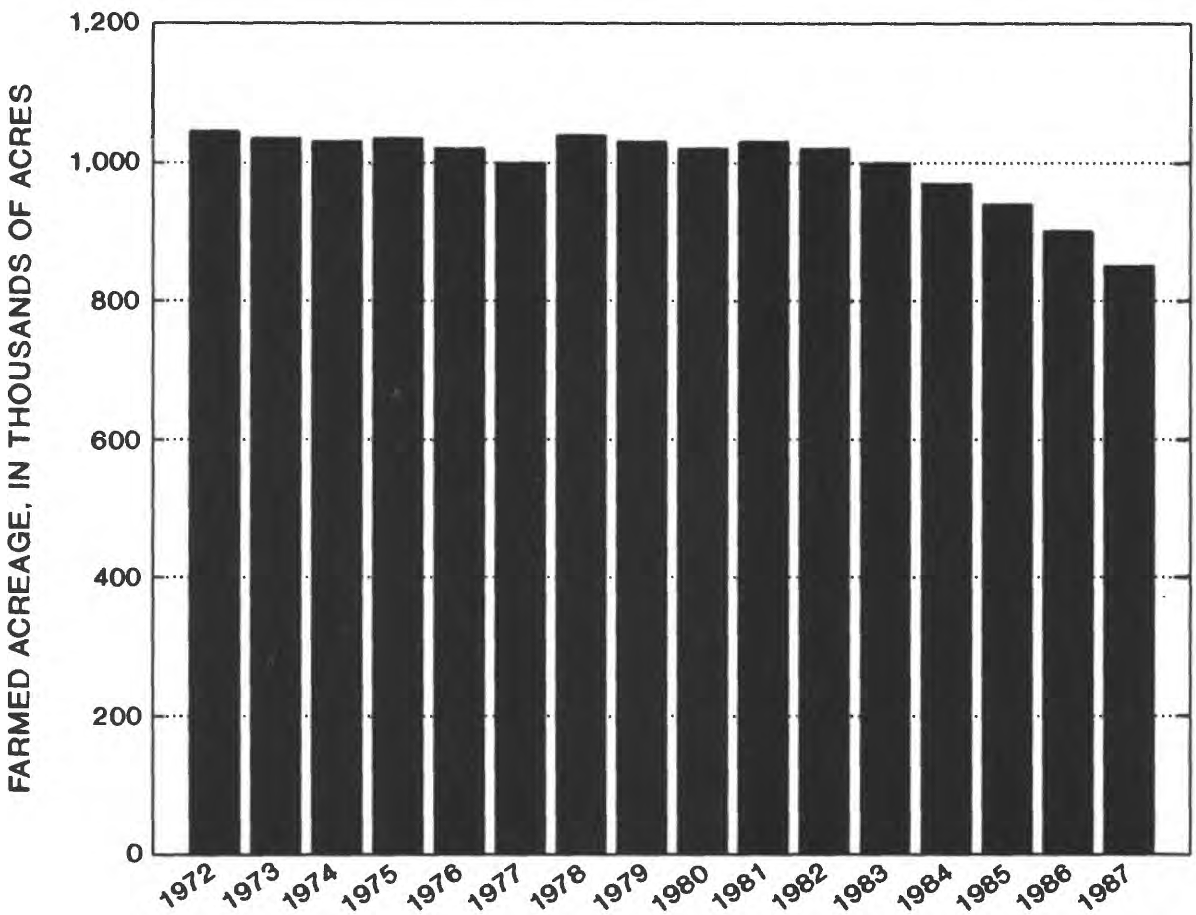


Figure 3.--Farmed acreage in New Jersey, 1972-87. (Data from New Jersey Agricultural Statistics Service, 1989)

A model was developed to estimate the number of irrigated hectares by crop type and the volume of water needed for irrigation under normal and drought conditions of rainfall in the Delaware River basin for 1980, 1990, and 2000 (H.H. Taylor and J.E. Hostetler, U.S. Department of Agriculture, written commun., 1981). The number of irrigated hectares and the volume of water required by crop type were estimated from historical data on irrigation practices, projected trends in the United States economy, and monthly rainfall records over a 46-year period.

Titus and others (1990) estimated the demand for agricultural water for irrigation use under normal and drought conditions in New Jersey for 1990. Three scenarios of irrigated acreage in 1990 were considered: (1) no change in acreage from 1984 through 1990, (2) a 2-percent annual increase in acreage from 1984 through 1990, and (3) a 2-percent annual decrease in acreage from 1984 through 1990. The soil water deficit for field-grown crops in New Jersey in 1990 was calculated by using the Thornthwaite method (Mather, 1978).

Acknowledgments

Appreciation is extended to Dr. M. Ferdows Ali of the New Jersey Department of Agriculture for his assistance throughout the project, and to Robert Battaglia of the New Jersey Agricultural Statistics Service for supplying data and information used in this report. The authors wish to thank the farmers who participated in the field study and other members of the New Jersey agricultural community who provided valuable information for this study.

METHOD FOR PREDICTING WATER DEMAND FOR CROP USES

Methods were developed to predict water demand for crop uses in New Jersey in 1990, 2000, 2010, and 2020. Separate methods were developed to predict water demand for field-grown crops, cranberries, and container-grown nursery crops. In this report, field-grown crops are defined as orchard crops, field-grown nursery crops, blueberries, strawberries, vegetables, and field crops. The prediction of water demand for crop uses involved two main steps. First, the number of irrigated acres for each crop type in 1990, 2000, 2010, and 2020 was predicted. Second, irrigation quantities were determined for each crop type. Predictions of water demand for each crop type then were made by multiplying the predicted number of irrigated acres for each crop type by the irrigation quantities needed for each crop type.

Predicting Harvested Acreage

In order to estimate the number of irrigated acres in New Jersey in 1990, 2000, 2010, and 2020, it was first necessary to determine the number of harvested acres in these years. The approach used to estimate the number of harvested acres was to develop a predictive model that would relate statistically a dependent variable to the value of one or more predictor variables.

Model Development

Many types of data were considered for use as predictor variables in the statistical model, including agricultural-land statistics, crop-production and -price data, climate data, and population and other socioeconomic data. Finally, only those data that met the following criteria were used: data for which consistent historical records and forecasts were available, and data collected and maintained at the municipal level.

Forecasts of the independent variable(s) to the year 2020 were needed to predict values of the dependent variable (harvested acres). Because scatterplot and regression analysis with State- and county-level population and farm-acreage data yielded results that are statistically less significant than did analyses made with municipal-level data, municipal-level data were used to develop the statistical model and to predict numbers of harvested acres.

The only type of data that met the two criteria for use as an independent variable in the model was population data. Figure 4 shows the population of New Jersey as a function of New Jersey farmed acreage for 5 years during 1950-87. These years were chosen because U.S. Census data on both population and farmed acreage were readily available. These two variables are highly correlated in an inverse relation. Because this relation was observed at the State level, analysis of population and farmed-acreage data were made at the municipal level.

The inverse relation between suburban population growth and the decrease in agricultural land has been documented in the literature. Using aggregate time-series farm-sector data for New Jersey from 1949 to 1982, Lopez and others (1988) found a statistically significant relation between increasing suburbanization and the conversion of rural land to urban land. Lockeretz (1989) showed that the rate of decline of farmland increased with proximity to a metropolitan center for midwestern states. Campbell and Decter (1980) documented the pervasiveness of the speculation of agricultural land by non-residents and investors in New Jersey which leads to suburban development.

On the basis of the supporting documentation and the relation observed in figure 4, a statistical prediction model for harvested acres was developed for this study by using population density as the independent (predictor) variable and the ratio of harvested acres to non-harvested acres as the dependent variable. The ratio of harvested to non-harvested acres was used as the dependent variable instead of the number of harvested acres because the ratio gives an indication of how much land in an MCD is agricultural in relation to other uses. An important assumption of the statistical prediction model is that suburbanization will continue to occur in the same pattern in the future as it has in the past. Population projections for the State indicate that the number of people in rural and urban fringe MCD's will continue to increase (Greenberg and Neuman, 1977; Delaware Valley Regional Planning Commission, 1982).

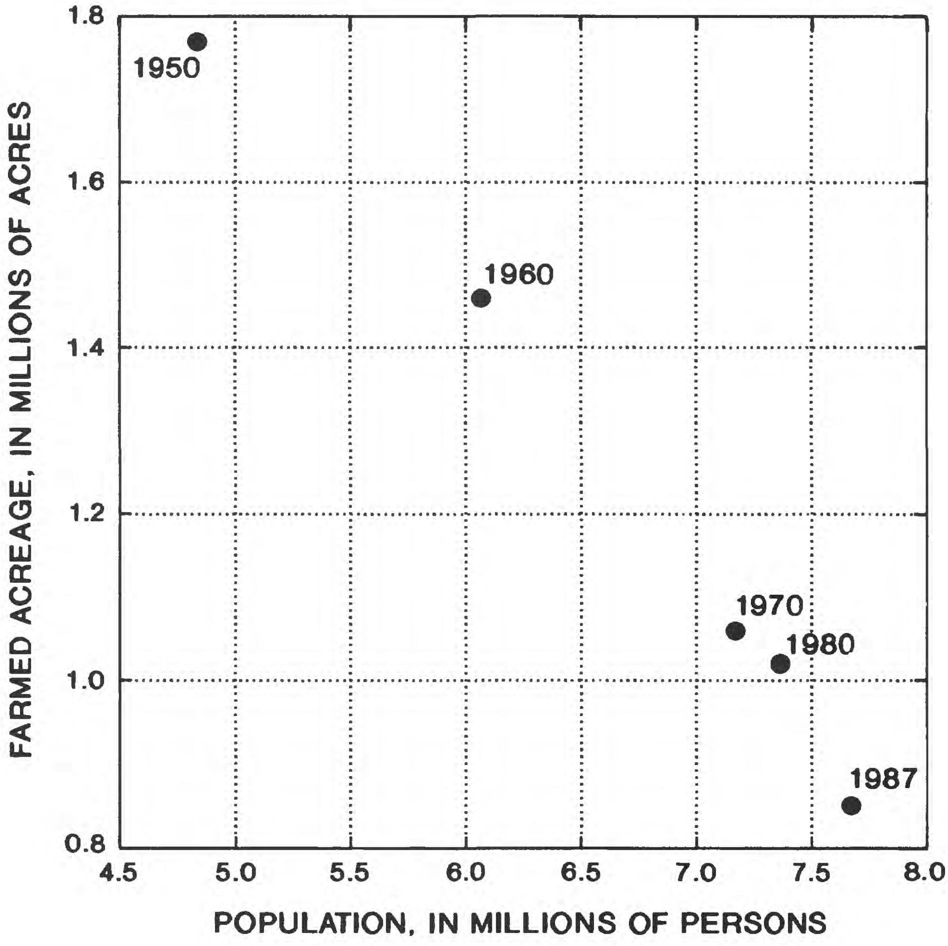


Figure 4.--Relation of farmed acreage to population in New Jersey. (Farmed-acreage data from New Jersey Agricultural Statistics Service, 1989, population data from New Jersey Department of Labor, 1984, 1989)

Initial data analysis at the State level was performed by using data on farmed acreage, which includes harvested acreage, pasture land, and land owned by farmers but not cultivated. The statistical model was developed using MCD-level data to predict the number of harvested acres--that is, acres under cultivation by farmers. Actual harvested-acreage data for 1984 by MCD were used to estimate the parameters in the predictive regression equations.

Population data for 1984 for the 567 MCD's in New Jersey were obtained from the New Jersey Department of Labor (1986). Population densities for each MCD were calculated by dividing the number of persons in an MCD by the number of acres in the MCD. Harvested-acreage data for 1984 for the 567 MCD's were obtained from the New Jersey Division of Taxation (1984). Data from 1984 were used exclusively in developing the model because 1984 was the only year for which irrigated-acreage data were available at the MCD level. Irrigated-acreage data at the MCD level were required for one step in the development of the statistical prediction model.

In developing the statistical prediction model, MCD's that contained harvested acreage were first stratified into four groups on the basis of each MCD's physiographic features and proximity to an urban center. Higher correlation values between the independent variable and the dependent variable were calculated when the MCD's were stratified than when they were not. Predictive regression equations were fitted to population and harvested-acreage data for each stratified group of MCD's.

Stratification of Minor Civil Divisions

Initially, the 567 MCD's in the State were divided into two groups--MCD's in counties north of the Fall Line and MCD's in counties south of the Fall Line. This division was made because the two regions are distinctly different physiographically and agriculturally. Next, all MCD's that contained no harvested acres in 1984 were identified. These were termed the "no farmland" MCD's and were excluded from the model because it was assumed that agriculture would not be reintroduced in these primarily urbanized municipalities. Several of the no farmland MCD's are undeveloped. In the southern region, some of the no farmland MCD's are underlain by sandy soils unsuitable for agriculture. In the northern region, some of the no farmland MCD's are rocky and hilly, making them also unsuitable for agriculture. Others contain parklands protected by the State, precluding any kind of development, including agriculture. Figure 5 shows the MCD's in New Jersey that contained no harvested acreage in 1984.

Exploratory data analysis was performed separately on the MCD's in the southern and northern regions that contained harvested land in 1984 to determine the most statistically significant form of the variable for prediction purposes and to identify possible groupings and patterns within the data. Population density and the ratio of harvested to non-harvested land in these MCD's were calculated, scatterplots were constructed, and regression analysis was performed.

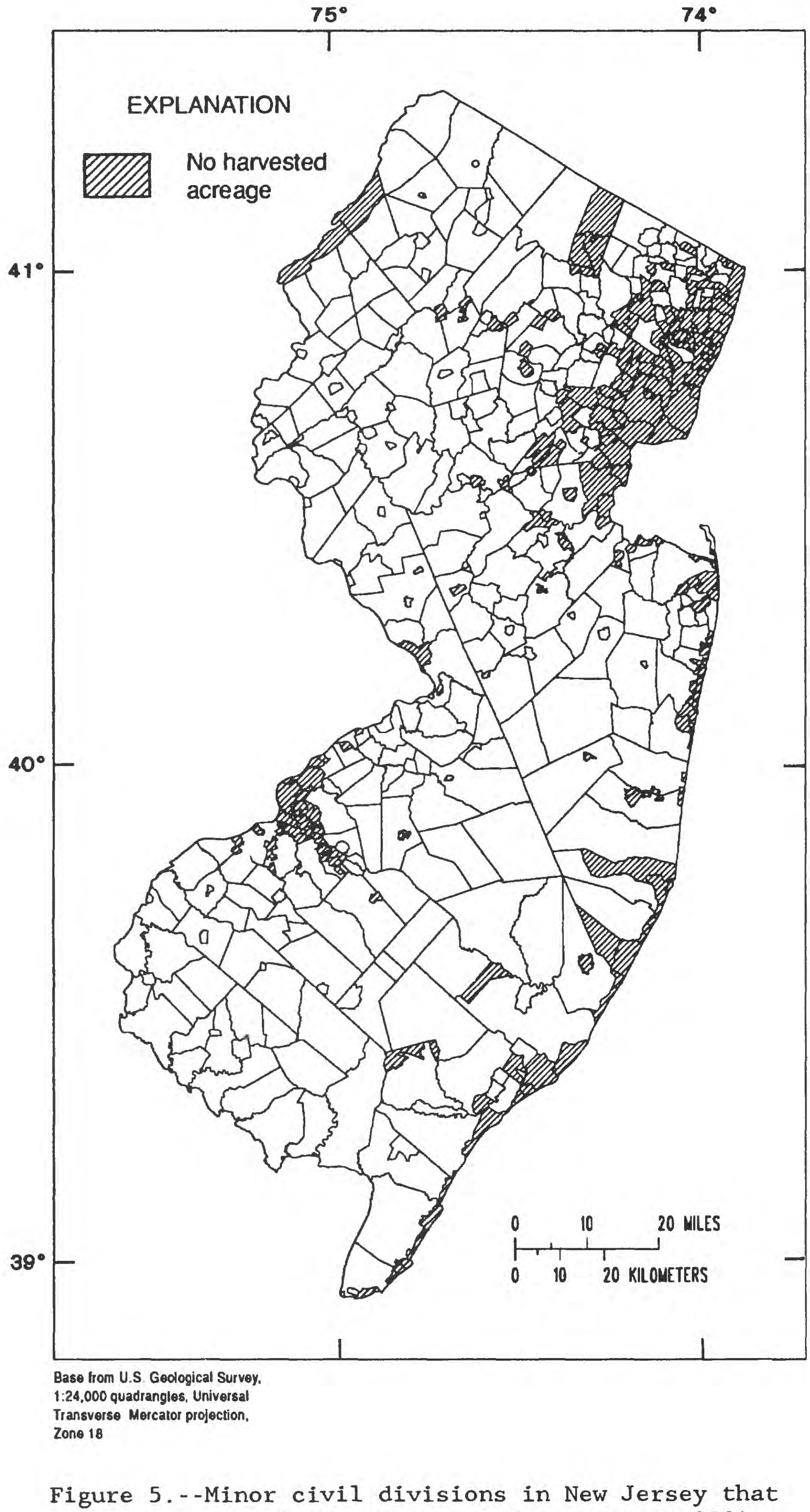


Figure 5.--Minor civil divisions in New Jersey that contained no harvested acreage in 1984.

Southern region.--Figure 6 shows the scatterplot of population density in relation to the ratio of harvested to non-harvested land for MCD's in the southern region. A straight-line regression and a quadratic regression with the added predictor variable of the square of the population density were performed on the variables. The resulting regression equations and test statistics are shown in table 3. Computed t-ratios indicated a predictive relation between the two variables, but adjusted R^2 values indicated that little of the variation in the ratio of harvested to non-harvested land was explained by population density. The natural logarithm of each of the two variables was calculated, and the two log-transformed variables were plotted in a scatterplot (fig. 7). A clustering of data points in a concave-downward curve indicates that the two variables are related. Results of the regression analysis performed on the two log-transformed variables are shown in table 3.

The MCD's whose data points plotted in the curvilinear cluster were plotted on a municipal map of New Jersey. These MCD's generally are more intensely farmed than those whose data points plotted outside the cluster. MCD's whose data points plotted within the cluster were termed "southern rural" MCD's because they were removed from urban and suburban development and contained a relatively large number of harvested acres.

Although the data points for most of the MCD's plotted in the concave-downward cluster, data points for other MCD's plotted in the scatterplot did not fit this pattern. Residuals from the regression of the two log-transformed variables were examined and those MCD's whose data points had a large standard residual were identified. Generally, these MCD's data points were outside the cluster in the scatterplot. The MCD's whose data points plotted outside the cluster then were plotted on a municipal map of New Jersey. Geographically, these MCD's seemed to fit into two distinct groups.

MCD's in the first group outside the southern rural cluster bordered urban MCD's with no harvested farmland and were characterized by comparatively high population densities. These were termed "urban fringe" MCD's. MCD's in the second group outside the southern rural cluster were characterized by comparatively low population densities and bordered either urban/suburban or rural areas or both. Further analysis showed that the MCD's in the second group were subject to various constraints on agriculture and other types of development. Several of these MCD's contained large areas of publicly owned or protected land; others contained large areas consisting of wetlands or sandy soils unsuitable for irrigated agriculture or concentrated development. Because no single characteristic described the MCD's in the second group, they were termed simply "miscellaneous" MCD's.

Because the MCD's in the southern region could be separated into three distinct groups, further data analysis was performed with this stratification. MCD's in the southern rural, urban fringe, and "miscellaneous" groups are listed in appendixes 1, 2, and 3, respectively.

Scatterplots of the relation between log-transformed population density and the log-transformed ratio of harvested to non-harvested acres for MCD's in the southern rural, urban fringe, and "miscellaneous" MCD groups are shown in figures 8 through 10, respectively. Results of regression analysis for both straight-line and quadratic equations for these three groups are shown in tables 4 through 6, respectively.

Figure 6.--Relation of population density to the ratio of harvested to non-harvested acreage in minor civil divisions in the southern region of New Jersey in 1984.

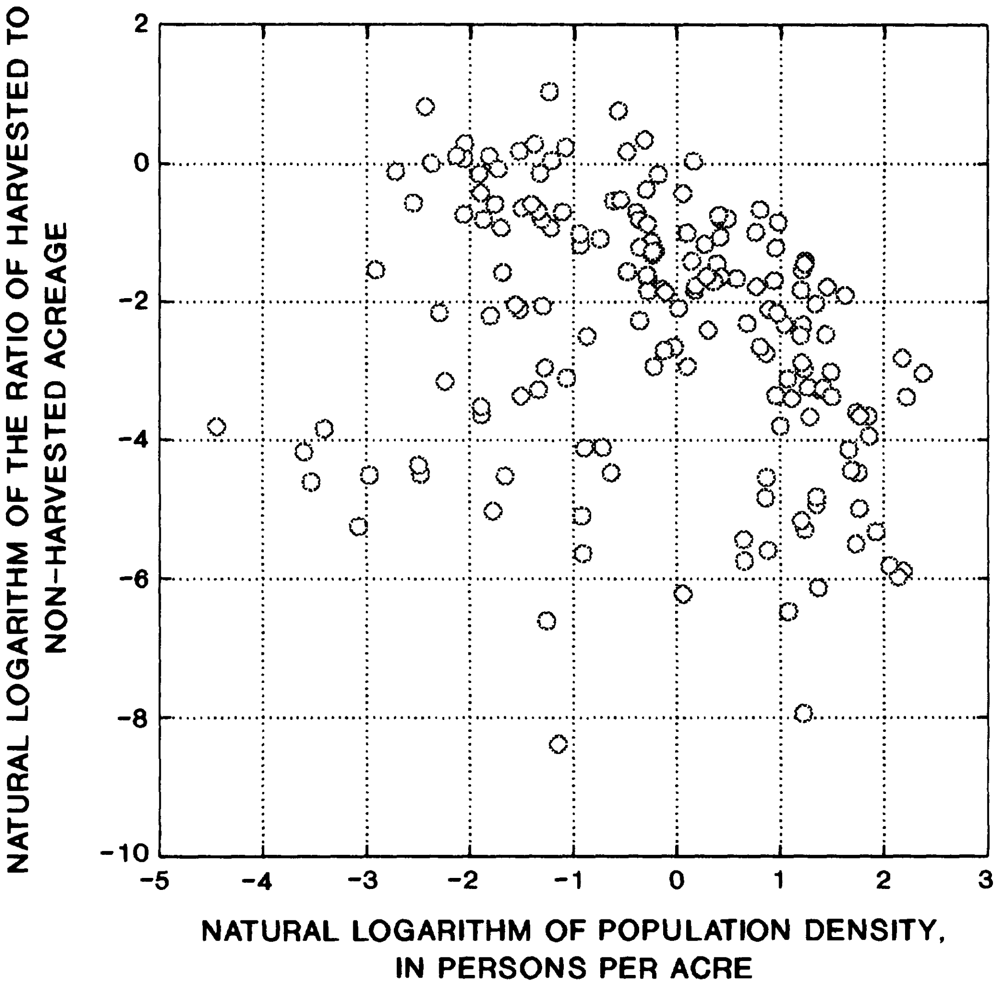


Figure 7.--Relation of the natural logarithm of population density to the natural logarithm of the ratio of harvested to non-harvested acreage in minor civil divisions in the southern region of New Jersey in 1984.

Table 3.--Results of regression analysis of population and harvested-acreage data for minor civil divisions in the southern region of New Jersey containing harvested farmland

[MCD, minor civil division; y, the ratio of harvested to non-harvested acreage in an MCD; x, the population density (persons per acre) in an MCD; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variable]

Regression of base variables

Linear equation

	$y = 0.432 - 0.0717x$		
t-ratio	(10.33)	(-4.91)	
p	(0.000)	(0.000)	
n = 170	R^2(adj) = 0.120		

Quadratic equation

	$y = 0.501 - 0.161x + 0.0121x^2$		
t-ratio	(10.17)	(-4.25)	(2.54)
p	(0.000)	(0.000)	(0.012)
n = 170	R^2(adj) = 0.148		F = 15.70

Regression of log-transformed variables

Linear equation

	$\ln(y) = -2.49 - 0.372\ln(x)$		
t-ratio	(-17.63)	(-3.84)	
p	(0.000)	(0.000)	
n = 170	R^2(adj) = 0.075		

Quadratic equation

	$\ln(y) = -1.90 - 0.649\ln(x) - 0.302[\ln(x)]^2$		
t-ratio	(-11.17)	(-6.31)	(-5.47)
p	(0.000)	(0.000)	(0.000)
n = 170	R^2(adj) = 0.211		F = 23.58

As the results in table 4 indicate, a quadratic equation best fitted the data for the independent and dependent variables in the southern rural group. Computed t-ratios for the quadratic term are significant at the 95-percent confidence level. The form of the quadratic equation is

$$\ln(y_i) = a + b_1 \ln(x_i) + b_2[\ln(x_i)]^2 ,$$

where y_i = the ratio of harvested to non-harvested acres in MCD_i ;
x_i = the ratio of the number of persons to total acres in MCD_i ; and
a, b_1, and b_2 = constants.

For the urban fringe group, a straight-line equation (table 5) produced the best fit to the data. The equation is

$$\ln(y_i) = a + b \ln(x_i) ,$$

where y_i = the ratio of harvested to non-harvested acres in MCD_i;
x_i = the ratio of the number of persons to total acres in MCD_i; and
a and b = constants.

Results of scatterplot analysis and regression analysis for MCD's in the "miscellaneous" group (fig. 10 and table 6) indicated a very weak predictive relation between log-transformed population density and the log-transformed ratio of harvested to non-harvested acres. Evidently a factor in addition to population density was needed to predict values of harvested acreage. MCD's in the "miscellaneous" group are different from MCD's in the southern rural and urban fringe groups because "miscellaneous" MCD's are subject to constraints on development and contain large areas of uncultivated and undeveloped land. Thus, it was assumed that division of population and the number of harvested acres in an MCD by the number of arable (suitable for cultivation) acres in the MCD would result in an improved predictive variable.

Arable land areas were calculated for each MCD in the "miscellaneous" category by using data from a geographical information land-use data set that was based on aerial photography (Anderson and others, 1976). Agricultural land and urban land were included in the arable-land category. Urban land was included in this category because it is commonly agricultural land that has been developed. Wetlands, barren land, and bodies of water were excluded from the arable-land category. Forestland also was excluded because forestland in the "miscellaneous" MCD's consists largely of pine forests on sandy soils, and because much of it is protected or publicly owned. The number of acres of arable land in an MCD was calculated by multiplying the total number of acres in the MCD by the percentage of arable land in the MCD as determined from the land-use data set.

New dependent and independent variables were defined for MCD's in the "miscellaneous" group--the ratio of harvested acres to all other acres in an MCD that are arable (dependent variable), and the ratio of the number of persons to total acres in an MCD that are arable (independent variable). A scatterplot of the log-transformed variables is shown in figure 11. Results of regression analysis for both straight-line and quadratic equations are shown in table 7. The regression equation with the best fit is a quadratic equation of the form

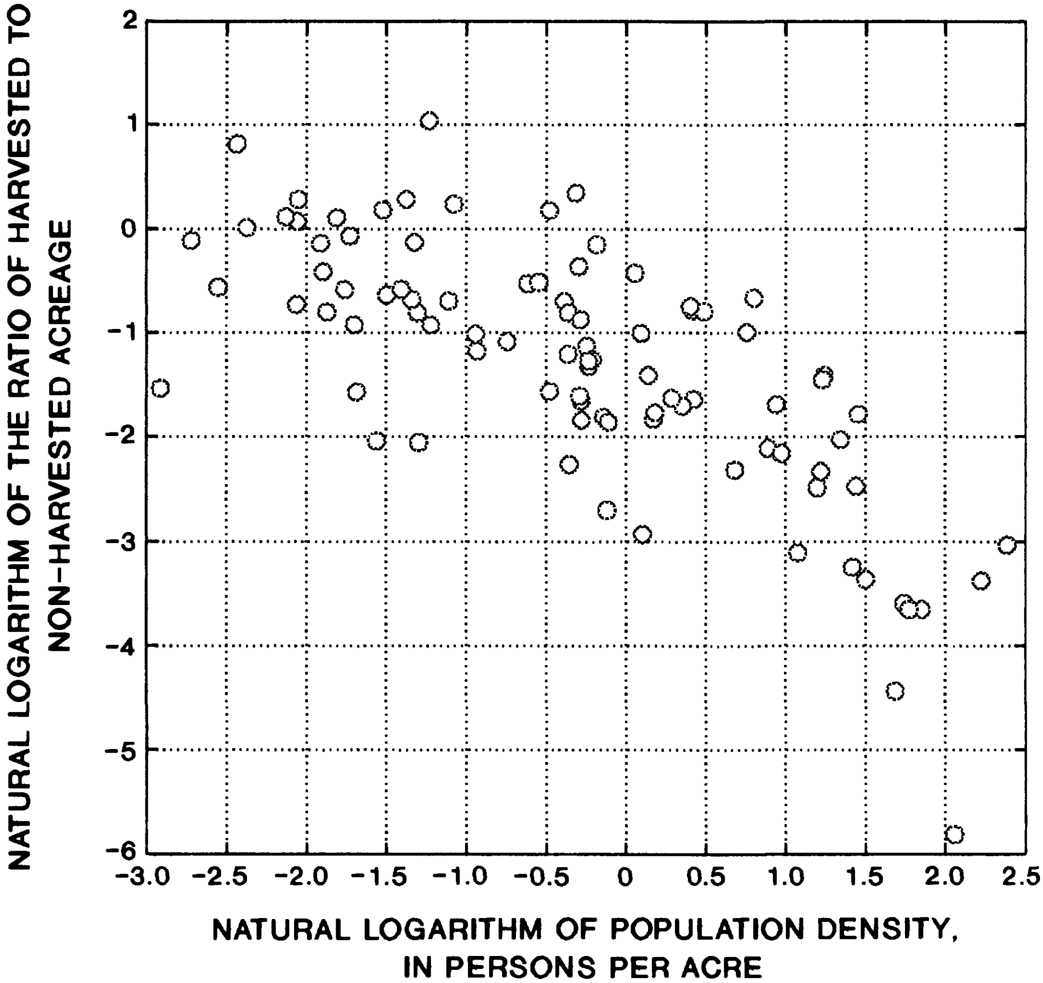


Figure 8.--Relation of the natural logarithm of population density to the natural logarithm of the ratio of harvested to non-harvested acreage in minor civil divisions in the southern rural group in 1984.

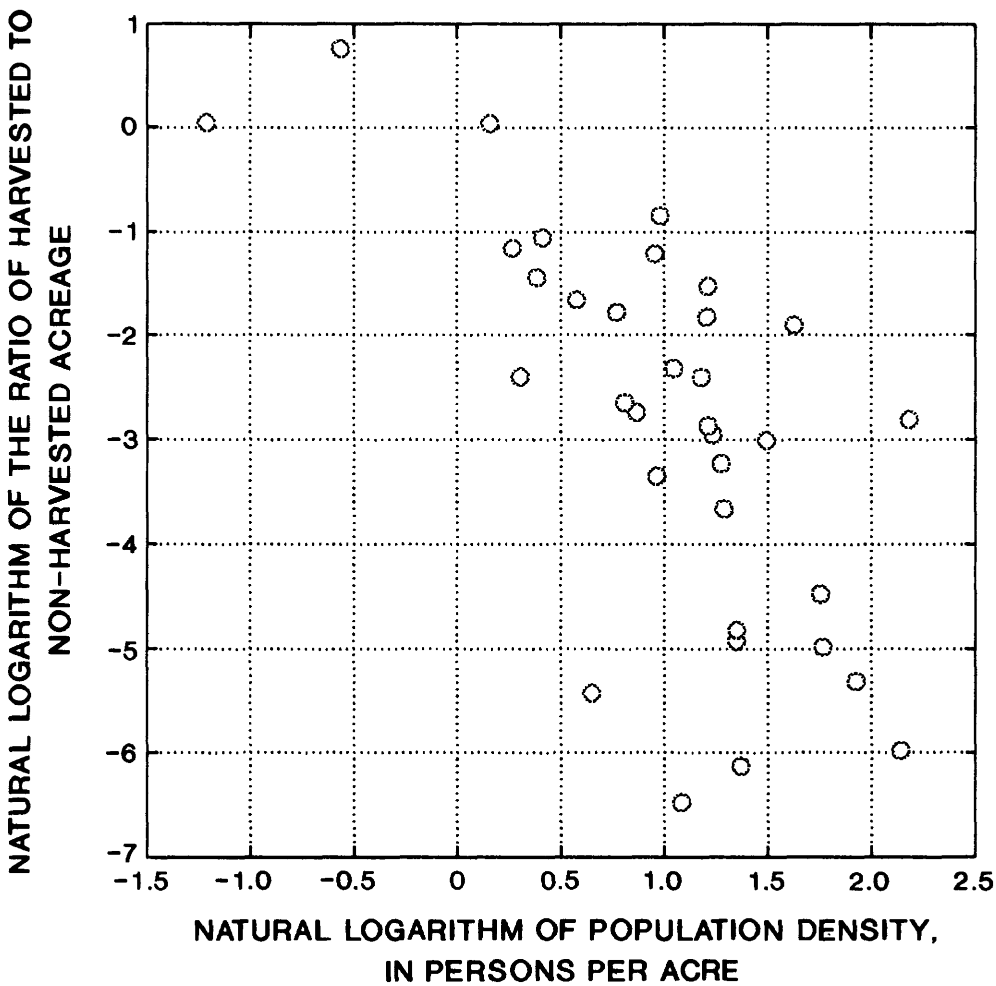


Figure 9.--Relation of the natural logarithm of population density to the natural logarithm of the ratio of harvested to non-harvested acreage in minor civil divisions in the urban fringe group in 1984.

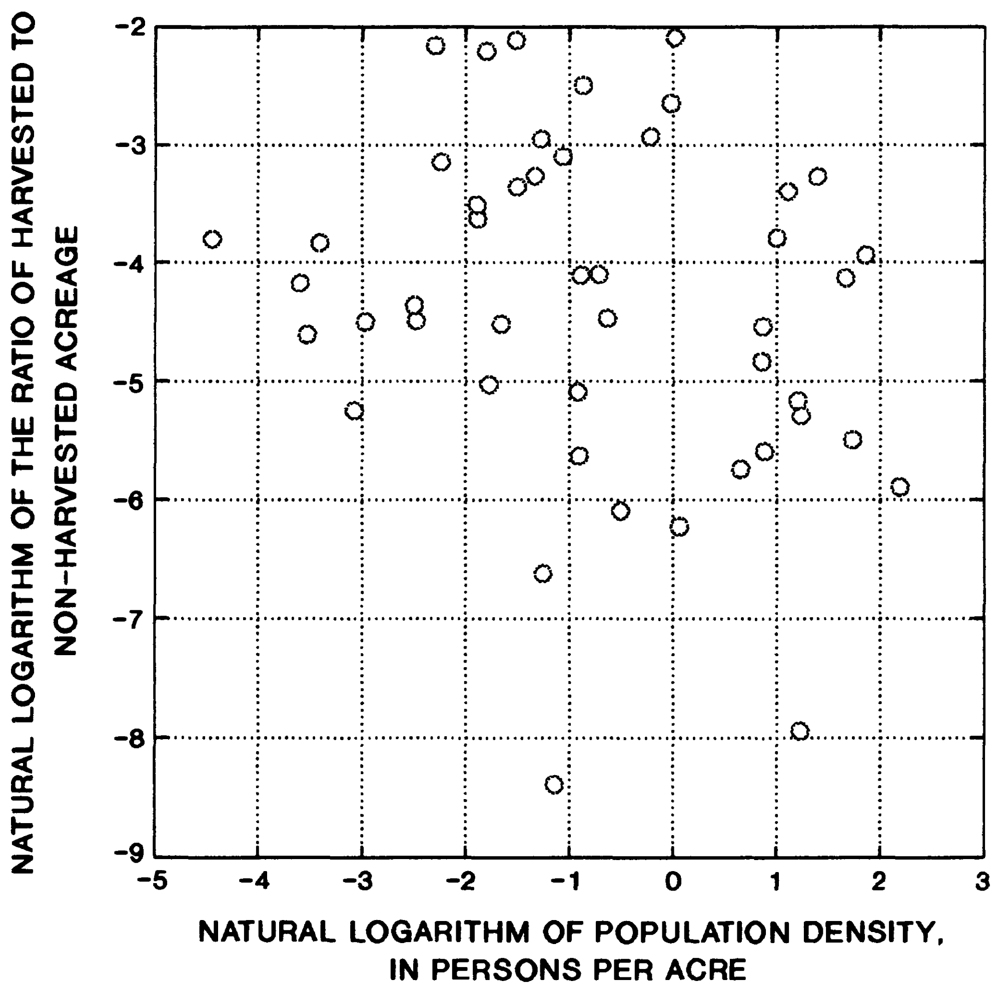


Figure 10.--Relation of the natural logarithm of population density to the natural logarithm of the ratio of harvested to non-harvested acreage in minor civil divisions in the "miscellaneous" group in 1984.

Table 4.--Results of regression analysis of population and harvested-acreage data for southern rural minor civil divisions

[MCD, minor civil division; y, the ratio of harvested to non-harvested acreage in an MCD; x, the population density (persons per acre) in an MCD; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variable]

Linear equation

$$\ln(y) = -1.53 - 0.695\ln(x)$$

t-ratio	(-17.21)	(-10.27)
p	(0.000)	(0.000)

n = 90 R^2(adj) = 0.540

Quadratic equation

$$\ln(y) = -1.25 - 0.787\ln(x) - 0.177[\ln(x)]^2$$

t-ratio	(-11.50)	(-11.74)	(-3.91)
p	(0.000)	(0.000)	(0.000)

n = 90 R^2(adj) = 0.604 F = 68.94

Table 5.--Results of regression analysis of population and harvested-acreage data for urban fringe minor civil divisions

[MCD, minor civil division; y, the ratio of harvested to non-harvested acreage in an MCD; x, the population density (persons per acre) in an MCD; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variable]

Linear equation

$$\ln(y) = -1.07 - 1.770\ln(x)$$

t-ratio	(-2.52)	(-5.06)
p	(0.017)	(0.000)

n = 34 R^2(adj) = 0.427

Quadratic equation

$$\ln(y) = -1.06 - 1.673\ln(x) - 0.070[\ln(x)]^2$$

t-ratio	(-2.44)	(-3.08)	(-0.22)
p	(0.021)	(0.004)	(0.824)

n = 34 R^2(adj) = 0.409 F = 12.43

Table 6.--Results of regression analysis of population and harvested-acreage data for "miscellaneous" minor civil divisions

[MCD, minor civil division; y, the ratio of harvested to non-harvested acreage in an MCD; x, the population density (persons per acre) in an MCD; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variable]

Linear equation

	$\ln(y) =$ -4.49	-0.194ln(x)	
t-ratio	(-19.90)	(-1.57)	
p	(0.000)	(0.124)	
n = 47	R^2(adj) = 0.031		

Quadratic equation

	$\ln(y) =$ -4.38	-0.288ln(x)	$-0.056[\ln(x)]^2$
t-ratio	(-16.44)	(-1.68)	(-0.80)
p	(0.000)	(0.100)	(0.430)
n = 47	R^2(adj) = 0.023		F = 1.54

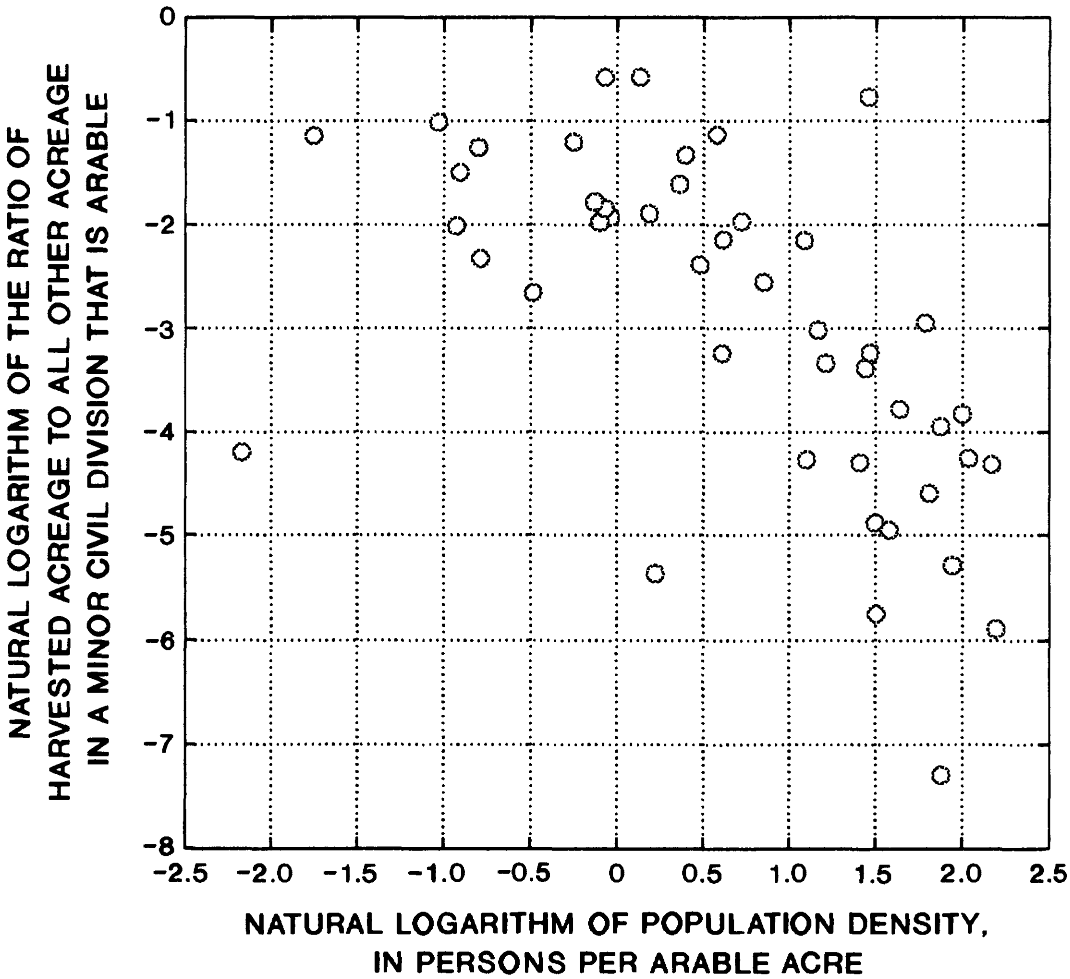


Figure 11.--Relation of the natural logarithm of the ratio of population to the number of arable acres in a minor civil division and the natural logarithm of the ratio of harvested acreage to all other acreage in a minor civil division that is arable in minor civil divisions in the "miscellaneous" group in 1984.

Table 7.--Results of regression analysis of population and harvested-acreage data for "miscellaneous" minor civil divisions after variables were redefined

[MCD, minor civil division; v, the ratio of harvested acreage to all other acreage in the MCD that is arable; u, the ratio of the number of persons in an MCD to the total number of acres in the MCD that are arable; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variable]

Linear equation

	$\ln(v) =$ -2.38	-0.884ln(u)	
t-ratio	(-10.57)	(-4.97)	
p	(0.000)	(0.000)	
n = 47	R^2(adj) = 0.345		

Quadratic equation

	$\ln(v) =$ -1.80	-0.533ln(u)	$-0.506[\ln(u)]^2$
t-ratio	(-7.44)	(-3.01)	(-4.01)
p	(0.000)	(0.004)	(0.000)
n = 47	R^2(adj) = 0.512		F = 24.59

$$\ln(v_i) = a + b_1\ln(u_i) + b_2[\ln(u_i)]^2 ,$$

where v_i = the ratio of harvested acres to all other acres in MCD_i that are arable;
u_i = the ratio of the number of persons to total acres in MCD_i that are arable; and
a, b_1, and b_2 = constants.

Northern region.--A scatterplot of the relation between population density and the ratio of harvested to non-harvested land for MCD's in the northern region is shown in figure 12. A straight-line and a quadratic regression of the variables were performed; the regression equations and test statistics are shown in table 8. A scatterplot of the relation between the two log-transformed variables is shown in figure 13. As in the scatterplot for the southern region, data points for MCD's in the northern region clustered in a line, indicating that the two variables are related. Results of regression analysis performed on the two log-transformed variables are shown in table 8.

Eight of the MCD's in the regression analysis were identified as having large standard residuals. Six of eight MCD's were found to be non-irrigated in 1984. MCD's in the northern region then were divided into two groups: those that contained irrigated farmland in 1984 and those that did not. The two groups of MCD's were plotted on a municipal map of New Jersey. Most of the northern-region MCD's that contained irrigated farmland in 1984 were found to be comparatively large and rural and were termed the "northern irrigated" MCD group. A scatterplot of the log-transformed population density and the log-transformed ratio of harvested to non-harvested acres for MCD's in the northern irrigated group is shown in figure 14. Results of regression analysis of population and harvested-acreage data for both straight-line and quadratic equations are shown in table 9. MCD's in the northern irrigated group are listed in appendix 4.

For the northern irrigated MCD group, a straight-line equation produced the best fit to the data. The equation is

$$\ln(y_i) = a + b \ln(x_i) ,$$

where y_i = the ratio of harvested to non-harvested acres in MCD_i;
x_i = the ratio of the number of persons to total acres in MCD_i; and
a and b = constants.

The characteristics of the MCD's that fell in the second group in the northern region--those that contained no irrigated farmland in 1984--were diverse. One subset of this non-irrigated MCD group consisted of comparatively small MCD's near the urban centers in Union, Essex, and southeastern Passaic Counties. The MCD's in this subset contained comparatively small numbers of harvested acres. Another subset consisted of small "crossroads" towns in rural areas. The MCD's in this subset also contained comparatively small numbers of harvested acres. The remaining MCD's in the non-irrigated group were large in area and contained greater numbers of harvested acres per MCD. This land, however, was devoted primarily to field crops and pasture, only a small percentage of which was irrigated.

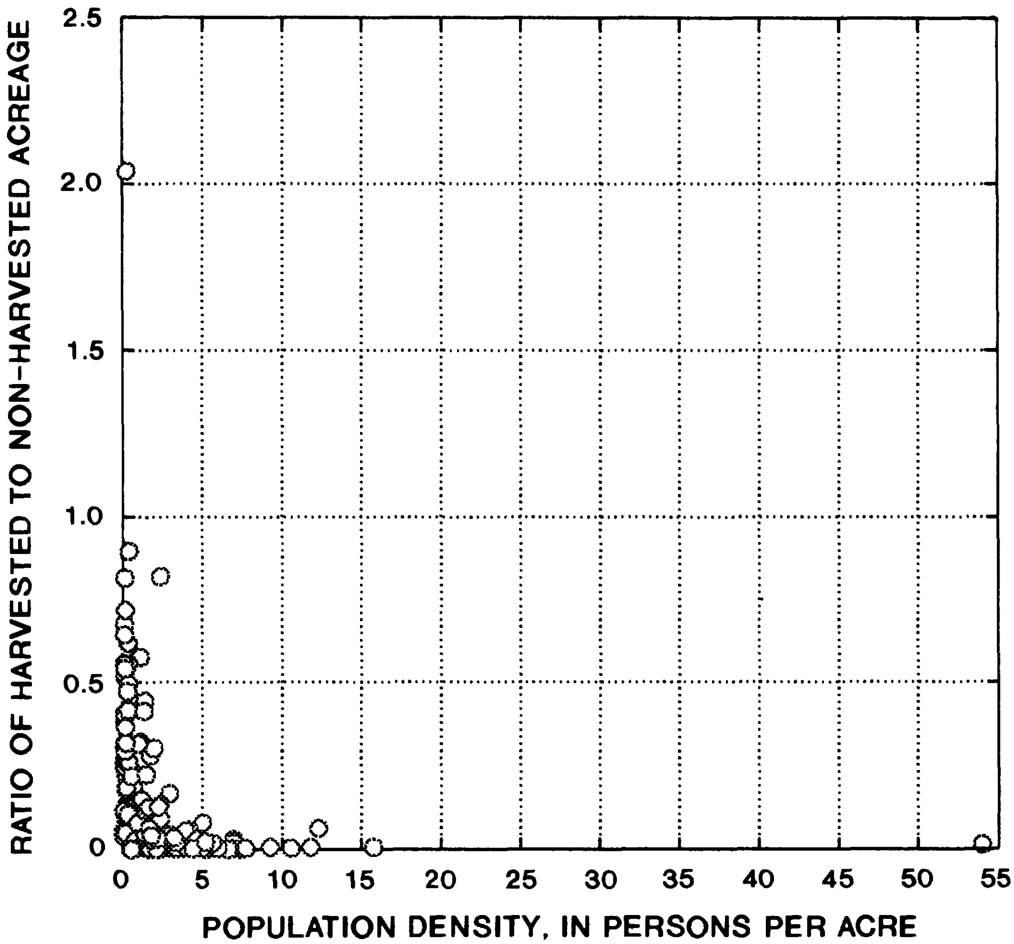


Figure 12.--Relation of population density to the ratio of harvested to non-harvested acreage in minor civil divisions in the northern region of New Jersey in 1984.

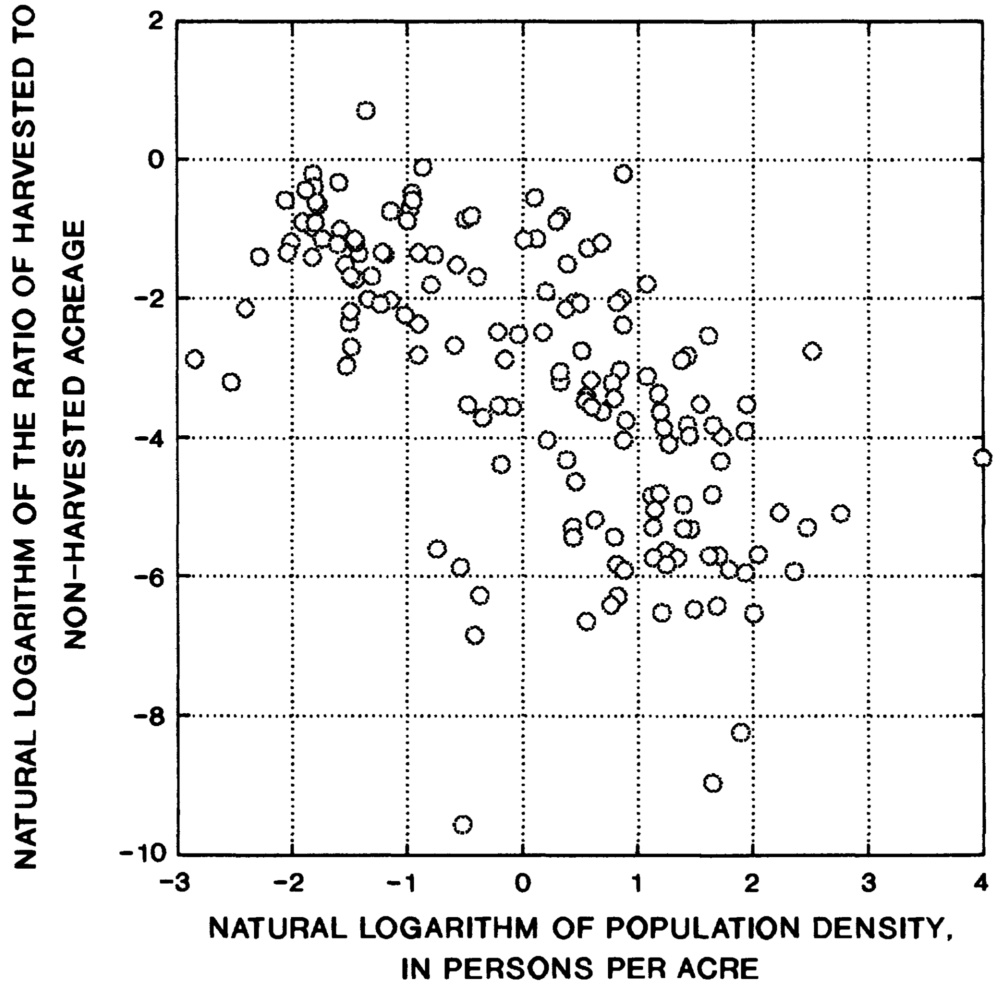


Figure 13.--Relation of the natural logarithm of population density to the natural logarithm of the ratio of harvested to non-harvested acreage in minor civil divisions in the northern region of New Jersey in 1984.

Table 8.--Results of regression analysis of population and harvested-acreage data for minor civil divisions in the northern region of New Jersey containing harvested farmland

[MCD, minor civil division; y, the ratio of harvested to non-harvested acreage in an MCD; x, the population density (persons per acre) in an MCD; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variables]

Regression of base variables

Linear equation

$$y = 0.192 - 0.0122x$$

t-ratio	(8.75)	(-3.06)
p	(0.000)	(0.003)

n = 155 R^2(adj) = 0.051

Quadratic equation

$$y = 0.256 - 0.046x + 0.0008x^2$$

t-ratio	(10.09)	(-5.34)	(4.37)
p	(0.000)	(0.000)	(0.000)

n = 155 R^2(adj) = 0.152   F = 14.79

Regression of log-transformed variables

Linear equation

$$\ln(y) = -3.07 - 0.951\ln(x)$$

t-ratio	(-23.97)	(-9.96)
p	(0.000)	(0.000)

n = 155 R^2(adj) = 0.389

Quadratic equation

$$\ln(y) = -3.09 - 0.953\ln(x) - 0.010[\ln(x)]^2$$

t-ratio	(-17.91)	(-9.89)	(0.16)
p	(0.000)	(0.000)	(0.876)

n = 155 R^2(adj) = 0.385   F = 49.26

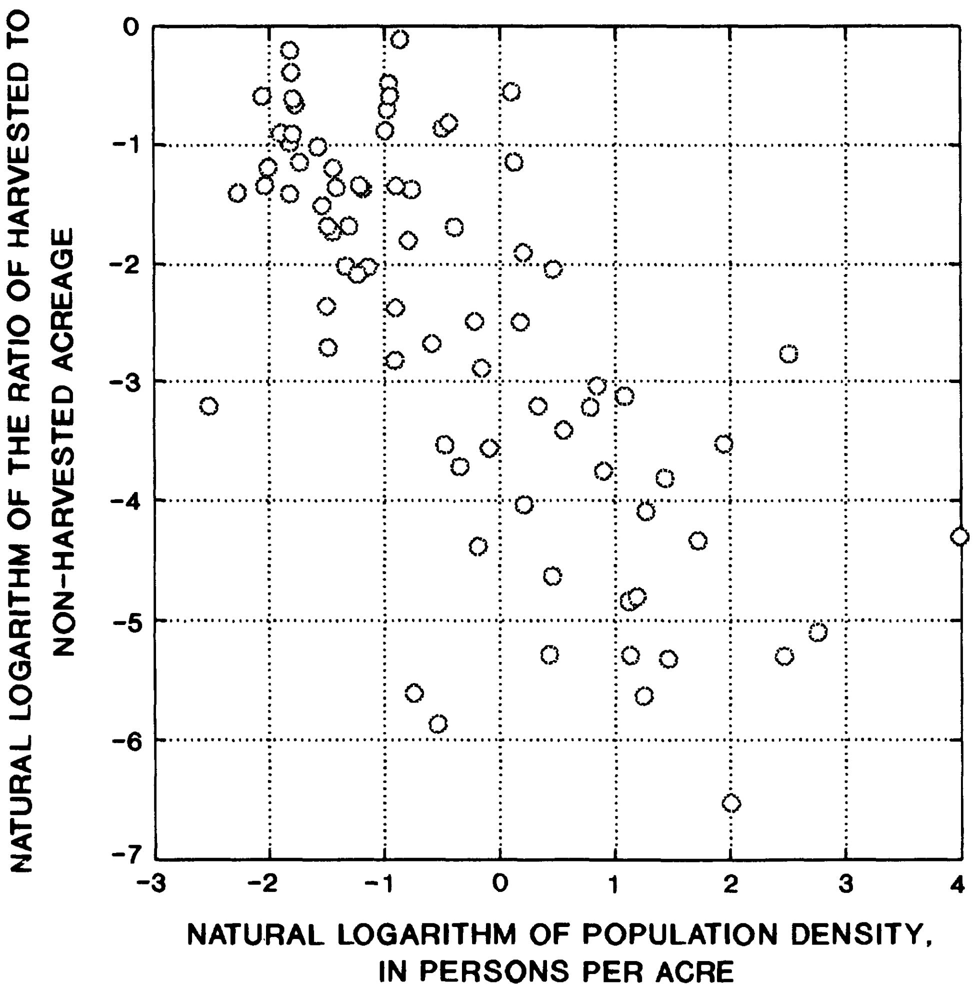


Figure 14.--Relation of the natural logarithm of population density to the natural logarithm of the ratio of harvested to non-harvested acreage in minor civil divisions in the northern irrigated group in 1984.

Table 9.--Results of regression analysis of population and harvested-acreage data for northern irrigated minor civil divisions

[MCD, minor civil division; y, the ratio of harvested to non-harvested acreage in an MCD; x, the population density (persons per acre) in an MCD; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variable]

Linear equation

$$\ln(y) = -2.82 - 0.848\ln(x)$$

t-ratio	(-20.54)	(-8.66)
p	(0.000)	(0.000)

n = 78 R^2(adj) = 0.490

Quadratic equation

$$\ln(y) = -2.96 - 0.873\ln(x) - 0.066[\ln(x)]^2$$

t-ratio	(-16.11)	(-8.71)	(-1.14)
p	(0.000)	(0.000)	(0.260)

n = 78 R^2(adj) = 0.492 F = 38.25

A scatterplot of log-transformed population density and the log-transformed ratio of harvested to non-harvested acres for MCD's in the non-irrigated group is shown in figure 15. Results of regression analysis for both straight-line and quadratic equations are shown in table 10. These results indicated that the MCD's in this group were too diverse to be modeled solely by using a population predictor. No further effort was made to model the MCD's in this group because they contained no irrigated farmland in 1984 and because they were land areas on which non-irrigated crops have been grown historically. Plate 1 shows the six groups of MCD's in New Jersey in 1984: no farmland, southern rural, urban fringe, "miscellaneous," northern irrigated, and northern non-irrigated.

Derivation of predictive equations

Predictive regression equations were fitted to the population and harvested-acreage data in each of the following four groups: (1) southern rural, (2) urban fringe, (3) "miscellaneous," and (4) northern irrigated. Not every MCD in each group was used in calculating the final coefficients for each regression equation. Data for a few MCD's in the urban fringe, "miscellaneous," and northern irrigated groups had large standard residuals and were consistent outliers in regression analysis. Upon further examination, the outlier MCD's were found to be predominantly small, with a high population density and a small number of harvested acres; four nearly met the criteria for no farmland MCD's. The distribution of population and harvested farmland in these outlier MCD's was unlike that in the other MCD's being modeled. Therefore, the outlier MCD's were eliminated from the calculation of predictive regression equations. The elimination of the outliers improved the predictive ability of the regression equation, because the R^2, the F-statistic, and the t-ratio for the predictor variable increased. Outlier MCD's are listed in table 11 and are shown in figure 16.

Because the population values associated with the statistical outliers were not used in the regression equations that were used to predict the number of harvested acres, the harvested acreage for each outlier MCD was allowed to decrease at the same rate as the aggregate predicted harvested acreage of the group to which it was assigned. For example, Edison Township is an outlier MCD in the urban fringe group. The harvested acreage in this MCD was computed to decline 19 percent every 10 years, the rate at which the aggregate predicted harvested acres declined from 1990 to 2000 in the urban fringe group.

Table 12 shows descriptive statistics for the first-order independent and dependent variables that were used in deriving predictive regression equations for each of the four MCD groups. The number of observations (n) used in each regression equation is given, as well as the maximum, minimum, and mean of the two model variables.

Table 13 shows the four regression equations used to predict the number of harvested acres along with their corresponding test statistics. T-ratios and p-values are given for each predictor variable. The number of observations (n) used in each regression is given, as are the adjusted coefficient of determination (adjusted R^2) and F-statistic for each regression. The F-statistic is not reported for straight-line regressions because it is equivalent to the t-ratio.

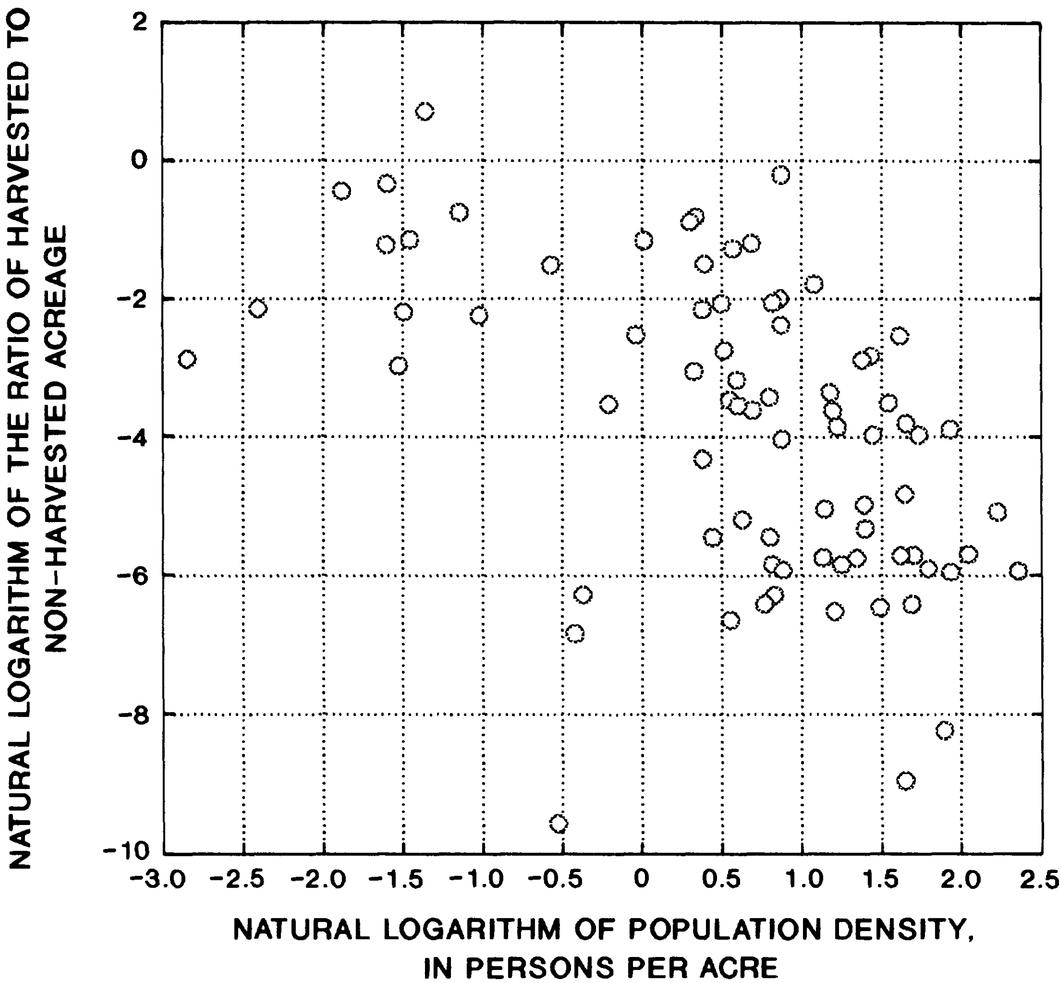


Figure 15.--Relation of the natural logarithm of population density to the natural logarithm of the ratio of harvested to non-harvested acreage in minor civil divisions in the northern non-irrigated group in 1984.

Table 10.--Results of regression analysis of population and harvested-acreage data for minor civil divisions in the northern region of New Jersey that contained no irrigated farmland in 1984

[MCD, minor civil division; y, the ratio of harvested to non-harvested acreage in an MCD; x, the population density (persons per acre) in an MCD; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variable]

Linear equation

$$\ln(y) = -3.29 - 0.944\ln(x)$$

t-ratio	(-13.41)	(-4.91)	
p	(0.000)	(0.000)	
n = 77	R^2(adj) = 0.233		

Quadratic equation

$$\ln(y) = -3.01 - 0.942\ln(x) - 0.173[\ln(x)]^2$$

t-ratio	(-9.03)	(-4.92)	(-1.23)
p	(0.000)	(0.000)	(0.221)
n = 77	R^2(adj) = 0.238		F = 12.89

Table 11.--Outlier minor civil divisions eliminated from regression analysis

Minor civil division	County	Group	Number of harvested acres in 1984
Gibbsboro Borough	Camden	Urban fringe	6
Hi-Nella Borough	Camden	Urban fringe	8
Sayreville Borough	Middlesex	Urban fringe	16
Edison Township	Middlesex	Urban fringe	42
Lower Township	Cape May	"Miscellaneous"	2,068
Ocean Township	Monmouth	"Miscellaneous"	262
Manchester Township	Ocean	"Miscellaneous"	119
Mahwah Township	Bergen	Northern irrigated	198
Morris Township	Morris	Northern irrigated	95
West Milford Township	Passaic	Northern irrigated	183
Byram Township	Sussex	Northern irrigated	37
Montague Township	Sussex	Northern irrigated	1,116
Cranford Township	Union	Northern irrigated	6
Westfield Township	Union	Northern irrigated	6

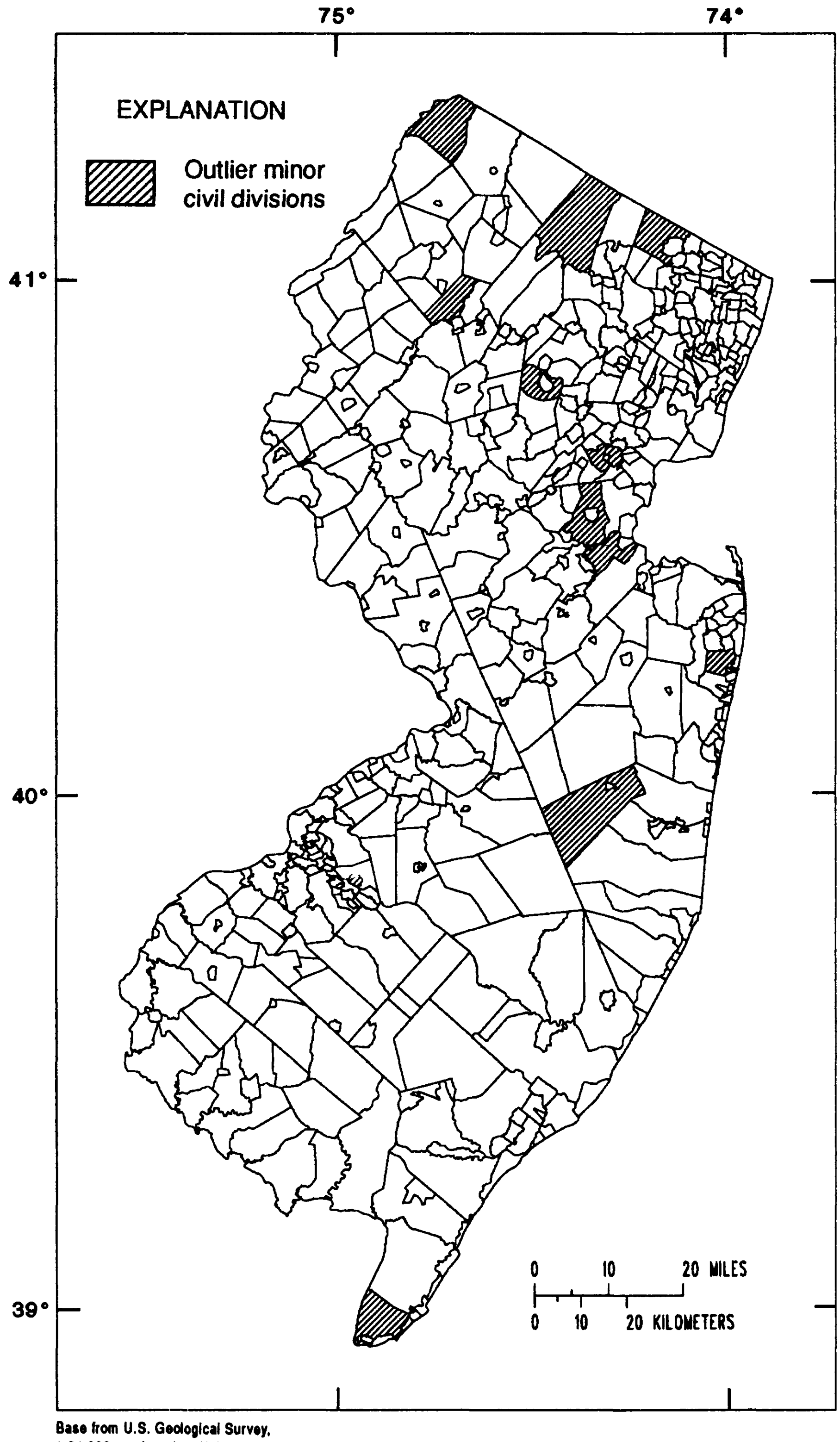


Figure 16.--Locations of outlier minor civil divisions eliminated from regression analysis.

Table 12.--Descriptive statistics for population density and the ratio of harvested to non-harvested acreage in a minor civil division for each of the four minor civil division groups

[MCD, minor civil division; in the "miscellaneous" MCD group, population density is defined as the population divided by the total number of acres of arable land in an MCD; harvested acreage was divided by the total acreage of non-harvested arable land for the dependent variable; n, number of MCD's in each group; Max, maximum value; Min, minimum value]

MCD group		Independent variable (Population divided by the number of harvested acres)			Dependent variable (Number of harvested acres divided by the number of non-harvested acres)		
	n	Max	Min	Median	Max	Min	Median
Southern rural	90	2.8	0.003	0.32	10.9	0.05	0.75
Urban fringe	30	2.1	.003	.09	8.5	.30	3.0
"Miscellaneous"	44	1.3	.001	.08	9.0	.17	2.1
Northern irrigated	71	.90	.001	.13	15.8	.10	.55

Test statistics indicate that the regression equations are useful in predicting the number of harvested acres. All estimated t-ratios for predictor variables are significant at the 0.05 level, indicating a high degree of utility of the predictor variables. Adjusted coefficients of determination for all four regression equations are greater than 0.60, indicating that 60 percent or more of the variation in harvested acreage is explained by population density. The F-statistic for each regression equation is significant at the 0.01 level, supporting the utility of the model for predicting harvested acreage.

Because adjusted coefficients of determination are less than 1.00 for the regression equations, it is clear that some other variable or variables are necessary to explain the remaining variation in harvested acreage that is not explained by population density. Data needed to define these variables, however, were either not found or were not quantifiable. Predictions of harvested acreage were made by using the regression equations developed with population density as the sole predictor because test statistics indicated that predictions could be made with reasonable confidence.

Predicting harvested acreage is a three-step process. First, predicted values of the log-transformed ratio of harvested to non-harvested acreage in an MCD are obtained by inputting values of population density and population density squared for a given year into the predictive regression equations for each MCD group. Second, the antilogarithms of these predicted values are taken. Third, the predicted number of harvested acres in an MCD is determined by solving for harvested acreage in the ratio of harvested acreage to non-harvested acreage.

A verification step was performed to determine the accuracy of the predictive regression equations. Population data for 1985 by MCD obtained from the New Jersey Department of Labor (1986) were used to predict harvested acreage by using the four predictive regression equations in table 13. Values of the predicted number of harvested acres were summed for all MCD's in all four groups to produce an aggregate value of 623,202 predicted harvested acres in 1985. Actual harvested acreage values obtained from the New Jersey Division of Taxation (1985) were summed for all MCD's in all four groups to produce an aggregate value of 636,105 actual harvested acres in 1985. A prediction error of 0.02 was calculated equal to the aggregate predicted value minus the aggregate actual value divided by the aggregate actual value. This small prediction error indicated that the predictive regression equations can be used to predict values of harvested acres with a good degree of accuracy, assuming that the relation between population density and harvested acres is valid and stable over time.

Application of a classification procedure to minor civil divisions

For the model to be dynamic, it was necessary for MCD's to be able to move from one group to another over the prediction period. For example, all of the harvested farmland in an urban fringe MCD in 1990 could be developed by 2020; thus, an urban fringe MCD could become a no farmland MCD during the prediction period. An MCD that is southern rural in 2000 could become an urban fringe MCD by 2010 as development extends farther from an urban center into an agricultural area, resulting in an increase in population and a decrease in the number of harvested acres.

Table 13.--Regression equations used to predict harvested acreage in 1990, 2000, 2010, and 2020, and corresponding test statistics

[MCD, minor civil division; y, the ratio of harvested to non-harvested acreage in an MCD; x, the population density (persons per acre) in an MCD; v, the ratio of harvested acreage to all other acreage in an MCD that is arable; u, the ratio of the number of persons to total number of acres in an MCD that is arable; n, the number of observations; R^2(adj), coefficient of determination adjusted for degrees of freedom; F, test statistic for global model utility; p, observed significance level; t-ratio, a statistic used to make inferences about the significance of the coefficient of an independent variable]

Southern rural MCD group

$$\ln(y) = -1.25 - 0.787\ln(x) - 0.177[\ln(x)]^2$$

t-ratio	(-11.50)	(-11.74)	(-3.91)
p	(0.000)	(0.000)	(0.000)
n = 90	R^2(adj) = 0.604	F = 68.94	

Urban fringe MCD group

$$\ln(y) = -0.546 - 1.304\ln(x) - 0.516[\ln(x)]^2$$

t-ratio	(-1.86)	(-3.68)	(-2.32)
p	(0.074)	(0.001)	(0.028)
n = 30	R^2(adj) = 0.693	F = 33.80	

Table 13.--Regression equations used to predict harvested acreage in 1990, 2000, 2010, and 2020, and corresponding test statistics--Continued

"Miscellaneous" MCD group			
	$\ln(y) = -1.47$	$-0.871\ln(x)$	$-0.441[\ln(x)]^2$
t-ratio	(-6.73)	(-4.24)	(-3.10)
p	(0.000)	(0.000)	(0.004)
n = 44	$R^2(\text{adj}) = 0.676$		F = 44.72

Northern irrigated MCD group		
	$\ln(y) = -2.800$	$-1.042\ln(x)$
t-ratio	(-24.45)	(-11.90)
p	(0.000)	(0.000)
n = 71	$R^2(\text{adj}) = 0.668$	

Therefore, a procedure was needed to reclassify MCD's from one group to another from 1990 through 2020. Given the assumptions of the model, land-use change could be simulated only for the reclassification of southern rural MCD's to the urban fringe group. As mentioned previously, no farmland MCD's were assumed to remain non-agricultural, with no harvested cropland. "Miscellaneous" MCD's were assumed to remain in this category because the existing constraints on the development of agriculture were assumed not to change over time. Wetlands and pinelands probably will continue to be protected and soil types probably will remain constant throughout the planning period.

It is possible for MCD's in any group (especially those in the urban fringe and northern irrigated groups) to become no farmland MCD's. Mathematically, however, for MCD's with non-zero values of harvested acreage, the value of y_i, the ratio of harvested to non-harvested land for an MCD, is never allowed to reach zero in the model. Therefore, any MCD predicted to contain less than 5 harvested acres during the prediction period was assigned to the no farmland group. This cutoff value is the minimum non-zero value for the number of harvested acres in an MCD in 1984, the base year of the model.

A procedure was developed to allow a southern rural MCD to be reclassified as an urban fringe MCD on the basis of its distance from an urban center and its population density. The procedure developed uses a form of multivariate statistical analysis called linear-discriminant analysis (LDA), which is used to classify observations into two or more groups on the basis of specified predictors (Morrison, 1976, p. 230-245). The procedure also uses a decision rule developed to handle MCD's misclassified by means of LDA. Predictor data for base year 1984 were used in the development of the classification procedure because this base year was the same as that for data used in the development of the predictive regression equations.

LDA and the decision rule were used not only to reclassify southern rural MCD's as urban fringe over the prediction period, but also to validate the original classification of MCD's into southern rural and urban fringe groups made by using scatter plot and regression analysis. A southern rural MCD determined by means of LDA and the decision rule to belong to the urban fringe group was moved to the urban fringe group. Conversely, an urban fringe MCD determined by means of LDA and the decision rule to belong to the southern rural group was moved to the southern rural group. New predictive regression equations were not computed based on this reclassification.

LDA requires that predictor data for each observation be assigned a group number by the user. Predictor data for southern rural MCD's were assigned to group 1 and data for urban fringe MCD's were assigned to group 2. Assigned group numbers and associated predictor data for urban fringe and southern rural MCD's were compiled and analyzed by means of LDA. LDA designated a predicted group number for each observation on the basis of the observation's given predictor data.

Several predictor variables were tested by using the LDA procedure. Table 14 shows the percentage of the total number of MCD's analyzed that were designated by LDA to be correctly assigned to their group for each of four experimental predictor variables. The four predictor variables tested were

(1) area, (2) population density in 1984, (3) distance from the MCD to an urban center, and (4) combined area of all MCD's contiguous to the MCD being analyzed. Results of the analysis indicate that population density and distance from an urban center resulted in the highest percentage of "correctly" designated MCD's of the four predictor variables tested. The combination of the square of the distance of an MCD from an urban center as a predictor variable, along with the population density of the MCD, resulted in the highest percentage of MCD's designated by LDA to be correctly assigned to their group.

For the variable termed "distance," three urban centers were defined as influencing suburbanization in the New Jersey Coastal Plain--the Camden/Philadelphia urban center, the Trenton urban center, and the New Brunswick urban center (associated with New York City development). The centroids of the plane regions for the City of Camden, the City of Trenton, and the City of New Brunswick were defined as the points from which the centroids of the plane region for the MCD's would be measured. If an MCD was located between two urban centers, two values were determined for distance from an urban center, and the shorter of the two distances was chosen to represent the distance of that MCD from an urban center.

About 80 percent (99 MCD's) of the 90 MCD's that were assigned to group 1 (southern rural) and the 34 MCD's that were assigned to group 2 (urban fringe) were classified in their assigned group by means of LDA on the basis of population density and the square of the distance of the MCD from an urban center as predictor variables. Results of LDA obtained by using these two predictor variables are shown in table 15.

Sixty-eight of the 90 MCD's assigned to the southern rural group, and 31 of the 34 MCD's assigned to the urban fringe group, were classified correctly. In total, 25 MCD's were misclassified by means of LDA. The misclassified MCD's appeared to belong to one of two distinct groups. About half the misclassified MCD's are located on the border between urban fringe MCD's and southern rural MCD's. LDA resulted in their classification as urban fringe MCD's because they are characterized by relatively high population densities and a relatively short distance from an urban center. The other group of misclassified MCD's are small "crossroads" towns located within other southern rural MCD's. These small MCD's are characterized by relatively high population densities and are sufficiently near urban centers to be classified as urban fringe MCD's by means of LDA.

A decision rule was developed to determine the appropriate classification for the misclassified MCD's. For southern rural MCD's classified by means of LDA as urban fringe, if the MCD was bordered on at least one side by an urban fringe MCD, it was reclassified as urban fringe. If it was not, then it remained in the southern rural group. For urban fringe MCD's whose LDA-predicted classification was southern rural, if the MCD was completely surrounded by no farmland and (or) urban fringe MCD's it remained in the urban fringe group. If it was not, it was reclassified as southern rural. An MCD predicted by means of LDA to be a southern rural MCD would have to be completely surrounded by no farmland and (or) urban fringe MCD's in order to be classified as urban fringe because, in many cases, these MCD's are the small "crossroads" towns located within other southern rural MCD's and are more accurately classified as southern rural.

Table 14.--Percentage of the total number of minor civil divisions analyzed that were designated by means of linear discriminant analysis to be correctly assigned to their group for each of four experimental predictor variables

[MCD, minor civil division; percentage is the ratio of the number of MCD's that were assigned to their group by means of linear discriminant analysis to the total number of MCD's; area is the area of an MCD; distance is distance of an MCD from an urban center; contiguous area is the combined area of all MCDs contiguous to the MCD's being analyzed]

Predictor variable	Percentage
Area	61.3
Population density	75.0
Distance	77.4
Contiguous area	70.2

Table 15.--Results of linear discriminant analysis of population density and the square of the distance of the minor civil division from an urban center for southern rural and urban fringe minor civil divisions

[MCD, minor civil division; N, the number of observations; PDEN, population density of an MCD; DIST, distance of an MCD from an urban center]

	Southern rural	Urban fringe	Total
Group:	1	2	
N:	90	34	124

Summary of classification

Group by means of linear discriminant analysis	True group 1	True group 2
1	68	3
2	22	31
Total N	90	34
N correct classifications	68	31
Percentage correct	75.6	91.2

Total number of correct classifications = 99

Total number of incorrect classifications = 25

Total percentage of correct classifications = 79.8

Linear discriminant function for group

	1	2
Constant	-1.4506	-1.4095
PDEN	.4868	.8130
$(DIST)^2$	.0105	.0034

By using the decision rule described above, 14 of the 25 misclassified MCD's were ultimately classified as southern rural, and 11 were classified as urban fringe. In total, 14 MCD's were reclassified into another group: 11 MCD's were reclassified from southern rural to urban fringe, and 3 MCD's were reclassified from urban fringe to southern rural. Eleven MCD's, all of them southern rural, remained in the southern rural group. MCD's classified in the southern rural and urban fringe groups for 1984 after application of the classification procedure are listed in appendix 5.

LDA incorporates an assumption of multivariate normality of the predictor variables. The marginals of both population density of an MCD and distance of an MCD from an urban center were skewed. Conover (1980, p. 338) recommends that discriminant analysis be applied to rank-transformed data. The two predictor variables were ranked and analyzed by means of LDA. Results were similar to those produced by using the non-ranked data. On the basis of these results, non-ranked data were used in the LDA procedure.

The classification procedure developed by using LDA and the decision rule was used to classify southern rural and urban fringe MCD's for each of the prediction years (1990, 2000, 2010, and 2020). The population density for each MCD was calculated for the four prediction years. For each prediction year, the calculated population density and the distance of an MCD from an urban center were used as input data for LDA. The form of the linear discriminant function used can be shown as

$$\text{MCD type} = f(\text{PDEN}, \text{DIST}^2),$$

where MCD type = 1 for southern rural,
2 for urban fringe;
PDEN = the population density of an MCD; and
DIST^2 = the square of the distance of an MCD from an urban center.

Table 16 shows the MCD's whose classification was changed by means of the classification procedure from southern rural to urban fringe over the prediction period, and the year in which the classification changed.

Table 16.--Minor civil divisions whose classification by means of the classification procedure was changed from southern rural to urban fringe over the prediction period

Minor civil division	County	Year of change
Evesham Township	Burlington	1990
Marlboro Township	Monmouth	1990
Washington Township	Mercer	2000
Allentown Borough	Monmouth	2000
Monroe Township	Middlesex	2000
Cranbury Township	Middlesex	2010
Englishtown Borough	Monmouth	2010
Manalapan Township	Monmouth	2010

Population projections for MCD's were needed as data input to the predictive regression equations and the classification procedure. Whenever possible, these projections were obtained from county planning agencies. Other projections were obtained from the Delaware Valley Regional Planning Commission (1982) and Greenberg and Neumann (1977). Population projections from these sources were not always available for the four model prediction years. When population projections were not available, available population projections and, in some cases, actual 1980 data, were used in extrapolation. Appendix 6 shows the population projections, by MCD, used as input to the predictive regression equations and the classification procedure, along with the sources of data.

Population projections were used in the predictive regression equations and the classification procedure to obtain predictions of harvested land for 1990, 2000, 2010, and 2020. Predicted harvested acreages are only as accurate as the population projections, the validity of the model assumptions, and the reliability of the regression equations and classification procedure developed.

Producing Estimates of Harvested Acreage

Harvested acreage was predicted for 1990, 2000, 2010, and 2020 by using the classification procedure and the predictive regression equations developed for the four MCD groups (southern rural, urban fringe, "miscellaneous," and northern irrigated) assumed to contain irrigated acres during the prediction period.

Harvested-acreage data for 1984 used to calculate coefficients for the regression equations and to test the performance of the model were obtained from the New Jersey Division of Taxation (NJDT) (1984). These data were available at the MCD level and the county level and were used in the harvested-acreage prediction model because MCD-level data were necessary for its development. The New Jersey Agricultural Statistics Service (NJASS) verifies the NJDT data by means of quality-control checks and publishes them in annual agricultural-statistics reports. The NJASS harvested-acreage data, however, are available only at the county level. The harvested-acreage data reported by NJASS were assumed to be more accurate than the data in the NJDT reports because of the quality-control checks performed on them.

In order to increase the accuracy of predicted harvested acreages produced by using the raw harvested-acreage data in the harvested-land prediction model, predicted harvested acreages were multiplied by an adjustment factor. The adjustment factor was defined as the ratio of aggregate harvested acreages for New Jersey obtained from the NJASS Annual Reports (New Jersey Agricultural Statistics Service, 1987, 1989) to aggregate harvested acreages obtained from the NJDT (New Jersey Division of Taxation, 1984, 1985, 1988). Adjustment factors for three recent years were calculated, and their arithmetic mean was calculated. Predicted harvested acreages for each county for the four prediction years were multiplied by this mean (0.938) to obtain final predicted harvested acreages.

Predicting Irrigated Acreage

The predicted harvested acreage for each of the prediction years was subdivided among six basic crop groups: orchards, nursery crops, cranberries, other berries, vegetables, and field crops. The number of irrigated acres in each crop group was determined from the predicted harvested acreage in that group by using information derived from analysis of irrigated-acreage data and from interviews with members of the New Jersey agricultural community.

The number of irrigated acres was predicted separately for each of the six crop groups because the demand for water and the percentage of harvested acres irrigated vary from one crop group to another. The methods used to estimate predicted harvested and predicted irrigated acreage were different for each crop group because of differences in data availability and observed acreage trends in each crop group. The number of harvested and irrigated crop acres was predicted by county because crop-specific information was available at the county level but not at the MCD level. In many cases acreage data for 1987, the most recent data available, were used to calculate ratios used to predict the number of harvested and irrigated acres. Harvested-acreage data for 1984 were used in the prediction of county-level harvested vegetable- and field-crop acreage; 1987 data were not available. Time periods for which trends in acreage data were examined varied among crop groups according to data availability.

Crop Type

Orchards

The actual total number of acres in orchards (apples, cherries, grapes, nectarines, pears, peaches, and plums) showed no significant trend during the 14-year period 1974-87. Orchard acreage varied slightly from year to year with an overall small decline during this period (U.S. Bureau of the Census, 1976, p. III-7 and III-8; 1989, p. 228). The U.S. Census of Agriculture reports 22,801 acres in orchards in 1974, 22,044 acres in 1978, 22,632 acres in 1982, and 20,924 acres in 1987. In 1987, more than 70 percent of total orchard acreage was in Atlantic, Burlington, Camden, and Gloucester Counties (U.S. Bureau of the Census, 1989, p. 228-229). Because total harvested acreage is predicted to decrease between 1990 and 2020 in these counties, it is assumed that orchard acreage also will decrease. Harvested orchard acreage probably also will decrease in all other counties during the prediction period.

The rate of decrease of orchard acreage was chosen to be 0.6 percent per year, the overall rate at which total orchard acreage decreased in the State from 1974 to 1987 (U.S. Bureau of the Census, 1976, 1989). In order to determine the number of orchard acres in each county in 1990, 1987 orchard acreage in each county (U.S. Bureau of the Census, 1989, p. 228) was multiplied by .994 three times to allow for a decrease from 1987 to 1990. For each of the three 10-year periods after 1990 in the prediction period, county orchard acreage was calculated to decrease 6 percent (0.6 percent times 10 years).

Because more than 95 percent of orchard acreage in New Jersey is planted in only two crop types (apples and peaches), the predicted number of acres in orchard crops was divided between these two groups. All orchard crops were assumed to be either apples or peaches. A distinction was made between apples and peaches because the percentage of harvested acreage that is irrigated differs for these two crop types.

Two percentages were calculated: the ratio of apple acreage to apple acreage plus peach acreage and the ratio of peach acreage to peach acreage plus apple acreage. These two percentages add to 100 percent and were assumed to remain constant during the prediction period. They were calculated by using 1987 data for each county and were multiplied by the predicted number of orchard acres for the four prediction years to produce estimates of predicted apple acreage and predicted peach acreage. Predicted apple and peach acreages were added together for the four prediction years to produce an estimate of the predicted number of orchard acres in each county.

Ten percent of apple acreage and 90 percent of peach acreage in the southern part of New Jersey is estimated to be irrigated during an average climate year (Jerome Frecon, Gloucester County Agricultural Extension Service, oral commun., 1990). For each of the 11 counties in the Coastal Plain province (Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Middlesex, Monmouth, Ocean, and Salem), predicted apple acreage was multiplied by 0.10 to produce estimates of predicted irrigated apple acreage, and predicted peach acreage was multiplied by 0.90 to produce estimates of predicted irrigated peach acreage.

Forty percent of apple acreage and 70 percent of peach acreage in the northern part of New Jersey is estimated to be irrigated during an average climate year (William Cowgill, Hunterdon County Agricultural Extension Service, oral commun., 1990). For each of the 10 counties (Bergen, Essex, Hudson, Hunterdon, Morris, Passaic, Somerset, Sussex, Union, and Warren) in the northern provinces, predicted apple acreage was multiplied by 0.40 to produce estimates of predicted irrigated apple acreage, and predicted peach acreage was multiplied by 0.70 to produce estimates of predicted irrigated peach acreage.

Predicted irrigated apple and predicted irrigated peach acreages in each county were added to obtain the predicted number of irrigated orchard acres for the four prediction years. Estimated irrigation percentages for apples and peaches were assumed to remain constant over the prediction period.

Nursery Crops

Nursery crops in New Jersey can be divided into two groups: field-grown nursery crops and container-grown nursery crops. Field-grown nursery crops consist of open rows of trees, shrubs, and other plants rooted in large pots, burlap sacks, or the ground. For this study, sod is grouped with field-grown nursery crops. Container-grown nursery crops consist of plants in small pots commonly propagated as cuttings from adult plants. These pots are densely packed into greenhouses. Some greenhouses with container-grown nursery crops are covered all year by glass, plastic, or the roof of a permanent structure. Others are covered only in the winter to retain the heat of the day.

Nursery crops are grown throughout New Jersey. In 1988, Monmouth County ranked first in the State in nursery-crop acreage (4,528 acres), followed by Cumberland County (2,005 acres) and Gloucester County (1,895 acres) (New Jersey Agricultural Statistics Service, 1989, p. 85).

From 1956 through 1987, nursery-crop acreage in New Jersey increased significantly. Figure 17 is a graph of actual acreage in nursery crops in New Jersey from 1956 through 1987 (New Jersey Crop Reporting Service, 1962, p. 40; 1964, p. 29; 1967, p. 61; 1970, p. 58; 1974, p. 52; 1978, p. 72; 1982, p. 50; 1985, p. 69; New Jersey Agricultural Statistics Service, 1989, p. 85). The steep increases in acreage from 1956 to 1965 and from 1979 to 1987 can be attributed to the increase in the landscaping market caused by the construction of new houses and commercial buildings in New Jersey and surrounding states.

Revenue from nursery operations increased from $92.2 million in 1981 to $206.6 million in 1987. During the same period, the ratio of nursery revenue to revenue from all other agricultural products doubled, from 0.22 to 0.44 (New Jersey Agricultural Statistics Service, 1987, p. 83; 1989, p. 81).

The demand for nursery crops probably will remain high and may increase as a result of the population growth that is projected to occur in the State during the prediction period. Nursery growers will likely sustain their acreage and may plant additional acres in nursery crops to accommodate the demand.

Because a trend in nursery-crop acreage through time was observed, a regression analysis was performed with time as the independent variable and acres of nursery crops as the dependent variable. Actual acreage data for 32 years (1956-87) were used in the regression analysis. The computed straight-line equation is

$$y = 7{,}858 + 173\,x,$$

where y = the number of acres of nursery crops in New Jersey, and

x = year (year 1 is 56).

Test statistics are not shown because the residuals exhibited autocorrelation. The error pattern indicated that one or more additional variables were needed to explain the variation in nursery acreage through time. The computed straight-line equation was used as a naive estimator for predicting future nursery-crop acreage.

The four prediction years (minus 1900) were entered into the regression equation, producing estimates of the predicted number of nursery-crop acres for the State in 1990, 2000, 2010, and 2020. State estimates were disaggregated by county. The percentage of the total number of nursery-crop acres in each county was calculated from 1987 nursery-crop-acreage data (U.S. Bureau of the Census, 1989, p. 232). These county percentages were multiplied by the estimates of the total predicted number of nursery-crop acres to produce county estimates. The county percentages calculated from the 1987 data were assumed to remain constant during the prediction period.

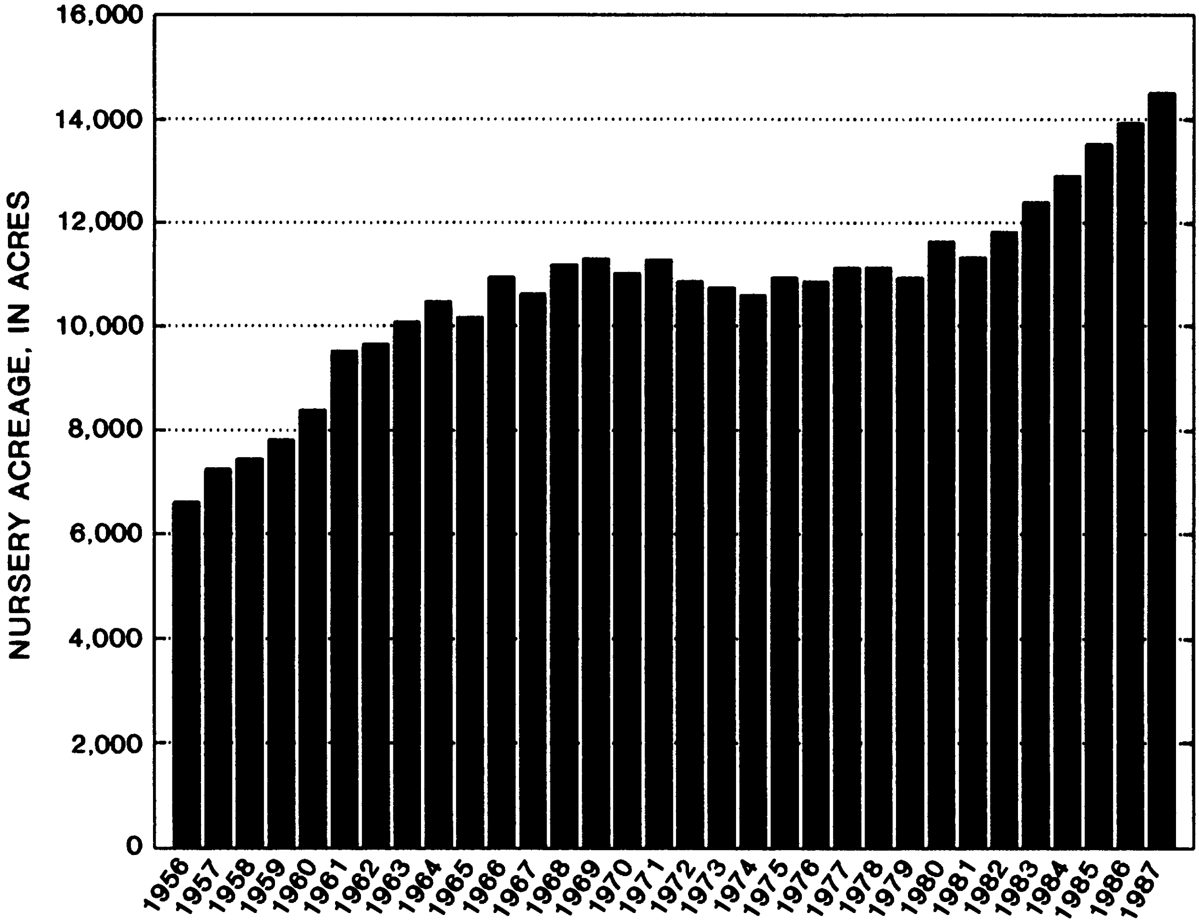


Figure 17.--Nursery-crop acreage in New Jersey, 1956-87. (Data from New Jersey Crop Reporting Service, 1962, 1965, 1968, 1971, 1974, 1978, 1982, 1985, New Jersey Agricultural Statistics Service, 1989)

Container-nursery-crop acreage is estimated to account for 10 percent of total nursery-crop acreage in New Jersey (Ralph Sayer, New Jersey Department of Agriculture, oral commun., 1990). The other 90 percent consists of field-grown nursery crops. County estimates of predicted nursery acreage were multiplied by 0.1 and 0.9 to produce estimates of predicted container-nursery acreage and predicted field-grown nursery acreage, respectively. The percentages of container- and field-grown nursery acreage are assumed to remain constant during the prediction period.

All container-grown nursery crops in the State were assumed to be irrigated (Ralph Sayer, New Jersey Department of Agriculture, oral commun., 1990). For field-grown nursery crops, the ratio of irrigated field-grown nursery acreage to harvested-field-grown nursery acreage was calculated for each county from 1987 harvested- and irrigated-nursery-crop-acreage data (U.S. Bureau of the Census, 1989, p. 232). The calculated county ratios were multiplied by the county estimates of predicted field-grown nursery acreage, producing county estimates of predicted irrigated field-grown nursery acreage. The irrigation ratios were assumed to remain constant during the prediction period.

Cranberries

Cranberry acreage has remained relatively constant at about 3,000 acres since the mid-1950's (New Jersey Crop Reporting Service, 1962, p. 41; 1965, p. 36; 1971, p. 34; 1978, p. 44; 1982, p. 31; 1985, p. 43; New Jersey Agricultural Statistics Service, 1989, p. 67). During the 14-year period 1975-88, the number of acres of cranberries harvested averaged about 3,100 acres (table 17); harvested cranberry acreage in 1988 was 3,300 acres (New Jersey Agricultural Statistics Service, 1989, p. 67). An additional 100 acres is expected to be cultivated for cranberries in the future (Joseph Darlington, American Cranberry Growers Association, oral commun., 1989). Cranberry growing in New Jersey is concentrated in the Pinelands region of the Coastal Plain province. Agriculture and other development in this area are restricted by Federal and State laws.

The number of cranberry acres harvested in the State were assumed to be constant at 3,400 acres during the prediction period. The percentage of total cranberry acreage in each county was calculated from 1987 cranberry-acreage data (Robert Battaglia, New Jersey Agricultural Statistics Service, written commun., 1989). In 1987, cranberries were grown in only three counties (Atlantic, Burlington, and Ocean). The percentage in each county was defined as the ratio of the number of acres of cranberries in that county to the total number of acres of cranberries in the State. The 3,400 acres of cranberries predicted for the State was multiplied by the county percentages for Atlantic, Burlington, and Ocean Counties to produce county estimates of the predicted number of harvested acres of cranberries in each of these three counties.

All land on which cranberries are grown is irrigated. Cranberry growers flood the cranberry bogs in autumn for harvesting and in winter for protection against frost and wind damage. In addition, more than 50 percent of cranberry acreage is irrigated in summer for cooling (Joseph Darlington, American Cranberry Growers Association, oral commun., 1989). Therefore, predicted irrigated cranberry acreage is equal to predicted harvested cranberry acreage.

Table 17.--Actual harvested acreage in cranberries, blueberries, and strawberries, 1975-88

[Data from New Jersey Crop Reporting Service, 1978, 1982, 1985; New Jersey Agricultural Statistics Service, 1989]

Year	Harvested acreage		
	Cranberries	Blueberries	Strawberries
1975	3,100	7,700	900
1976	3,100	7,600	800
1977	3,000	7,700	800
1978	3,000	7,800	700
1979	3,000	7,800	650
1980	2,900	8,100	900
1981	2,900	7,800	900
1982	3,000	7,500	1,000
1983	3,100	7,800	1,000
1984	3,200	7,900	1,000
1985	3,300	7,700	1,100
1986	3,300	7,900	900
1987	3,200	7,600	800
1988	3,300	7,700	700

Other Berries

Cranberries are not the only berry crops grown in New Jersey; blackberries, blueberries, raspberries, and strawberries also are grown. In 1987, blueberries and strawberries comprised 98 percent of the 8,530 acres on which other berries were grown (U.S. Bureau of the Census, 1989, p. 230-231). In this study, all "other berries" were assumed to be either blueberries or strawberries. To determine changes in acreage through time, blueberry- and strawberry-acreage trends were examined.

During the period 1975-88, blueberry acreage varied from 7,500 to 8,100 acres, and averaged about 7,800 acres (table 17). Like cranberry farming, blueberry farming is concentrated in the Pinelands region of the New Jersey Coastal Plain, where development is restricted. The number of blueberry acres harvested in the State was assumed to be constant at 7,800 during the prediction period.

Statewide, the number of acres of strawberries harvested ranged from 650 to 1,100 during 1975-88, and averaged about 900 (table 17). Strawberries are grown in almost all counties in the State. Recent data (1981-88) indicate neither an increase nor a decrease in strawberry acreage. Therefore, it was assumed that the number of acres of strawberries would remain constant at 900 acres during the prediction period.

The same method used for cranberries was used to predict the number of harvested and irrigated acres of blueberries and strawberries in each county. The ratio of the number of harvested acres in each county to the number of harvested acres in the State was calculated for each crop on the basis of 1987 acreage data (U.S. Bureau of the Census, 1989, p. 230). The predicted number of acres for each crop was multiplied by the corresponding county acreage ratios to produce estimates of predicted harvested acreage for each crop by county.

By using 1987 harvested- and irrigated-acreage data (U.S. Bureau of the Census, 1989, p. 230), the ratio of the number of irrigated acres to the number of harvested acres for each crop was calculated for each county. These ratios were multiplied by the estimates of predicted harvested acreage in each county, producing estimates of the predicted number of irrigated acres for each crop by county. The irrigation ratios for both crops were assumed to remain constant during the prediction period.

Vegetables and Field Crops

After accounting for harvested acreage devoted to orchards, nurseries, and berries, the remaining harvested acreage was subdivided between the two remaining major crop groups (vegetables and field crops) for each county in each of the four prediction years.

Trends in harvested field-crop and vegetable acreage through time were examined. Figures 18 and 19 are graphs of harvested vegetable acreage and harvested field-crop acreage, respectively, from 1972 through 1987. Field-crop acreage increased during the 1970's and decreased during the 1980's. The increase in the late 1970's was the result of Federal price supports for soybeans that began during this period. Soybeans account for a significant percentage of field-crop acreage in New Jersey (New Jersey Crop Reporting Service, 1974, p. 5; 1978, p. 5; 1982, p. 5; 1985, p. 9; New Jersey Agricultural Statistics Service, 1989, p. 39); in 1980, soybean acreage comprised 36 percent of total field-crop acreage (New Jersey Crop Reporting Service, 1982, p. 2). When the incentive to grow soybeans was discontinued, soybean acreage and, hence, field-crop acreage, declined.

Vegetable acreage decreased during the 1970's but leveled off to about 60,000 acres statewide in the 1980's. Vegetable acreage has increased in proportion to field-crop acreage. Figure 20 is a graph of the ratio of vegetable acreage in the State to the sum of vegetable acreage and field-crop acreage from 1981 through 1987. The trend is decidedly upward, indicating that vegetable acreage increased in relation to field-crop acreage. The total number of harvested field-crop acres greatly exceeded the total number of harvested vegetable acres, however; in 1987, for example, the number of harvested field-crop acres was almost seven times the number of harvested vegetable acres (New Jersey Agricultural Statistics Service, 1989).

The increase in harvested vegetable acreage in proportion to harvested field-crop acreage is the result of economic considerations. Vegetables are high-value crops that can be sold at retail, rather than at a much lower wholesale price. Farmers' markets, "pick-your-own" farms, and roadside stands have become increasingly popular in many suburban areas and allow farmers to capitalize on consumers' preference for fresh, high-quality produce and direct contact with the grower (Lockeretz, 1989, p. 206). In an economic study based on New Jersey data on produce prices and revenue, Lopez and others (1988) found that suburbanization encourages vegetable production but discourages production of certain field crops and other commodities. Results of the study showed that suburbanization significantly increases the prices that farmers can charge for vegetables.

In order to relate statistically harvested vegetable acreage to harvested field-crop acreage, a regression was performed with time as the independent variable and the ratio of harvested vegetable acreage in the State to the sum of harvested vegetable acreage and field-crop acreage in the State as the dependent variable. Actual harvested-vegetable- and-field-crop-acreage data for 7 years (1981-87) were used in the regression analysis. Data reported prior to 1981 were not used because the high soybean-acreage values would have distorted the ratio. A first-order equation best fitted the data. The computed straight-line equation is

$$y = 0.0887 + 0.00512\ x\ ,$$

where y = the ratio of harvested vegetable acreage in the State to the sum of harvested vegetable acreage and field crop acreage in the State, and
x = year (year 1 is 1981).

Results of the regression analysis produced an adjusted coefficient of determination (R^2) of 0.885. The computed t-statistic for the independent variable is 6.85. Computed test statistics were significant at $p = 0.001$.

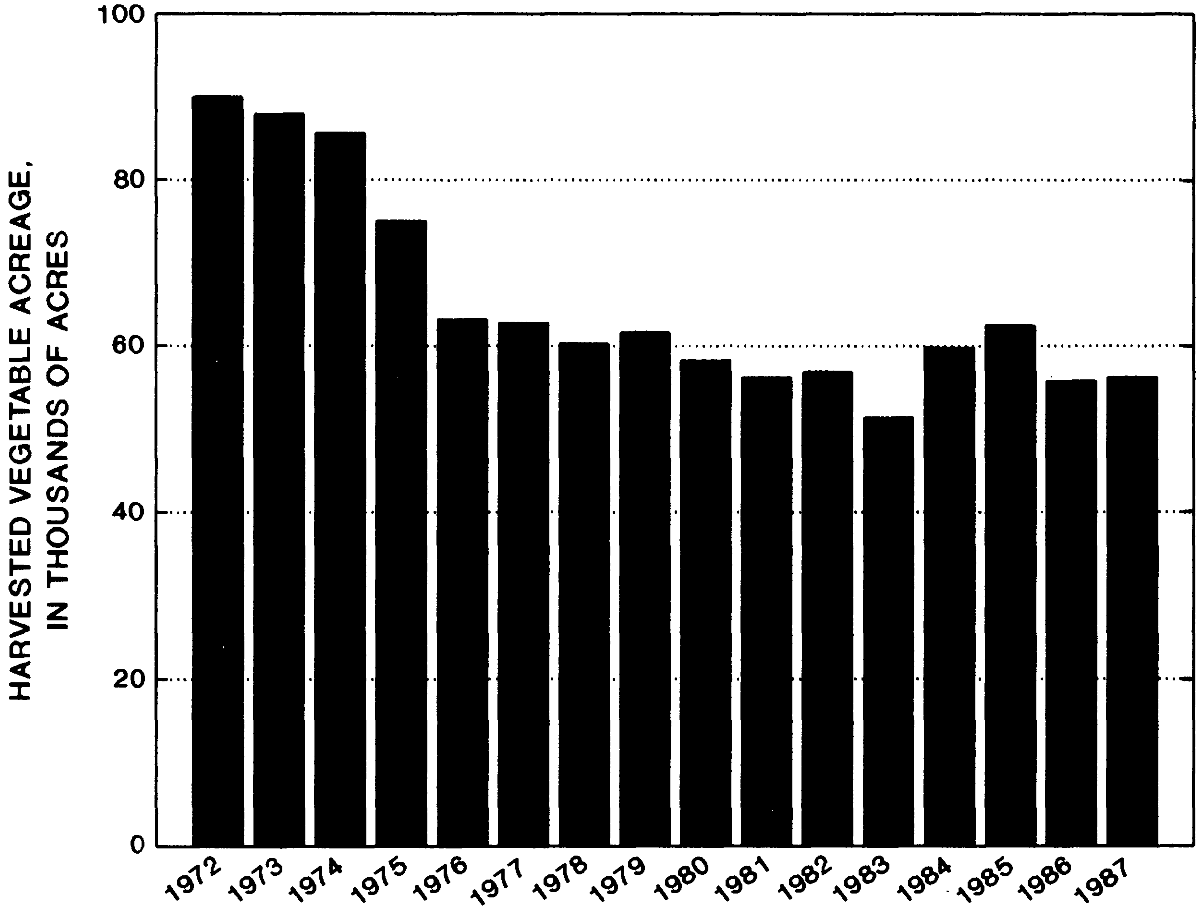


Figure 18.--Harvested vegetable acreage in New Jersey, 1972-87. (Data from New Jersey Crop Reporting Service, 1974, 1978, 1982, 1985, New Jersey Agricultural Statistics Service, 1989)

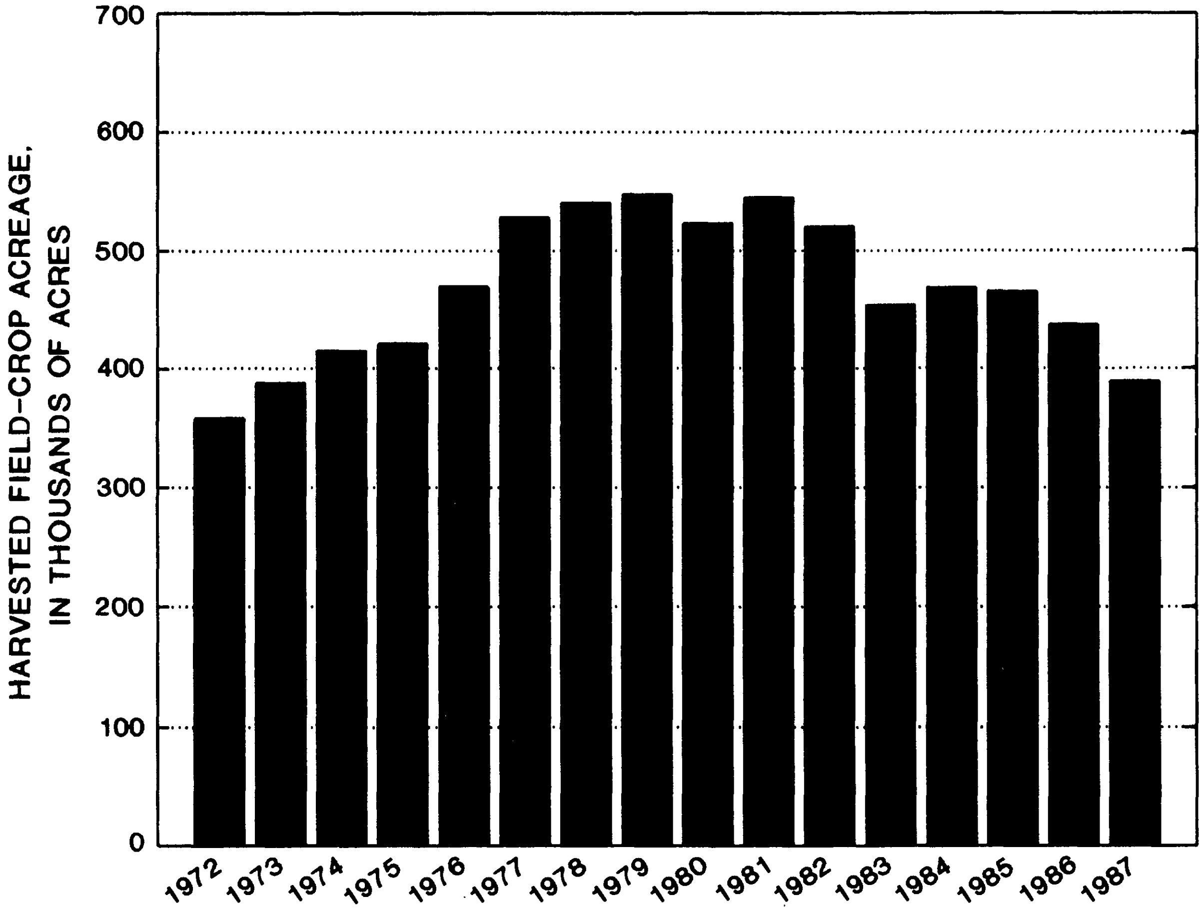


Figure 19.--Harvested field-crop acreage in New Jersey, 1972-87. (Data from New Jersey Crop Reporting Service, 1974, 1978, 1982, 1985, New Jersey Agricultural Statistics Service, 1989)

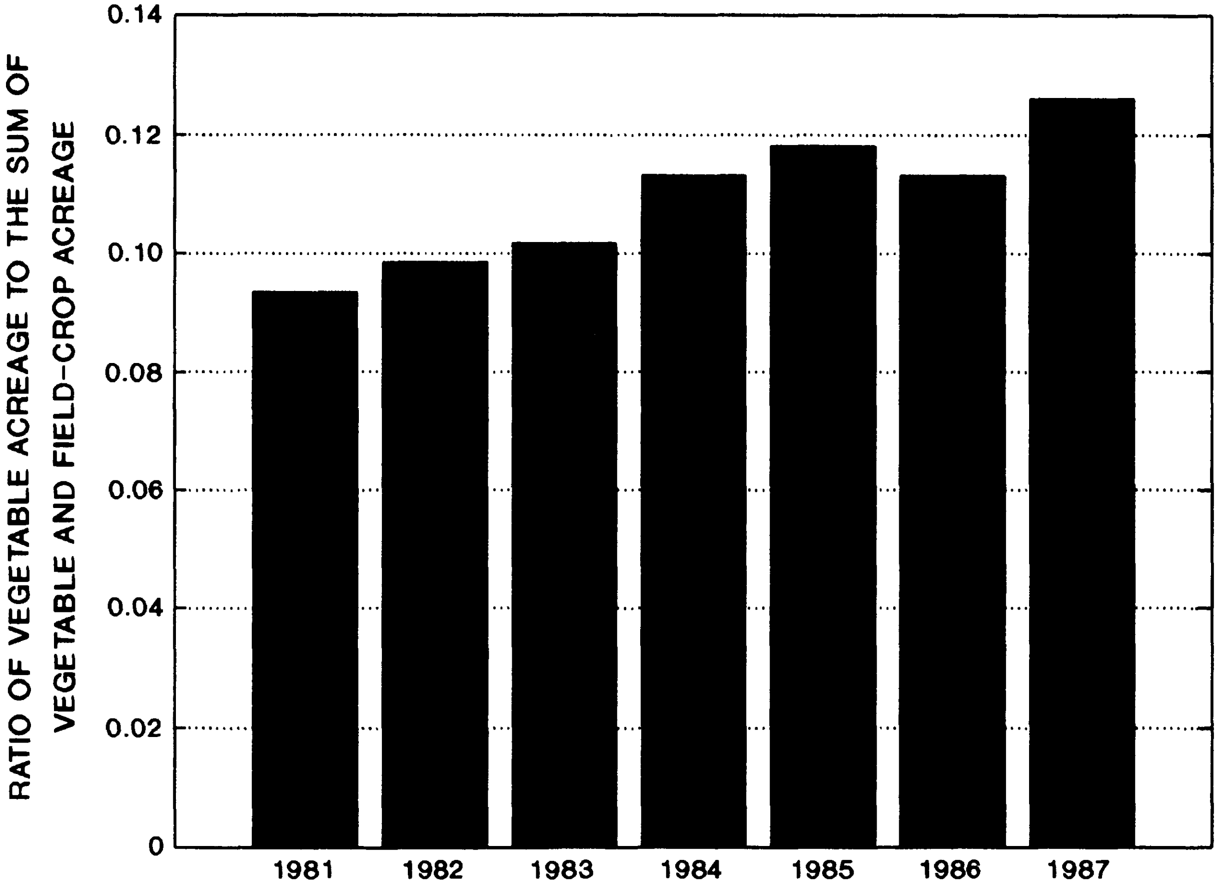


Figure 20.--Ratio of vegetable acreage to the sum of vegetable and field-crop acreage in New Jersey, 1981-87. (Data from New Jersey Crop Reporting Service, 1982, 1985, New Jersey Agricultural Statistics Service 1989)

The computed straight-line equation was used as a naive estimator to predict harvested vegetable and field-crop acreage on the basis of the assumption that recent (1981-87) trends in the ratio of the number of vegetable acres to the number of field-crop acres are likely to continue.

Because vegetables are heavily water-dependent and typically require irrigation each year, they are an important component of the computation of water demand for field-grown crops. A separate, more thorough analysis to predict the number of harvested vegetable acres on the basis of market and other factors may produce more accurate estimates than the naive model applied here.

Table 18 shows the predicted ratio of harvested vegetable acreage to the sum of harvested-vegetable and -field-crop acreage (termed the "vegetable-acreage ratio") and the predicted ratio of harvested field-crop acreage to the sum of harvested field-crop and vegetable acreage (termed the "field-crop-acreage ratio") for each of the four prediction years. The vegetable-acreage ratio increased 5 percent per decade (or 0.5 percent per year) and the field-crop-acreage ratio decreased 5 percent per decade.

Table 18.--Vegetable-acreage ratios[1] and field-crop-acreage ratios[2] for New Jersey in 1990, 2000, 2010, and 2020

Year	Vegetable-acreage ratio[1]	Field-crop-acreage ratio[2]
1990	0.14	0.86
2000	.19	.81
2010	.24	.76
2020	.29	.71

[1] The predicted ratio of harvested vegetable acreage to the sum of harvested vegetable and field-crop acreage.

[2] The predicted ratio of harvested field-crop acreage to the sum of harvested vegetable and field-crop acreage.

Predicted vegetable and field-crop acreages were disaggregated by county by multiplying them by actual county vegetable-acreage and field-crop-acreage ratios. Actual county vegetable-acreage and field-crop-acreage ratios were calculated from 1984 harvested vegetable- and field-crop-acreage data obtained from the New Jersey Farmland Assessment Survey (Robert Battaglia, New Jersey Agricultural Statistics Service, written commun., 1989). The ratio (termed the "actual county vegetable-acreage ratio") of the number of vegetable acres in each county to the sum of the number of vegetable and field-crop acres in each county was calculated. The actual county field-crop-acreage ratio was calculated by subtracting the actual county vegetable-acreage ratio from one. Actual county vegetable- and field-crop-acreage ratios were assumed to remain constant during the prediction period.

Predicting harvested vegetable acreage required three steps. First, the predicted orchard, nursery-crop, cranberry, and "other berry" acreages were subtracted from the total predicted harvested acreage to determine the acreage of vegetables and field crops combined. Second, the resulting acreage was multiplied by the actual county vegetable-acreage ratio. Third, the product of this multiplication was then multiplied by the vegetable-acreage ratio to obtain an estimate of the predicted number of harvested vegetable acres. Predictions of harvested vegetable acreage were made for each county for each of the four prediction years. Predictions of field-crop acreage were made by subtracting harvested vegetable acreage from the combined vegetable and field-crop acreage. These predictions also were made for each county for each of the four prediction years.

An example calculation of predicted harvested vegetable acreage for Atlantic County in 1990 is as follows: Vegetable acreage = (16,704) x (0.745) x (1.03), where 16,704 is the number of acres to be divided between vegetables and field crops, 0.745 is the actual county vegetable-acreage ratio, and 1.03 is the predicted vegetable-acreage ratio. The predicted vegetable-acreage ratio of 1.03 was calculated on the basis of an increase of 0.5 percent per year from 1984 (the base year) through 1990.

The percentage of harvested vegetable acreage irrigated in each county was calculated on the basis of 1987 data on harvested and irrigated vegetable acreage (U.S. Bureau of the Census, 1989, p. 218). This percentage was defined as the number of acres of irrigated harvested vegetables in each county divided by the number of acres of harvested vegetables in each county; this ratio was assumed to remain constant during the prediction period. The predicted harvested vegetable acreage in each county was multiplied by the corresponding irrigation percentage to produce estimates of predicted irrigated harvested vegetable acreage.

The irrigation percentage for field crops could not be calculated by county because data on irrigated acreage for some field crops were unavailable at the county level. Instead, a statewide ratio of irrigated harvested field-crop acreage to harvested field-crop acreage was calculated for 1987 (U.S. Bureau of the Census, 1989, p. 212-217). The predicted harvested field-crop acreage in each county was multiplied by this ratio (0.033) to obtain the predicted number of irrigated harvested field-crop acres. The irrigation percentage for field crops in the State was assumed to remain constant during the prediction period.

Total Predicted Irrigated Acreage

The predicted number of irrigated acres for all crop types was summed to produce estimates of total irrigated acreage by county for the four prediction years.

Predicting Water Demand for Field-Grown Crops

In order to predict water demand for field-grown crops, it was necessary to estimate the amount of irrigation water that would be applied to the predicted number of irrigated acres of field-grown crops in the State. A daily water-balance model was used to calculate optimum irrigation amounts. This model required data on climate, soil water-holding capacity, and the water requirements of specific crops.

Optimum irrigation amounts were calculated by using temperature and precipitation data from a recent 29-year period. It was assumed that optimum irrigation amounts calculated for this period were representative of long-term New Jersey climatic conditions and could be used as estimates of optimum irrigation amounts over the prediction period.

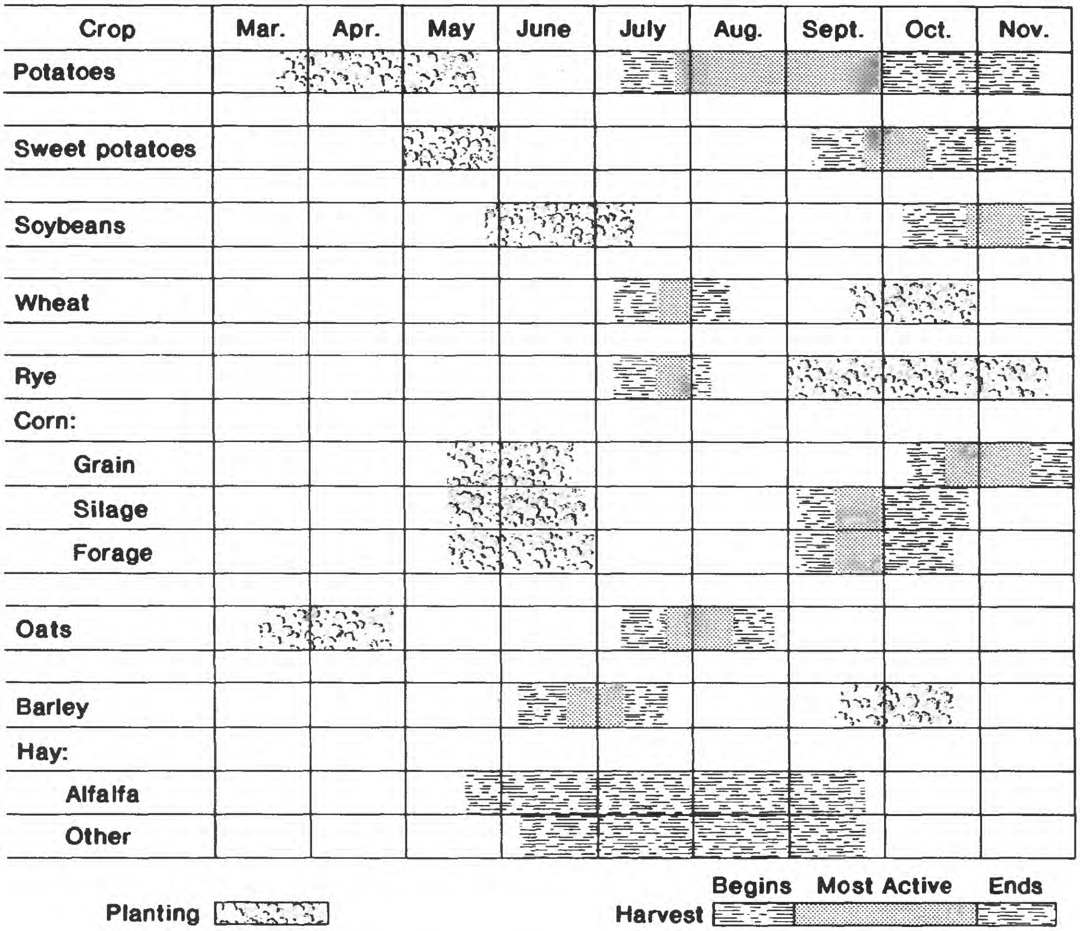
Optimum irrigation amounts were estimated for six general soil types for each of the 20 New Jersey counties that contain farmland. These estimates are considered to be optimum because they are estimates of the amount of water that produces maximum crop yields and keeps plants from permanently wilting. In practice, however, farmers commonly use more or less water than the predicted optimum amount. The decisions involved in irrigation--when and how much--are not likely to match exactly the soil requirements. A farmer's decision to irrigate often is based on many factors other than immediate soil conditions, such as weather predictions and pumping costs. Some farmers decide to irrigate on the basis of the "feel" of the soil, others irrigate on the basis of the "look" of their plants, and still others use alternative criteria in making their decisions.

The efficiency of the irrigation system used also affects the amount of irrigation water a farmer uses. For example, if a farmer needs to apply 100 gallons of water to replenish soil moisture and his irrigation system is 80 percent efficient, the farmer must actually use 125 (100/.80) gallons of water. As mentioned previously in this report, efficiencies of irrigation systems used in New Jersey range from 50 to 90 percent.

Ideally, estimates would allow for additions to or subtractions from the optimum amount resulting from farmers' irrigation practices and the efficiency of their irrigation equipment. The optimum amount would be multiplied by a factor that adjusts for the irrigation practices and equipment. In this report, however, all predictions of water demand for field-grown crops are estimates of optimum irrigation amounts and are not multiplied by an adjustment factor.

In order to obtain a range of predictions of water demand for field-grown crops, optimum irrigation amounts were calculated for three climatological scenarios: (1) wet year, (2) average year, and (3) drought year. A wet-year scenario is defined by the minimum annual irrigation amount during 1953-81. An average-year scenario is defined by the mean annual irrigation amount during 1953-81. A drought-year scenario is defined by the maximum annual irrigation amount during 1953-81. The three climatological scenarios were defined by using temperature and precipitation data for 1953-81 because a virtually complete data set was available for 15 weather stations throughout the State for those years. Optimum irrigation amounts were calculated for the three climatological scenarios in each of the 20 agricultural counties by using local county soil water-holding capacity information and local climatological data. Yearly and monthly irrigation amounts were calculated. Monthly irrigation amounts were calculated for March through November, the months when field-grown crops in New Jersey are irrigated, from planting through harvesting. Figure 21 shows the usual planting and harvesting dates for field crops in New Jersey and the usual full-bloom and harvesting dates for fruits and berries in New Jersey. Figure 22 shows the usual planting and harvesting dates for fresh and processed vegetables in New Jersey. The schedule of irrigation from planting through harvesting varies with crop type and weather.

21a.--USUAL PLANTING AND HARVESTING SCHEDULE FOR FIELD CROPS IN NEW JERSEY



21b.--USUAL FULL-BLOOM AND HARVESTING SCHEDULE FOR FRUITS AND BERRIES IN NEW JERSEY

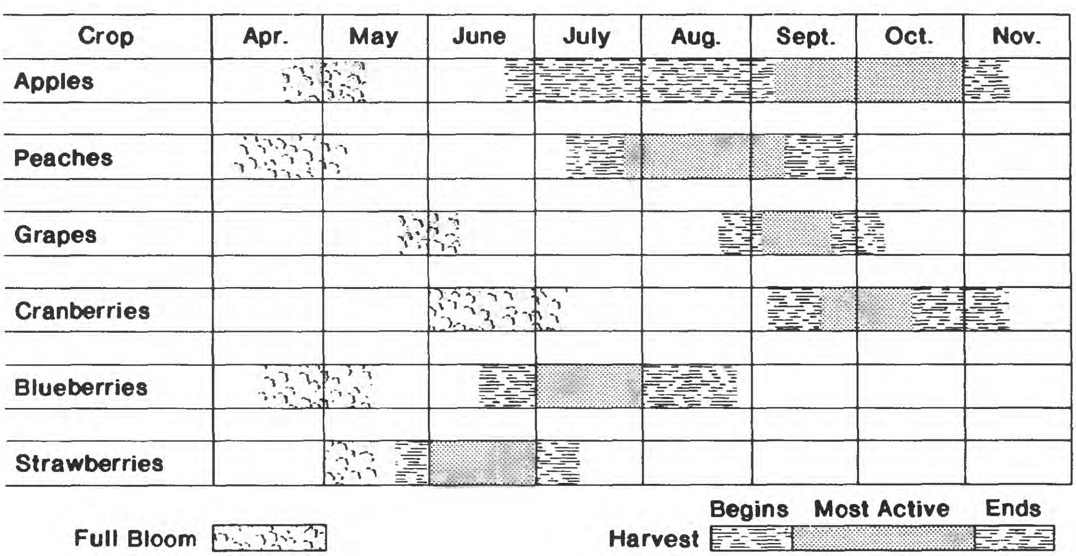


Figure 21.--(a) Usual planting and harvesting schedule for field crops, and (b) usual full-bloom and harvesting schedule for fruits and berries in New Jersey. (Modified from New Jersey Agricultural Statistics Service, 1986)

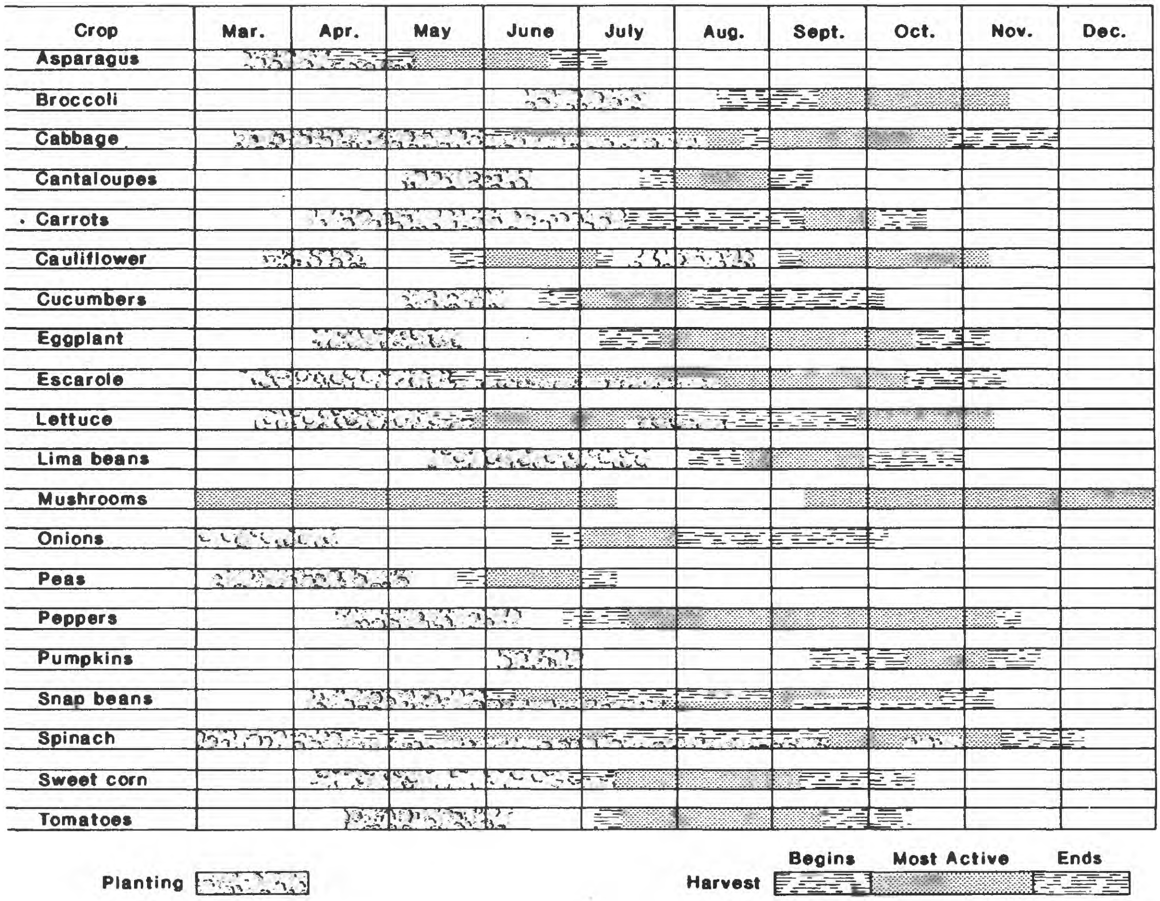


Figure 22.--Usual planting and harvesting schedule for fresh and processed vegetables in New Jersey. (Modified from New Jersey Agricultural Statistics Service, 1986)

The irrigation amounts in inches calculated for the three climatological scenarios in the 20 agricultural counties were multiplied by 27,167 to convert the units to gallons per acre. The number of gallons per acre was then multiplied by the predicted number of irrigated acres of field-grown crops in each county for the four prediction years. The resulting estimates are yearly and monthly predictions of water demand in gallons for field-grown crops by county. Daily predictions were computed by dividing the water demand for each month by the number of days in that month.

As mentioned previously in this report, irrigated-acreage data for 1987 were used to calculate the predicted number of irrigated acres by crop type. These data were used because they were the most recent data available and because time periods used to examine trends in acreage data varied among crop groups as a result of data availability.

An increase or decrease in the number of irrigated acres during the prediction period would affect the amount of water demand for field-grown crops. In their work estimating the short-term demand for agricultural water for irrigation use in New Jersey, Titus and others (1990) considered scenarios of irrigated-acreage change. They calculated a 2-percent annual increase and a 2-percent annual decrease in irrigated acreage for all crop types during the prediction period 1984-90 to obtain a range of values of water demand for irrigated crops.

A similar approach was taken in this report to account for possible changes in the number of acres of field-grown crops irrigated during the prediction period. Two scenarios were considered: (1) a 2-percent annual increase in predicted irrigated acreage for field-grown crops from 1990 through 2020, and (2) a 2-percent annual decrease in predicted irrigated acreage for field-grown crops from 1990 through 2020. A 2-percent annual change in irrigated acreage was considered reasonable because the U.S. Census of Agriculture reported a 10-percent increase in irrigated acreage in New Jersey from 1982 to 1987 (U.S. Bureau of the Census, 1989, p. 1); however, for predictions to the year 2020, the 2-percent increase and 2-percent decrease per year should be considered as only a rough estimate of change during the prediction period.

The predicted number of irrigated acres of field-grown crops in 2000, 2010, and 2020 calculated for each of the two acreage-change scenarios was multiplied by the optimum irrigation amount for each of the three climatological scenarios to produce estimates of predicted water demand for field-grown crops under the two acreage-change scenarios. The optimum irrigation amounts used in the calculations were State total amounts summed for all counties.

Model Description

A Thornthwaite daily water-balance model (Thornthwaite and Mather, 1955; Mather, 1978) was used to calculate soil moisture and to determine when irrigation was required. The Thornthwaite water balance has been shown to provide reliable estimates of daily soil moisture in humid-temperate regions (Mather, 1978). The Thornthwaite daily water balance requires inputs of daily potential evapotranspiration (PE) and daily precipitation (P). First, precipitation is used to satisfy potential-evapotranspiration demands for water. Precipitation in excess of potential evapotranspiration is used to replenish soil-moisture storage. If soil-moisture storage is at capacity, excess precipitation becomes a soil-water surplus and, eventually, runoff.

Soil moisture is critical to healthy plant growth. Irrigation is necessary when the amount of precipitation is insufficient to maintain soil moisture. Not all precipitation is available for replenishing soil-moisture storage and for subsequent evapotranspiration. Surface runoff from agricultural watersheds after a significant rainfall can deplete the moisture supply available for consumptive use by crops. For this study, effective precipitation (PEFF)--the amount of precipitation available for soil-moisture recharge and consumptive use by crops--was calculated on the basis of total rainfall. Table 19 lists the equations used to calculate the value of effective precipitation from a given value of total precipitation (McCabe and others, 1985, p. 3).

The Thornthwaite model for the calculation of soil-moisture storage can be represented by the equation

$$SM_i = SM_{i-1} + PEFF_i - AE_i,$$

where SM_i = the quantity of moisture in the soil at the end of day_i;

SM_{i-1} = the quantity of moisture left in the soil at the end of day_{i-1};

$PEFF_i$ = the effective precipitation (precipitation - runoff) on day_i; and

AE_i = the actual evapotranspiration on day_i.

For purposes of this study, PE is defined as evapotranspiration that is not limited by a lack of available water. Estimation of actual evapotranspiration (AE), evapotranspiration that is limited by available water, requires an adjustment of PE for both soil-moisture content and crop growth stage. For this study, PE is calculated first and then adjustments are made for the estimation of AE.

PE was calculated by using the Hamon model (Hamon, 1961). A simplified expression for the Hamon calculation of PE is

$$PE = C \times D^2 \times P_t,$$

where PE = the average potential evapotranspiration in inches per day;

D = the possible hours of sunshine per day in units of 12 hours;

P_t = the saturated water-vapor density (absolute humidity) at the mean daily temperature, in grams per cubic meter multiplied by 10^{-2}; and

C = 0.55, a number chosen to yield appropriate yearly values of potential evapotranspiration.

Table 19.--Equations used to calculate the value of effective precipitation from a given value of precipitation

[p, precipitation, in inches; peff, effective precipitation, in inches; from McCabe and others, 1985, p. 3]

Precipitation	Equation used to calculate peff
$0 \leq p \leq 0.11$	peff = p
$0.11 < p \leq 0.36$	peff = [(-0.2 x p) + 1.02] x p
$0.36 < p \leq 0.76$	peff = [(-0.125 x p) + 0.99] x p
$0.76 < p \leq 1.51$	peff = [(-0.067 x p) + 0.95] x p
$1.51 < p \leq 2.51$	peff = [(-0.05 x p) + 0.925] x p
$2.51 < p$	peff = 0.8 x p

The Hamon model requires inputs of mean daily temperature and length of day to calculate PE. Daily estimates of PE are similar to those produced by the Thornthwaite model, but the Hamon model requires fewer input data and provides less extreme estimates of PE during winter and summer months (Hamon, 1961, p. 116). This is particularly important in this study because most irrigation water for consumptive use is applied during summer.

Information on soil type specific to each county was used to improve the accuracy of the estimate of AE in this study. A two-layer soil-moisture-storage model was used to calculate soil-moisture content. The top soil layer was assumed to be 6 inches thick. The bottom soil layer was assumed to be 18 inches thick. A distinction was made between top and bottom layers because it is easier for a plant to extract water from a top soil layer than from a bottom soil layer because of gravity. Deep-rooted crops and fruit trees have roots at depths greater than 24 inches, but this depth is assumed to be the practical limit for most irrigation applications (U.S. Soil Conservation Service, 1983, p. 2.6).

Transpiration rate varies with crop type because each crop has a different area and leaf-surface texture. Additionally, as a plant grows, the total area and character of the leaf surface change, and the transpiration rate changes. Thus, to estimate AE for an agricultural crop on a daily basis, PE must be adjusted for changes in vegetative cover.

Several crop growth-stage coefficient curves that show the ratio of actual evapotranspiration to potential evapotranspiration as a function of the percentage of the growing season have been published (U.S. Soil Conservation Service, 1967). Figure 23 is a crop growth-stage coefficient curve for sweet corn. An AE/PE ratio was calculated for each percentage increment of the growing season for 10 crops whose crop growth-stage coefficient curves were published by the U.S. Soil Conservation Service (1967). The PE estimate on any given day was multiplied by the corresponding AE/PE ratio for that percentage of the growing season. In equation form,

$$AE = PE \times Kc,$$

where AE = daily potential evapotranspiration corrected for the effects of vegetative cover, in inches;
PE = daily potential evapotranspiration computed by using the Hamon model; and
Kc = the ratio of AE to PE at a given percentage of the growing season.

Table 20 lists the 10 crops for which AE/PE ratios were determined from the curves in U.S. Soil Conservation Service (1967) in order to compute daily AE values. (See table 20 on page 74.) Because growth-stage coefficient curves were not available for all crops grown in New Jersey, some crops were grouped with those for which these curves were available, on the basis of similar rooting depths and plant characteristics. An AE/PE ratio of 1.0 was used for field-grown nursery crops because these plants are mature bushes and trees.

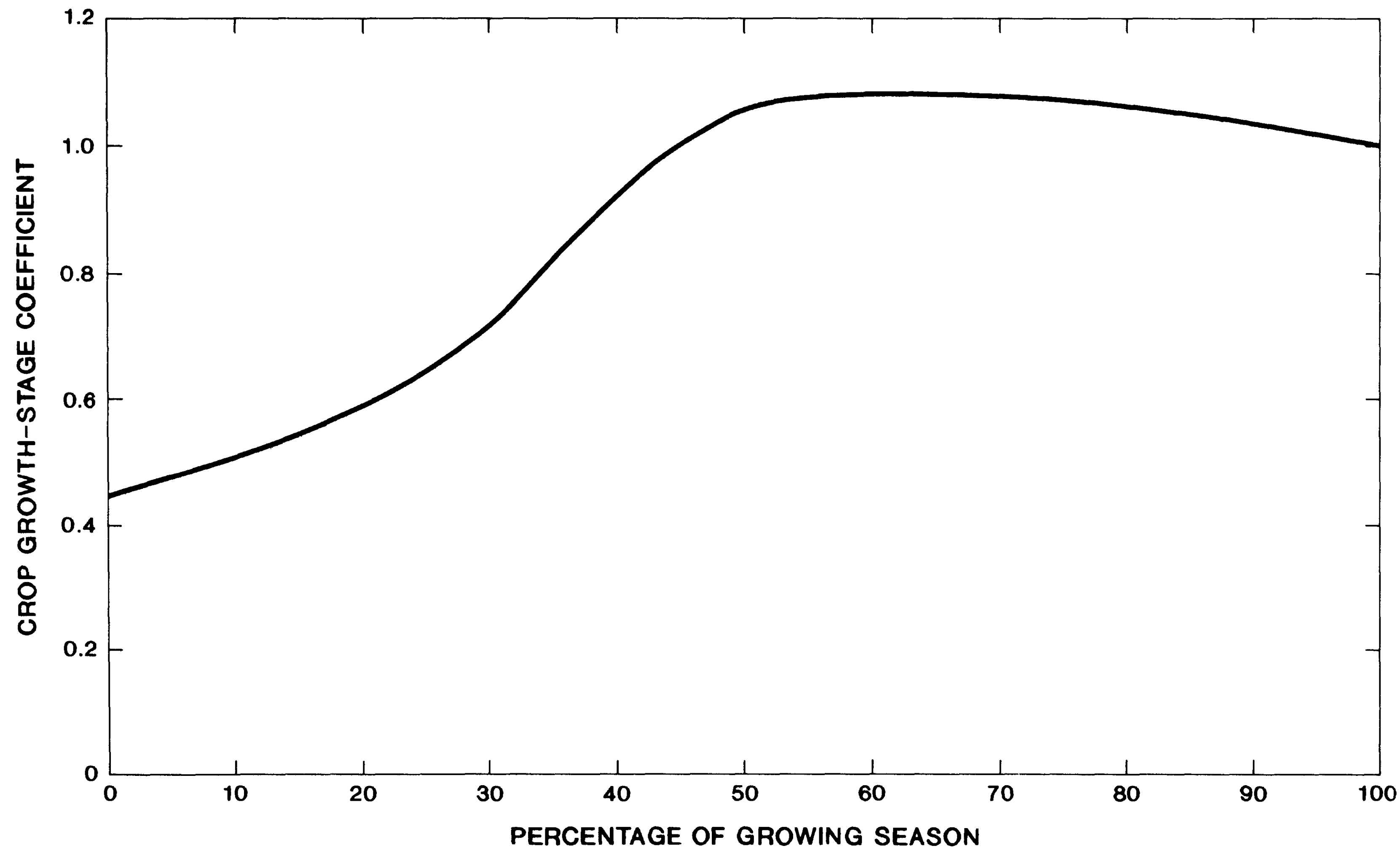


Figure 23.--Crop growth-stage coefficient curve for sweet corn. (Modified from U.S. Soil Conservation Service, 1967, p. 74, curve 5)

In a model simulation, water is withdrawn from the top soil-moisture layer at a rate equal to the rate of potential evapotranspiration. In the bottom soil-moisture layer, moisture is withdrawn at a decreasing rate that is based on the ratio of soil moisture in the bottom soil layer to the water-holding capacity of the bottom soil layer (Mather, 1978, p. 67-74).

Soil moisture alone is withdrawn when daily effective precipitation is less than potential evapotranspiration. Daily effective precipitation in excess of daily potential evapotranspiration goes into soil-moisture storage. Soil-moisture storage in the top layer must be filled before soil-moisture storage in the bottom layer begins to fill. When total soil-moisture storage reaches field capacity, any additional effective precipitation becomes surplus.

Irrigation guidelines for New Jersey indicate that farmers irrigate when daily soil-moisture storage drops to, or below, 50 percent of field capacity (U.S. Soil Conservation Service, 1983, p. 2.6). The amount of water applied during each irrigation was calculated to be 50 percent of the field capacity of the soil, assuming that a farmer will bring his soil back to field capacity for optimum irrigation.

One inch of daily effective precipitation was assumed to be the level at which a farmer may decide not to irrigate. It was assumed that rainfall occurred throughout the day on days with 1 inch or more of effective precipitation, and that a farmer is not likely to irrigate under these conditions.

Data Requirements for the Model

The Thornthwaite water-balance model requires data on mean daily temperature, daily total precipitation, latitude of the weather station, and available water-holding capacity of the soil.

Climate data

Data on total daily precipitation and mean daily temperature were compiled from 15 weather stations in 15 different New Jersey counties for the 29-year period 1953-81 (fig. 24). The geographical distribution of weather stations was used to account for variations in climate throughout the State. The weather station nearest the center of irrigated agricultural activity within each of the 15 counties was chosen to represent the climate there. Table 21 lists the counties that contain farmland and the names of the weather stations chosen to represent each county.

Daily records of precipitation and temperature at some weather stations were incomplete. When data from a weather station were missing, data from the closest weather station also used in the model were substituted.

Soil data

The water-holding capacity of a soil and the plant's water-use rate theoretically determine the frequency of irrigation and the amount of water to be applied at each irrigation. The soil acts as a reservoir, and its water supply must be replenished often enough so that water is available for withdrawal by the plant as required for optimum growth and production.

Table 20.--Crops for which the ratio of actual evapotranspiration to potential evapotranspiration was determined

Snap beans	Peas
Corn for grain	White potatoes
Sweet corn	Soybeans
Melons and cantaloupes	Tomatoes
Orchards, deciduous	Vegetables

Table 21.--National Oceanic and Atmospheric Administration weather stations in New Jersey from which precipitation and temperature data were used in the Thornthwaite water-balance model[1]

County	Station
Atlantic	Atlantic City Airport
Bergen	Newark Airport
Burlington	Pemberton 3 E
Camden	Hammonton 2 NNE
Cape May	Belleplain
Cumberland	Millville Airport
Essex	Newark Airport
Gloucester	Woodstown 2 NW
Hunterdon	Flemington 1 NE
Mercer	Trenton City
Middlesex	Freehold
Monmouth	Freehold
Morris	Morris Plains
Ocean	Pemberton 3 E
Passaic	Charlotteburg
Salem	Woodstown 2 NW
Somerset	Somerville
Sussex	Newton
Union	Newark Airport
Warren	Belvidere

[1] Data from some weather stations were used to represent precipitation and temperature in more than one county.

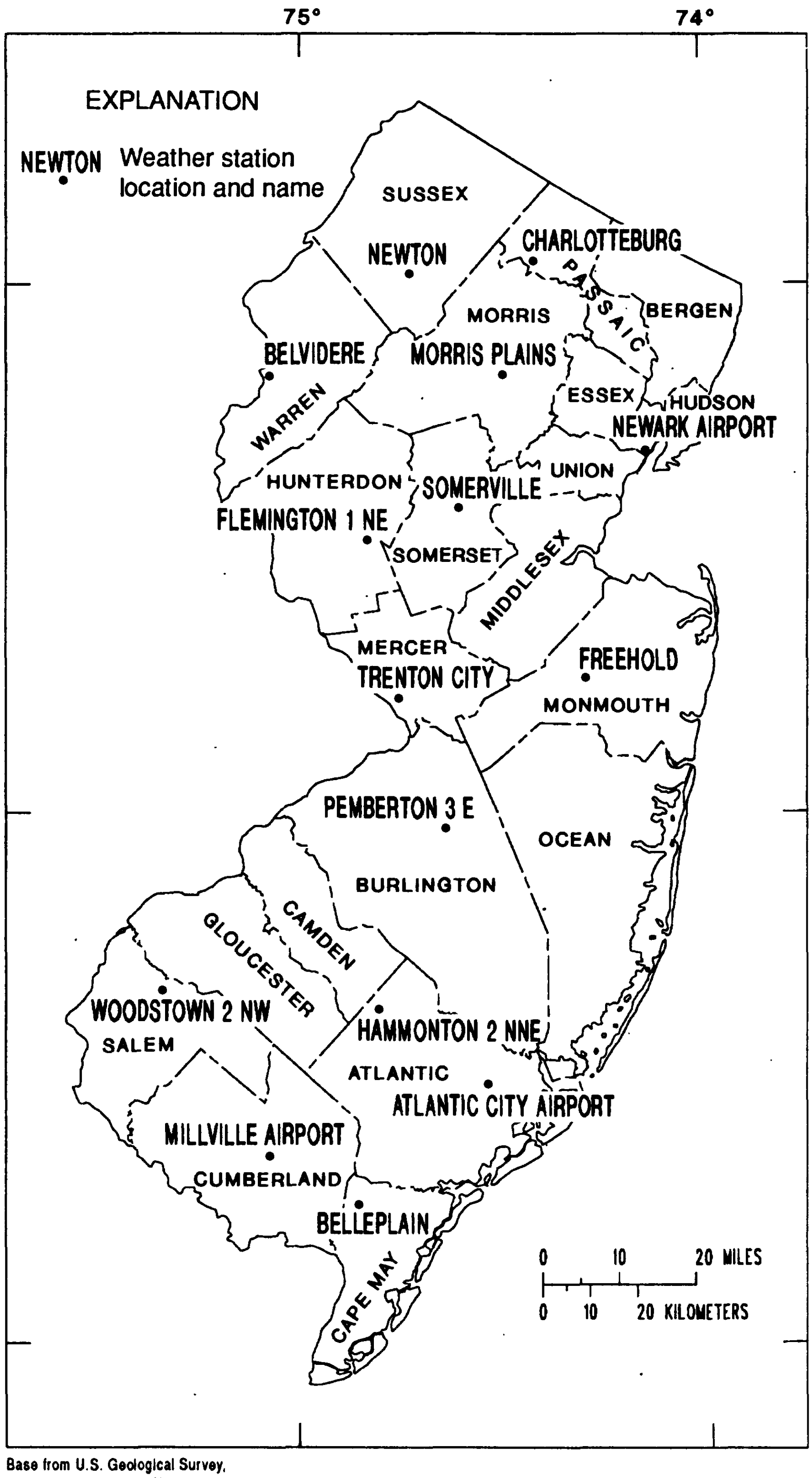


Figure 24.--Weather stations in New Jersey from which precipitation and temperature data were used in the Thorthwaite daily water-balance model.

The water-holding capacity of any soil is determined by its texture, its structure, and the amount of organic matter it contains. The first factor can be considered to be constant, whereas the latter two can be changed and modified by the farmer through various land-preparation and -cultivation practices (U.S. Soil Conservation Service, 1983, p. 2.1). Water-holding capacities of New Jersey soil series were obtained from the New Jersey Irrigation Guide (U.S. Soil Conservation Service, 1983).

The U.S. Soil Conservation Service maintains a geographical data base that contains data on the land area covered by each soil type found in New Jersey. The soils data base was related to a county data base and an agricultural-land data base (Anderson and others, 1976). For this study, six general soil types were defined: silt loam, loam, sandy loam, loamy sand, sand, and clay. An areal percentage was calculated for each of the six general soil types for each county by dividing the number of acres in the county overlain by each soil type by the total number of acres for all soil types in the county. The percentage of land area in each county overlain by each soil type was multiplied by the predicted number of irrigated acres in the county to obtain the number of irrigated acres in each county overlain by the soil type. The predicted number of irrigated acres overlain by a given soil type was assumed to be uniformly distributed throughout the county.

A map from Tedrow (1986) was used to identify the soil series that most closely represented each of the six general soil types in each county. For example, the soil series Freehold sandy loam was determined to most closely represent the sandy loam soil type in Monmouth County. The water-holding capacity of the top and bottom soil layers of each soil series selected was obtained from the New Jersey Irrigation Guide (U.S. Soil Conservation Service, 1983).

Predicting Water Demand for Cranberries

Cranberry plants require water throughout the year. Two methods are used to irrigate cranberry plants in New Jersey--spray irrigation and flood irrigation. Spray irrigation is the application of water with overhead sprinklers. Flood irrigation involves the movement of water from one area to another by means of gravity flow.

Cranberries are grown in bogs several feet below the land surface. In September and October, cranberry bogs are flooded for harvesting. After the harvest, water is released from the bogs to streams and reservoirs. In the cold winter months, growers reflood the bogs to protect the cranberry vines from frost and wind damage. Almost all cranberry growers in New Jersey use flood irrigation for harvesting and frost protection.

In the warm months, water is used to satisfy the nutritive needs of the plants and for cooling. Cranberry plants require cooling when the air temperature reaches 95 °F or above. Cranberry plants require about 6 in. of water per acre for spray irrigation during the warm months (Joseph Darlington, American Cranberry Growers Association, oral commun., 1989). They also require about 6 in. of water per acre of spray irrigation for frost protection during late winter and early spring, when the bogs are not flooded and the plants may be exposed to frost. More than 50 percent of cranberry acreage in New Jersey currently is spray-irrigated for cooling and frost protection (Joseph Darlington, American Cranberry Growers Association, oral commun., 1989).

New Jersey cranberry growers use an average of 4 acre-ft of water per acre per year--6 acre-in. per acre for irrigation in the warm months, 18 acre-in. per acre for harvesting in the fall, an additional 18 acre-in. per acre for flooding in the winter, and 6 acre-in. per acre for frost irrigation during the cold months when the bogs are not flooded (Joseph Darlington, American Cranberry Growers Association, oral commun., 1989). Cranberry plants probably require more than 4 acre-ft of water per acre during the year, however, because some water infiltrates the soil and eventually percolates down into the unconfined aquifer when the bogs are flooded.

Water use for cranberries is primarily nonconsumptive. Only a small amount of water is used consumptively by the plants during the warm months or is lost through evaporation from the bogs. Most of the water is returned to streams or percolates to the unconfined aquifer.

In this study, it was assumed that cranberry growers would continue to use 4 acre-ft of water per acre each year. The predicted number of harvested cranberry acres was multiplied by 4 acre-ft to produce estimates of predicted water demand for cranberries in acre-ft for the four prediction years; these units were converted to gallons.

Little information on water demand and use for cranberries is available in the literature. This lack of information precluded the precise estimation of cranberry water demand. In this report, the quantity of water used for cranberries is assumed to equal the quantity diverted from streams and reservoirs. The volume of water diverted is counted only once, at the source, although it can be reused for flood harvesting of more than one cranberry bog in the fall and for flood-frost protection for more than one winter month.

Predicting Water Demand for Container-Grown Nursery Crops

Estimates of water demand for irrigation of nursery crops were generated for field-grown nursery crops and container-grown nursery crops. Field-grown nursery crops are irrigated as vegetables and field crops are, with movable irrigation equipment. Water demand is highest in summer, when evapotranspiration is greatest. Sod, which is shallow-rooted, requires more frequent irrigation than trees and can sometimes need water from March through October. In this report, field-grown nursery crops are grouped with vegetables, field crops, orchards, and other berries for the prediction of water demand for field-grown crops.

Container-grown nursery plants require irrigation throughout the year. Water is not retained as easily in plant pots as in the soil profile of a field. During winter, when the greenhouses are covered, plants may require watering once a week. In spring and fall, plants require more water and more frequent irrigations. Plants such as roses and azaleas can require irrigation to prevent frost damage during bud development. Irrigation volume and frequency are greatest in July and August, when daily temperatures are highest. During these months, moisture evaporates quickly from the plant containers. Growers irrigate the container-grown plants for several hours each day during dry weather. Solid-set and permanent sprinkler systems are the most common types of irrigation equipment used for container-grown nursery plants.

Water demand for container-grown nursery plants was estimated by multiplying the predicted irrigated acreage of container-grown nursery plants by the estimated actual water use by container-grown nursery plants per acre. Actual water use was estimated by verifying water use reported to the NJDEPE by farmers through a field study.

During 1989, the U.S. Geological Survey conducted a field study to verify the pumpage reported by farmers to the NJDEPE. Farmers were contacted through field visits and through recommendations by the NJDA. Farmer participation in the study was voluntary. Early in 1989, 18 vibration time totalizers (VTT's) were attached to irrigation pipes on 10 farms located throughout the New Jersey Coastal Plain (fig. 25). A VTT is an instrument that contains a vibration sensor that monitors the running time of pumps (Cordes and Minghua, 1988, p. 1). Running time was multiplied by the capacity of the pump in gallons per minute. Some farmers interviewed suggested that actual pumpage rates could be lower than capacity because of the age of the pump or other factors. In these instances, the pumpage rate indicated by the farmer was used, rather than the capacity of the pump.

Pumpage volumes reported by farmers were compared with volumes determined by using the VTT time readings. A close correlation was found between the two data sets (r = 0.905). A comparison analysis of pumpage volumes for two farms growing only container-grown nursery crops also resulted in a high correlation (r = 0.99). Water use on both farms in 1989 was about 5 acre-ft per acre. Volume readings for one of the two container-nursery farms were verified further by means of intrusive flow meters installed by the nursery grower to obtain a more accurate pumpage record.

The pumpage reported for 1989 by the grower at whose farm the flow meters were installed was considered to be accurate because the volume determined from VTT readings and the volume determined from the flow-meter readings were consistent. Water use at this farm was considered to be representative of that by other container-nursery growers in the state. Analysis of previous reports of withdrawals by this grower showed water use ranging from 57.7 (acre-in./acre)/yr to 66.7 (acre-in./acre)/yr. This variation is most likely the result of variations in weather conditions. Results of this analysis showed that water use for container-grown nursery crops varies much less than water use for field-grown crops.

Estimates of water demand for container-grown nursery crops were made for each of the three climatological scenarios. On the basis of the results of the field study, a wet-year scenario was defined by 50 (acre-in./acre)/yr; an average-year scenario was defined by 60 (acre-in./acre)/yr; and a drought-year scenario was defined by 70 (acre-in./acre)/yr. Water demand for each of the three climatological scenarios was multiplied by the predicted number of irrigated acres of container-grown nursery crops for each of the four prediction years to produce estimates of water demand for container-grown nursery crops. The units were then converted to gallons.

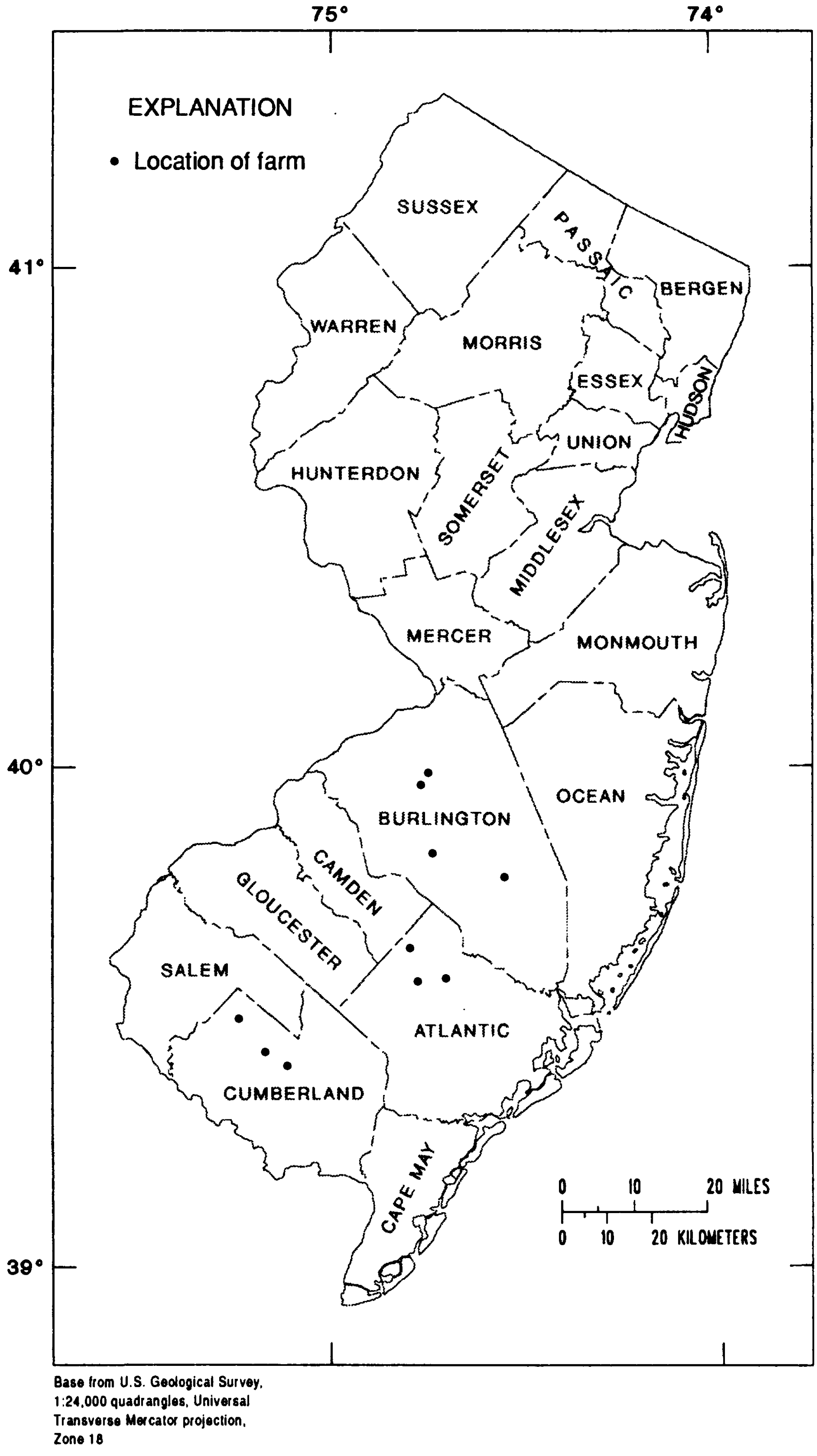


Figure 25.--Location of farms where field study was conducted in 1989.

METHOD FOR ESTIMATING WATER USE FOR LIVESTOCK AND SELECTED SECTORS OF THE FOOD-PROCESSING INDUSTRY IN 1987

Agricultural water use in New Jersey includes not only water used for crops, but also water used for the maintenance of livestock and the processing of food. Water use for livestock and selected sectors of the food-processing industry in 1987 was estimated, but no predictions of water demand for these two sectors were made because demand in these sectors depends on many factors--national, regional, and local--that are too variable to predict.

Livestock Water Use

Farmers use water for many purposes in the raising and maintenance of livestock and horses. In addition to direct consumption for nutritive needs of animals, water is used in the processing of milk, for the cleaning of animals, in evaporative cooling systems for livestock and poultry, in evaporation from stock-watering ponds, for waste disposal, and for other uses. Livestock water use comprises only a small part of total agricultural water use; in 1985, for example, water use for livestock accounted for only 2 percent of combined estimated water use for livestock and irrigation in New Jersey (Solley and others, 1988, p. 25 and 29). In some areas, however, livestock water use is a major component of agricultural water use.

A common method used to estimate water use for livestock is to multiply the number of animals and production numbers by coefficients of water use per animal and per type of production. This method is used in this report to estimate the water used by New Jersey livestock in 1987. Numbers of animals and production numbers were obtained from the New Jersey Farmland Assessment Survey (Robert Battaglia, New Jersey Agricultural Statistics Service, written commun., 1989) and from the New Jersey Agricultural Statistics Service (1989). The coefficients were obtained from the Cooperative Extension Service of the University of Maryland (Herbert Brodie, University of Maryland, written commun., 1988). Table 22 lists the data used to estimate water use for livestock in 1987.

Food-Processing Water Use

Water is used in food-processing plants for cooling and freezing and to wash fruit, vegetable, and meat products before canning and packaging; water also is incorporated into products such as soup. The food-processing industry in New Jersey grew out of a need to process and package foods grown and raised in the State. The trend in processing of local produce has changed in recent years; in the past, almost 75 percent of processing in the State used local produce, but in 1989 only about 5 percent of the food processed in New Jersey was grown locally. The majority of foods processed in New Jersey are obtained from various sources throughout the world (George Sparacio, New Jersey Food Processors Association, oral commun., 1989).

Water use for food-processing in 1987 was estimated by using the single-coefficient (per employee) method. In this method, the number of employees in a particular industry is multiplied by the per employee water-use rate for that industry. The U.S. Bureau of the Census (1986) published per employee water-use coefficients for specific types of manufacturing enterprises.

Table 22.--Data used to estimate livestock water use in New Jersey in 1987

[Numbers of animals and milk processing data from Robert Battaglia, New Jersey Agricultural Statistics Service, written commun., 1989, and New Jersey Agricultural Statistics Service, 1989; water-use coefficients from Herbert Brodie, University of Maryland, written commun., 1988]

Livestock category	Livestock unit	Water-use coefficient (gallons per year per animal or type of use)
Adult cattle	64,167 animals	4,000
Young cattle	22,665 animals	2,200
Milk processing	396,000 (1,000 pounds)	.25
Swine	38,123 animals	1,900
Feeder pig production	7,940 (1,000 pounds)	1.7
Adult sheep and goats	15,082 animals	900
Young sheep and goats	10,055 animals	550
Horses	59,900 animals	3,700
Ducks	81,693 animals	36.5
Chickens	2,032,354 animals	18.3
Turkeys	101,456 animals	54.8

Separate per employee water-use coefficients are given for large- and average-size establishments. Information about the number of employees in the New Jersey food-processing industry was obtained from the 1987 Census of Manufacturers (U.S. Bureau of the Census, 1990, p. 13).

Water use in 1987 was estimated for industries classified under the following three Standard Industrial Classification (SIC) codes: (1) 201, meat products; (2) 203, preserved fruits and vegetables; and (3) 209, miscellaneous food and like products. Seafood processing, an important New Jersey industry, is classified under SIC 209. Estimates by county were not made because data on the number of employees in an industry were not available at that level.

Table 23 presents the data used to produce estimates of water use for food-processing businesses classified under SIC codes 201, 203, and 209 in 1987. The total number of employees in businesses classified under each SIC category was divided among large- and average-size establishments. In a survey of food-processing establishments, Lopez and Henderson (1988, p. 87) found that about two-thirds of the establishments could be classified as small or average (fewer than 100 employees) and one-third could be classified as large (greater than 100 employees). Per employee water-use coefficients for average and large establishments are shown in table 23.

Table 23.--Data used to estimate food-processing water use in 1987 by New Jersey businesses classified under Standard Industrial Classification codes 201, 203, and 209

[Number of employees from U.S. Bureau of the Census, 1990; per employee water-use rates from U.S. Bureau of the Census, 1986]

Standard industrial classification code	Number of employees	Per employee water-use rates (gallons per employee per day)	
		Large-size plant	Average-size plant
201	4,100	635.2	343.8
203	6,300	715.5	387.3
209	6,000	1,286.7	696.5

APPLICATION OF METHODS FOR PREDICTING WATER DEMAND FOR CROP USES AND FOR ESTIMATING WATER USE FOR LIVESTOCK AND SELECTED SECTORS OF THE FOOD-PROCESSING INDUSTRY

Predictions of harvested and irrigated acreage and predictions of water demand for crops for the four prediction years, and estimates of water use for livestock and food processing in 1987, were made by using the methods described in this report. Results are presented below, in the same order as the methods.

Predictions of harvested acreage in 1990, 2000, 2010, and 2020

Tables 24 to 27 present predicted harvested acreage in MCD'S in New Jersey in 1990, 2000, 2010, and 2020, before correction with the adjustment factor described previously. The MCD group is indicated for each MCD. Outlier MCD's are indicated by an asterisk (*).

Predicted harvested acreage in New Jersey in 1990, 2000, 2010, and 2020 by county is presented in table 28. These estimates have not been corrected with the adjustment factor.

The final predictions for harvested acreage in New Jersey in 1990, 2000, 2010, and 2020 by county are shown in table 29. These predictions have been corrected by using an adjustment factor of 0.938. Harvested acreage in New Jersey is predicted to decrease from about 537,000 acres in 1990 to about 412,000 acres in 2020. Counties with the largest predicted decrease in the number of harvested acres (more than 10,000 acres) were Burlington, Gloucester, Hunterdon, Middlesex, Monmouth, and Sussex. Projections indicate that these counties will have large population increases during the prediction period. Harvested acreage in Cape May, Essex, Middlesex, and Sussex Counties is predicted to decrease by more than 40 percent from 1990 through 2020. In the Coastal Plain counties of Cumberland and Salem, harvested acreage will decrease less than 10 percent from 1990 through 2020. Harvested acreage is predicted to remain relatively constant during the prediction period in these counties.

Predictions of Harvested and Irrigated Acreage by Crop Type in 1990, 2000, 2010, and 2020

Predictions of harvested and irrigated acreage in New Jersey counties were made for orchard crops, container-grown nursery crops, field-grown nursery crops, cranberries, blueberries, strawberries, vegetables, and field crops (tables 30 to 37, respectively). Only nursery crops (container- and field-grown) are predicted to increase statewide in number of harvested and irrigated acres from 1990 through 2020. Orchard crops, vegetables, and field crops are predicted to decrease statewide in number of harvested and irrigated acres during the prediction period. Harvested and irrigated acreage devoted to growing cranberries, blueberries, and strawberries is predicted to remain constant from 1990 through 2020 in all New Jersey counties.

Table 38 presents total predicted irrigated acreage for all crop types in New Jersey by county in 1990, 2000, 2010, and 2020. Statewide, total irrigated acreage for all crop types is predicted to decrease about 7 percent from 1990 through 2020. At the county level, irrigated acreage is predicted to decrease in all but three New Jersey counties. Of the three counties in which irrigated acreage is predicted to increase, Salem County is predicted to have the largest increase (11.1 percent) in the number of irrigated acres from 1990 through 2020, followed by Union (4.8 percent), and Cumberland (4.2 percent) Counties. The largest predicted decreases in the number of irrigated acres for all crop types are for Middlesex (67.4 percent), Essex (45.9 percent), Sussex (44.4 percent), Cape May (34.8 percent), and Camden (28.9) Counties.

Table 28.--Predicted harvested acreage in New Jersey in 1990, 2000, 2010, and 2020, by county, before correction with the adjustment factor

County	Predicted harvested acreage			
	1990	2000	2010	2020
Atlantic	25,204	23,646	22,540	21,588
Bergen	860	790	731	682
Burlington	73,513	67,009	62,981	59,140
Camden	12,379	10,490	9,096	7,800
Cape May	4,531	3,598	2,965	2,518
Cumberland	59,088	57,672	56,230	54,772
Essex	140	108	85	68
Gloucester	56,274	51,744	48,674	45,376
Hunterdon	45,623	40,137	35,309	31,088
Mercer	32,198	29,522	26,568	23,812
Middlesex	22,873	18,447	10,619	5,171
Monmouth	54,010	50,284	46,858	42,346
Morris	11,576	9,905	8,473	7,252
Ocean	9,858	8,834	7,799	6,737
Passaic	435	399	373	343
Salem	81,120	80,685	80,413	80,091
Somerset	12,325	10,064	8,483	7,789
Sussex	34,191	25,188	18,500	13,431
Union	140	123	112	101
Warren	36,464	33,561	31,017	28,802
Total	572,802	522,206	477,826	438,907

Table 29.--Final predicted harvested acreage in New Jersey in 1990, 2000, 2010, and 2020, by county

[Predictions presented in this table are predictions in Table 28 multiplied by an adjustment factor of 0.938]

	Final predicted harvested acreage			
County	1990	2000	2010	2020
Atlantic	23,641	22,180	21,143	20,250
Bergen	807	741	686	640
Burlington	68,955	62,854	59,076	55,473
Camden	11,612	9,840	8,532	7,316
Cape May	4,250	3,375	2,781	2,362
Cumberland	55,425	54,096	52,744	51,376
Essex	131	101	80	64
Gloucester	52,785	48,536	45,656	42,563
Hunterdon	42,794	37,649	33,120	29,161
Mercer	30,202	27,692	24,921	22,336
Middlesex	21,455	17,303	9,961	4,850
Monmouth	50,661	47,166	43,953	39,721
Morris	10,858	9,291	7,948	6,802
Ocean	9,247	8,286	7,315	6,319
Passaic	408	374	350	322
Salem	76,091	75,683	75,427	75,125
Somerset	11,561	9,440	7,957	7,306
Sussex	32,071	23,626	17,353	12,598
Union	131	115	105	95
Warren	34,203	31,480	29,094	27,016
Total	537,288	489,828	448,202	411,695

Table 30.--Predicted harvested and irrigated orchard acreage in New Jersey in 1990, 2000, 2010, and 2020, by county

County	Harvested acreage				Irrigated acreage			
	1990	2000	2010	2020	1990	2000	2010	2020
Atlantic	2,463	2,312	2,162	2,011	1,679	1,576	1,474	1,371
Bergen	195	183	172	160	117	110	103	97
Burlington	1,239	1,164	1,088	1,012	655	616	575	535
Camden	1,975	1,854	1,733	1,613	1,365	1,282	1,198	1,115
Cape May	13	12	11	10	2	2	2	2
Cumberland	1,409	1,323	1,237	1,151	1,087	1,020	955	888
Essex	0	0	0	0	0	0	0	0
Gloucester	8,762	8,227	7,692	7,156	6,578	6,176	5,775	5,372
Hunterdon	737	692	647	602	377	354	331	308
Mercer	125	117	109	102	28	27	25	24
Middlesex	287	269	252	234	86	81	76	70
Monmouth	725	680	636	592	264	248	233	217
Morris	223	209	196	182	103	97	91	84
Ocean	78	73	68	63	39	36	33	31
Passaic	0	0	0	0	0	0	0	0
Salem	13	12	11	10	8	6	6	5
Somerset	208	195	183	170	101	94	88	81
Sussex	635	597	558	519	291	274	255	238
Union	0	0	0	0	0	0	0	0
Warren	534	502	469	436	264	248	232	216
Total	19,621	18,421	17,224	16,023	13,044	12,247	11,452	10,654

Table 31.--Predicted harvested and irrigated acreage of container-grown nursery crops in New Jersey in 1990, 2000, 2010, and 2020, by county

County	Harvested and irrigated acreage			
	1990	2000	2010	2020
Atlantic	36	41	46	50
Bergen	24	27	30	33
Burlington	109	122	136	149
Camden	11	12	13	15
Cape May	7	8	9	10
Cumberland	139	156	173	191
Essex	3	3	3	4
Gloucester	176	198	220	242
Hunterdon	96	108	120	132
Mercer	48	54	60	66
Middlesex	119	134	149	163
Monmouth	455	512	569	625
Morris	22	24	27	30
Ocean	10	12	13	14
Passaic	4	5	5	6
Salem	46	52	58	64
Somerset	45	50	56	61
Sussex	23	26	29	32
Union	4	5	5	6
Warren	13	15	16	18
Total	1,390	1,564	1,737	1,911

Table 32.--Predicted harvested and irrigated acreage of field-grown nursery crops in New Jersey in 1990, 2000, 2010 and 2020, by county

	Harvested acreage				Irrigated acreage			
County	1990	2000	2010	2020	1990	2000	2010	2020
Atlantic	329	370	410	452	247	278	308	340
Bergen	214	240	267	294	101	114	127	139
Burlington	979	1,101	1,223	1,345	423	475	528	581
Camden	96	109	121	132	49	55	62	67
Cape May	66	74	82	90	33	37	41	45
Cumberland	1,249	1,404	1,561	1,715	825	928	1,032	1,133
Essex	23	26	29	32	12	13	15	16
Gloucester	1,587	1,783	1,982	2,179	800	898	999	1,098
Hunterdon	867	974	1,082	1,190	232	260	289	318
Mercer	432	486	540	594	76	86	95	105
Middlesex	1,071	1,203	1,337	1,471	270	304	337	371
Monmouth	4,099	4,605	5,117	5,627	2,107	2,367	2,630	2,893
Morris	196	221	245	269	36	41	45	50
Ocean	94	104	116	128	17	19	21	23
Passaic	39	43	49	53	20	22	25	27
Salem	418	469	521	573	303	340	378	415
Somerset	403	453	503	554	127	143	159	175
Sussex	208	234	260	285	104	117	130	143
Union	37	41	46	51	22	25	28	31
Warren	117	132	147	161	59	66	74	81
Total	12,524	14,072	15,638	17,195	5,863	6,588	7,323	8,051

Table 33.--Predicted harvested and irrigated acreage of cranberries in New Jersey in 1990, 2000, 2010, and 2020, by county

County[1]	Acreage harvested and irrigated
Atlantic	89
Burlington	3,142
Ocean	169
Total	3,400

[1] Counties not listed contain no predicted harvested and irrigated cranberry acreage.

Table 34.--Predicted harvested and irrigated acreage of blueberries in New Jersey in 1990, 2000, 2010 and 2020, by county

County	Harvested acreage	Irrigated acreage
Atlantic	3,996	2,477
Bergen	0	0
Burlington	2,722	709
Camden	420	218
Cape May	65	34
Cumberland	12	12
Essex	0	0
Gloucester	50	26
Hunterdon	2	0
Mercer	0	0
Middlesex	0	0
Monmouth	451	424
Morris	2	0
Ocean	0	0
Passaic	0	0
Salem	4	0
Somerset	0	0
Sussex	65	0
Union	0	0
Warren	11	6
Total	7,800	3,906

Table 35.--Predicted harvested and irrigated acreage of strawberries in New Jersey in 1990, 2000, 2010, and 2020, by county

County	Harvested acreage	Irrigated acreage
Atlantic	24	20
Bergen	9	5
Burlington	205	111
Camden	21	16
Cape May	20	20
Cumberland	79	41
Essex	0	0
Gloucester	77	68
Hunterdon	46	6
Mercer	35	18
Middlesex	39	20
Monmouth	140	40
Morris	21	11
Ocean	35	0
Passaic	0	0
Salem	30	21
Somerset	24	12
Sussex	52	27
Union	0	0
Warren	43	29
Total	900	465

Table 36.--Predicted harvested and irrigated acreage of vegetables in New Jersey in 1990, 2000, 2010 and 2020, by county

County	Harvested acreage				Irrigated acreage			
	1990	2000	2010	2020	1990	2000	2010	2020
Atlantic	12,812	12,343	12,130	11,975	11,143	10,735	10,550	10,415
Bergen	230	186	144	105	101	81	63	46
Burlington	6,629	6,244	6,072	5,881	4,602	4,335	4,216	4,083
Camden	4,031	3,453	3,029	2,599	3,236	2,772	2,431	2,086
Cape May	1,965	1,614	1,371	1,196	804	660	561	489
Cumberland	22,241	22,693	23,074	23,390	14,812	15,113	15,367	15,577
Essex	97	70	48	28	46	33	23	13
Gloucester	12,146	11,547	11,270	10,852	7,622	7,246	7,072	6,810
Hunterdon	796	729	664	604	186	170	155	141
Mercer	1,613	1,545	1,447	1,346	728	697	653	607
Middlesex	3,234	2,663	1,456	547	2,312	1,904	1,041	391
Monmouth	8,794	8,395	7,978	7,262	3,799	3,626	3,446	3,137
Morris	1,409	1,253	1,109	978	416	370	328	289
Ocean	1,500	1,401	1,284	1,147	910	850	779	696
Passaic	235	220	209	194	201	188	179	166
Salem	17,590	18,331	19,100	19,849	13,865	14,449	15,055	15,645
Somerset	217	183	158	149	25	21	18	17
Sussex	1,883	1,438	1,089	808	110	84	64	47
Union	20	16	13	9	14	11	9	6
Warren	1,287	1,240	1,198	1,160	519	500	483	468
Total	98,729	95,564	92,843	90,079	65,451	63,845	62,493	61,129

Table 37.--Predicted harvested and irrigated acreage of field crops in New Jersey in 1990, 2000, 2010 and 2020, by county

County	Harversted acreage				Irrigated acreage			
	1990	2000	2010	2020	1990	2000	2010	2020
Atlantic	3,892	3,005	2,286	1,653	128	99	75	55
Bergen	135	96	64	41	4	3	2	1
Burlington	53,930	48,154	44,488	41,017	1,780	1,589	1,468	1,354
Camden	5,058	3,971	3,195	2,516	167	131	105	83
Cape May	2,114	1,582	1,223	971	70	52	40	32
Cumberland	30,296	28,429	26,608	24,838	1,000	938	878	820
Essex	8	2	0	0	0	0	0	0
Gloucester	29,987	26,654	24,365	22,007	990	880	804	726
Hunterdon	40,250	35,098	30,559	26,585	1,328	1,158	1,008	877
Mercer	27,949	25,455	22,730	20,193	922	840	750	666
Middlesex	16,705	12,995	6,728	2,396	551	429	222	79
Monmouth	35,997	32,383	29,062	25,024	1,188	1,069	959	826
Morris	8,985	7,561	6,348	5,320	297	250	209	176
Ocean	7,361	6,492	5,630	4,763	243	214	186	157
Passaic	130	106	87	69	4	3	3	2
Salem	57,990	56,785	55,703	54,595	1,914	1,874	1,838	1,802
Somerset	10,664	8,535	7,033	6,348	352	282	232	209
Sussex	29,205	21,214	15,300	10,837	964	700	505	358
Union	70	53	41	29	2	2	1	1
Warren	32,199	29,538	27,211	25,188	1,063	975	898	831
Total	392,925	348,108	308,661	274,390	12,967	11,488	10,183	9,055

Table 38.--Total predicted irrigated acreage for all crop types in New Jersey in 1990, 2000, 2010, and 2020, by county

County	Total predicted irrigated acreage			
	1990	2000	2010	2020
Atlantic	15,819	15,315	15,039	14,817
Bergen	352	340	330	321
Burlington	11,531	11,099	10,885	10,664
Camden	5,062	4,486	4,043	3,600
Cape May	970	813	707	632
Cumberland	17,916	18,208	18,458	18,662
Essex	61	49	41	33
Gloucester	16,260	15,492	14,964	14,342
Hunterdon	2,225	2,056	1,909	1,782
Mercer	1,820	1,722	1,601	1,486
Middlesex	3,358	2,872	1,845	1,094
Monmouth	8,277	8,286	8,301	8,162
Morris	885	793	711	640
Ocean	1,388	1,300	1,201	1,090
Passaic	229	218	212	201
Salem	16,157	16,742	17,356	17,952
Somerset	662	602	565	555
Sussex	1,519	1,228	1,010	845
Union	42	43	43	44
Warren	1,953	1,839	1,738	1,649
Total	106,486	103,503	100,959	98,571

Predictions of Water Demand for Crop Uses in 1990, 2000, 2010, and 2020

Predictions of water demand for crop uses consist of the predicted water demands for field-grown crops, cranberries, and container-grown nursery crops.

Field-Grown Crops

Table 39 presents predicted annual water demand for field-grown crops in New Jersey by county in 1990, 2000, 2010, and 2020 for the three climatological scenarios. For 1990, annual water demand for field-grown crops in New Jersey is predicted to be 4.53×10^9 gal for the wet-year scenario, 10.60×10^9 gal for the average-year scenario, and 16.82×10^9 gal for the drought-year scenario. For 2020, annual water demand for field-grown crops in New Jersey is predicted to be 4.10×10^9 gal for the wet-year scenario, 9.54×10^9 gal for the average-year scenario, and 15.07×10^9 gal for the drought-year scenario.

Statewide, water demand for field-grown crops is predicted to decrease 9.4 percent from 1990 through 2020 for the wet-year scenario, 10.1 percent for the average-year scenario, and 10.4 percent for the drought-year scenario. At the county level, predicted water demand for field-grown crops varies by year and climate scenario because the inputs to the Thornthwaite daily water-balance model change from year to year for each county. For example, the predicted number of irrigated acres of each crop type in a county changes from prediction year to prediction year, and consumptive water use differs among crop types. Thus, a county could have a predicted decrease in total irrigated acreage from one year to another, but a smaller decrease, or perhaps even an increase, in predicted water demand for field-grown crops. Generally, water demand for field-grown crops is largest in Atlantic, Cumberland, Gloucester, and Salem Counties.

Table 40 presents predicted monthly water demand (from March through November) for field-grown crops by county in 1990, 2000, 2010, and 2020 for the three climatological scenarios. Predicted water demand is zero for certain months for all counties for all four prediction years; tables are not shown for these months. The months during which predicted water demand is zero are March, April, May, October, and November for the wet-year scenario, and March and November for both the average- and drought-year scenarios.

Daily predictions of water demand for field-grown crops by county in 1990, 2000, 2010, and 2020 for the three climatological scenarios are shown in table 41. Daily predictions were calculated by dividing the monthly demand by the number of days in the month. For the drought-year scenario, daily demand predictions range from 0.0 Mgal/d for March and November to 213.31 Mgal/d in July 1990. Daily demand predictions for the wet-year scenario range from 0.0 Mgal/d for several months to 15.87 Mgal/d in July 1990.

Table 42 shows predicted annual water demand for field-grown crops under two possible acreage-change scenarios: (1) a 2-percent annual increase in predicted irrigated acreage for field-grown crops from 1990 through 2020, and (2) a 2-percent annual decrease in predicted irrigated acreage for field-grown crops from 1990 through 2020. These estimates are listed for each of the three climatological scenarios for the four prediction years. Estimates range from 1.75×10^9 gal to 26.69×10^9 gal.

Cranberries

Table 43 presents predicted irrigated acreage and predicted annual water demand for cranberry use by county in 1990, 2000, 2010, and 2020. Statewide water demand for cranberry use was predicted to be constant at 4.43×10^9 gal in all four prediction years. Cranberries are grown only in Atlantic, Burlington, and Ocean Counties, all located in the New Jersey Coastal Plain. Burlington County alone accounts for more than 90 percent of cranberry water demand.

Container-Grown Nursery Crops

Table 44 presents predicted annual water demand for container-grown nursery crops by county in 1990, 2000, 2010, and 2020 for the three climatological scenarios. For 1990, water demand for container-grown nursery crops is predicted to be 1.89×10^9 gal for the wet-year scenario, 2.27×10^9 gal for the average-year scenario, and 2.64×10^9 gal for the drought-year scenario. For 2020, water demand is predicted to be 2.60×10^9 gal for the wet-year scenario, 3.11×10^9 gal for the average-year scenario, and 3.63×10^9 gal for the drought-year scenario.

Statewide, water demand for container-grown nursery crops is predicted to increase 37.5 percent from 1990 through 2020 for all three climatological scenarios. This increase is predicted to occur in all New Jersey counties. The largest water demand for container-grown nursery crops--nearly one-third the total water demand in the State--is predicted for Monmouth County. Other counties in which water demand for container-grown nursery crops is predicted to constitute a large share of the total demand in the State include Gloucester (12.7 percent), Cumberland (10.0 percent), Middlesex (8.6 percent), and Burlington (7.8 percent) Counties.

All Crops

Table 45 presents predicted water demand for all crop uses in New Jersey by county in 1990, 2000, 2010, and 2020 for the three climatological scenarios. Predicted water demand for all crop uses was calculated by summing the water demands for field-grown crops, cranberries, and container-grown nursery crops. For 1990, water demand for all crop uses was predicted to be 10.85×10^9 gal for the wet-year scenario, 17.30×10^9 gal for the average-year scenario, and 23.90×10^9 gal for the drought-year scenario. For 2020, water demand for all crop uses was predicted to be 11.13×10^9 gal for the wet-year scenario, 17.09×10^9 gal for the average-year scenario, and 23.14×10^9 gal for the drought-year scenario. From 1990 through 2020, water demand for all crop uses is predicted to increase 2.6 percent for the wet-year scenario, to decrease 1.3 percent for the average-year scenario, and to decrease 3.2 percent for the drought-year scenario.

Predicted water demand for all crop uses is largest in Atlantic, Burlington, Cumberland, Gloucester, Monmouth, and Salem Counties. The large water demand for container-grown nursery crops in Monmouth County tends to make the total demand for all crop uses in the county high. Similarly, the large water demand for cranberries in Burlington County tends to make the total demand for all crop uses there high. Water demand for all crop uses is highest for Burlington County under all three climatological scenarios for all four prediction years.

Table 42.--Predicted annual water demand for field-grown crops in New Jersey for two possible acreage-change scenarios, 1990, 2000, 2010, and 2020

[Values of predicted water demand are in million gallons]

2-percent annual increase in irrigated acreage from 1990				
	Year			
Climatological scenario	1990	2000	2010	2020
Wet-year	4,089	5,248	6,122	6,997
Average-year	9,782	12,570	14,665	16,759
Drought-year	15,603	20,014	23,349	26,685

2-percent annual decrease in irrigated acreage from 1990				
	Year			
Climatological scenario	1990	2000	2010	2020
Wet-year	4,089	3,498	2,624	1,749
Average-year	9,782	8,380	6,285	4,190
Drought-year	15,603	13,343	10,007	6,671

Table 43.--Predicted irrigated acreage and predicted annual water demand for cranberry use in New Jersey in 1990, 2000, 2010, and 2020, by county

County[1]	Predicted irrigated acreage	Water demand[2] (million gallons)
Atlantic	89	116.06
Burlington	3,142	4,097.17
Ocean	169	220.38
Total	3,400	4,433.61

[1]Predicted water demand for cranberry use is zero for counties not listed.

[2]Water demand for cranberry use is predicted to remain constant for all four prediction years.

Demand by crop type as a percentage of total water demand for all crop uses changes over the prediction period. Under the average-year scenario, for example, water demand for container-grown nursery crops accounts for 13.1 percent of total water demand for all crop uses in 1990 and is predicted to increase to 18.2 percent in 2020. Water demand for field-grown crops accounts for 61.3 percent of total water demand for all crop uses in 1990 under the average-year scenario and is predicted to decrease to 55.8 percent in 2020. Water demand for cranberries is predicted to remain constant during the prediction period. From 1990 to 2020, water demand for cranberries as a percentage of total water demand for all crop uses under the average-year scenario is predicted to increase by less than 1 percent.

Water demand for crop uses, particularly for field-grown crops, are sensitive to changes in climate. Changes in climate could have a profound effect on crop water demand in the future. McCabe and Wolock (in press) investigated the effects of changes in mean annual temperature, mean annual precipitation, and the stomatal resistance of plants to transpiration from hypothetical conditions of increased carbon dioxide in the Earth's atmosphere on irrigation water demand. In this report, only historical climate data are used to predict water demand for crop uses; predictions are not made for scenarios of possible climate change.

Estimated Use of Water for Livestock and Selected Sectors of the Food-Processing Industry in 1987

Table 46 shows estimated livestock water use in New Jersey in 1987 by animal or type of production. Total estimated water use for livestock in New Jersey in 1987 was 0.78×10^9 gal. The largest amounts of water are used for cattle, horses, swine, and the processing of milk. Table 47 shows estimated

Table 46.--Estimated water use for livestock in New Jersey in 1987 by animal or use type

Animal or use type	Estimated water use (million gallons)
Adult cattle	256.67
Young cattle	49.86
Milk processing	99.00
Swine	72.43
Feeder pig production	13.50
Adult sheep and goats	13.57
Young sheep and goats	5.53
Horses	221.63
Ducks	2.98
Chickens	37.09
Turkeys	5.56
Total	777.82

Table 47.--Estimated water use for livestock in New Jersey in 1987, by county

County	Estimated water use (million gallons)
Atlantic	7.31
Bergen	10.31
Burlington	76.35
Camden	10.31
Cape May	9.08
Cumberland	19.14
Essex	1.02
Gloucester	63.86
Hunterdon	104.87
Mercer	19.40
Middlesex	8.15
Monmouth	65.27
Morris	24.13
Ocean	9.52
Passaic	2.56
Salem	88.80
Somerset	40.74
Sussex	100.99
Union	.82
Warren	115.18
Total	777.82

Table 48.--Estimated water use by selected New Jersey food-processing industries in 1987

[SIC, Standard Industrial Classification, from U.S. Office of Management and Budget, 1987]

SIC code	Industry	Estimated water use (million gallons)
201	Meat products	658.40
203	Preserved fruits and vegetables	1,139.65
209	Miscellaneous food and like products	1,951.87
	Total	3,749.92

total livestock water use in New Jersey in 1987 by county. In order of decreasing water demand, the largest estimated water demands for livestock were for Warren, Hunterdon, Sussex, Salem, and Burlington Counties. These counties contain relatively large numbers of cattle. Estimated water demand for livestock in 1987 in Monmouth County also was relatively large, because this county contains a large number of horses.

Table 48 presents the estimated use of water by selected sectors of the food-processing industry in 1987. The water use for all sectors for which water use was estimated was 3.75 x 10^9 gal. The sector that accounted for the largest estimated water use (about 52 percent) was miscellaneous food and like products, which includes seafood processing. Processing of preserved fruits and vegetables accounted for 30 percent of the total estimated use, and processing of meat products accounted for the remaining 18 percent of estimated use.

Predictions of Total Agricultural Water Demand in 1990, 2000, 2010, and 2020

In this report, total agricultural water demand in New Jersey is the sum of the water demands for crop uses, livestock, and the agricultural sectors of the food-processing industry.

In this report, predictions of water demand for all crop uses are presented for 1990, 2000, 2010, and 2020. Predictions of future water demand for livestock and the agricultural sectors of the food-processing industry were not made. In order to obtain rough predictions of total agricultural water demand in New Jersey, however, predictions of water demand for all crop uses in 1990, 2000, 2010, and 2020 were added to 1987 estimates of water use for livestock and the agricultural sectors of the food-processing industry (table 49), assuming that future water demand for livestock and agricultural sectors of the food-processing industry would remain the same as it was in 1987.

SUMMARY AND CONCLUSIONS

Water demand for field-grown crops, cranberries, and container-grown nursery crops in New Jersey was predicted for 1990, 2000, 2010, and 2020. Livestock water use and selected food-processing water use were estimated for 1987. Predictions and estimates of agricultural water demand are necessary because water supplies in New Jersey must be allocated among competing users, particularly in summer, when demand by all users is great.

Predictions of water demand for field-grown crops, cranberries, and container-grown nursery crops were made for 1990, 2000, 2010, and 2020 by multiplying the predicted number of irrigated acres in each crop group by estimated irrigation amounts. Irrigation amounts were estimated by using different methods for each of the three crop groups. Irrigated acreage was predicted by using historical irrigated-acreage data, and harvested acreage was predicted by using a statistical model relating population density to the number of harvested acres.

Table 49.--Predicted total agricultural water demand in New Jersey in 1990, 2000, 2010, and 2020

Use type	1990	2000	2010	2020
	Wet-year scenario			
	Water demand (million gallons)			
Crop uses	10,849.00	10,929.92	11,021.72	11,129.49
Livestock[1]	777.82	777.82	777.82	777.82
Food-processing[1]	3,749.92	3,749.92	3,749.92	3,749.92
Total[2]	15,376.74	15,457.66	15,549.46	15,657.23
	Average-year scenario			
	Water demand (million gallons)			
Crop uses	17,303.70	17,206.97	17,121.31	17,085.27
Livestock[1]	777.82	777.82	777.82	777.82
Food-processing[1]	3,749.92	3,749.92	3,749.92	3,749.92
Total[2]	21,831.44	21,734.71	21,649.05	21,613.01
	Drought-year scenario			
	Water demand (million gallons)			
Crop uses	23,896.76	23,602.62	23,327.83	23,135.61
Livestock[1]	777.82	777.82	777.82	777.82
Food-processing[1]	3,749.92	3,749.92	3,749.92	3,749.92
Total[2]	28,424.50	28,130.36	27,855.57	27,663.35

[1] Predictions of water demand for livestock and agricultural sectors of the food-processing industry are equal to 1987 estimates.

[2] Predictions of total agricultural water demand are made for 1990, 2000, 2010, and 2020 with the assumption that water demand for livestock and agricultural sectors of the food-processing industry remain the same as they were in 1987.

A statistical model was developed to predict the number of harvested acres. This model was designed to divide minor civil divisions (MCD's) into four groups on the basis of population density, proximity to an urban center, and agricultural activity. Regression equations used to predict harvested acreage were developed for these four MCD groups by using population density as the independent variable. Test statistics indicated that population density is significant in explaining more than 60 percent of the variation in harvested acreage. A classification procedure based on linear-discriminant analysis was developed to allow MCD's to change from one group to another over time on the basis of population density and proximity to an urban center.

Harvested acreage in New Jersey is predicted to decrease from about 537,000 acres in 1990 to about 412,000 acres in 2020. The predicted decrease in acreage (more than 10,000 acres) is largest in Burlington, Gloucester, Hunterdon, Middlesex, Monmouth, and Sussex Counties. Large population increases have been projected for these counties during the prediction period. Harvested acreage in the Coastal Plain Counties of Cumberland and Salem is predicted to decrease less than 10 percent from 1990 through 2020. These counties currently are stable agriculturally; population increases projected for them are relatively small during the prediction period, and they contain relatively large predicted numbers of irrigated acres.

The predicted harvested acreages for each county for each of the prediction years were divided among six basic crop types: orchards, nursery crops, cranberries, other berries, vegetables, and field crops. For the period 1990 through 2020, the number of acres on which nursery crops are grown is predicted to increase, whereas orchard, vegetable, and field-crop acreages are predicted to decline and berry acreages are predicted to remain constant in relation to current levels. The number of irrigated acres for each crop type was determined from the predicted number of harvested acres in that group by using information derived from analysis of irrigated-acreage data, field work, and interviews with members of the New Jersey agricultural community.

Statewide, total irrigated acreage for all crop types is predicted to decrease about 7 percent from 1990 through 2020. At the county level, irrigated acreage is predicted to decrease in all but three New Jersey counties. Salem County showed the largest increase (11.1 percent) in number of irrigated acres from 1990 through 2020, followed by Union (4.8 percent), and Cumberland (4.2 percent) Counties. In percent, the largest predicted decreases in irrigated acreage for all crop types are in Middlesex (67.4 percent), Essex (45.9 percent), Sussex (44.4 percent), Cape May (34.8 percent), and Camden (28.9 percent) Counties.

A Thornthwaite daily water-balance model was used to calculate soil-moisture levels and optimum irrigation amounts for field-grown crops in each of the 20 New Jersey counties that contain farmland. Optimum-annual and -monthly irrigation amounts were calculated for three climatological scenarios: wet year, average year, and drought year.

Optimum irrigation amounts were calculated by using temperature and precipitation data from a recent 29-year period. It was assumed that optimum irrigation amounts calculated for this period were representative of long-term New Jersey climatic conditions and could be used as estimates of optimum irrigation amounts over the prediction period.

Optimum-annual and -monthly irrigation amounts calculated by using the Thornthwaite water-balance model were multiplied by the corresponding predicted number of irrigated acres for field-grown crops in each county for the four prediction years. For 1990, water demand for field-grown crops is predicted to be 4.53 x 10^9 gal for the wet-year scenario, 10.60 x 10^9 gal for the average-year scenario, and 16.82 x 10^9 gal for the drought-year scenario. For 2020, water demand for field-grown crops is predicted to be 4.10 x 10^9 gal for the wet-year scenario, 9.54 x 10^9 gal for the average-year scenario, and 15.07 x 10^9 gal for the drought-year scenario. Prediction results indicate that the method for predicting water demand for field-grown crops is sensitive to changes in the climatological input data.

Estimates of predicted water demand for field-grown crops under two possible acreage-change scenarios were computed to provide a range of values. The acreage-change scenarios considered were (1) a 2-percent annual increase in the predicted number of irrigated acres for field-grown crops from 1990 through 2020, and (2) a 2-percent annual decrease in the predicted number of irrigated acres for field-grown crops from 1990 through 2020. Predictions of water demand for field-grown crops under the two acreage-change scenarios were computed at the State level for the three climatological scenarios and for the four prediction years. Predictions ranged from a low of 1.75 x 10^9 gal to a high of 26.69 x 10^9 gal.

Cranberry irrigation differs from irrigation of other plants because cranberry plants generally require only a small amount of water each year for consumptive use. The greatest amounts of water are used in harvesting and frost protection of the cranberry plants; this use is almost entirely nonconsumptive. Cranberry farming in New Jersey is concentrated in the Pinelands region in Atlantic, Burlington, and Ocean Counties.

Cranberry growers use about 4 acre-ft of water per acre each year. Predicted harvested cranberry acreages by county were multiplied by 4 acre-ft to produce county estimates of predicted water demand for cranberries for the four prediction years. Water demand for cranberries is predicted to be constant during the prediction period--4.43 x 10^9 gal in all four prediction years. Burlington County accounts for more than 90 percent of cranberry water demand in the State.

Water demand for container-grown nursery crops was estimated by multiplying the predicted number of acres of container-grown nursery crops by county by a Statewide estimate of actual water use for container-grown nursery plants. The estimate of actual water use was made by using the data on water use reported to the New Jersey Department of Environmental Protection and Energy by farmers. The reported data were verified through a field study conducted in 1989. Estimates of water demand for container-grown nursery crops were made for the three climatological scenarios and were multiplied by the predicted number of acres of container-grown nursery crops. For 1990, water demand for container-grown nursery crops is predicted to be 1.89 x 10^9 gal for the wet-year scenario, 2.27 x 10^9 gal for the average-year scenario, and 2.64 x 10^9 gal for the drought-year scenario. For 2020, water demand for container-grown nursery crops is predicted to be 2.60 x 10^9 gal for the wet-year scenario, 3.11 x 10^9 gal for the average-year scenario, and 3.63 x 10^9 gal for the drought-year scenario.

Predicted water demand for all crop uses was calculated by summing the water demands for field-grown crops, cranberries, and container-grown nursery crops. For 1990, water demand for all crop uses was predicted to be 10.85×10^9 gal for the wet-year scenario, 17.30×10^9 gal for the average-year scenario, and 23.90×10^9 gal for the drought-year scenario. For 2020, water demand for all crop uses was predicted to be 11.13×10^9 gal for the wet-year scenario, 17.09×10^9 gal for the average-year scenario, and 23.14×10^9 gal for the drought-year scenario. Water demand for all crop uses is predicted to increase 2.6 percent for the wet-year scenario, to decrease 1.3 percent for the average-year scenario, and to decrease 3.2 percent for the drought-year scenario from 1990 through 2020.

Predicted water demand for all crop uses is greatest in Atlantic, Burlington, Cumberland, Gloucester, Monmouth, and Salem Counties. The large water demand for container-grown nursery crops in Monmouth County results in a large total water demand for all crop uses in the county. Similarly, the large water demand for cranberries in Burlington County results in a large total water demand for all crop uses in the county.

Water use for livestock in 1987 was estimated by multiplying numbers of animals and production numbers by per capita and per use livestock water-use coefficients. Water demand for livestock in 1987 was estimated to be 0.78×10^9 gal. Most of this water was used by cattle and horses. Estimated water demand for livestock was largest in Burlington, Hunterdon, Salem, Sussex, and Warren Counties, which contain relatively large numbers of cattle. Estimated water demand for livestock in 1987 also was relatively large in Monmouth County, which contains a large number of horses.

Water use for food-processing in 1987 was estimated by multiplying the number of employees in selected sectors of the food-processing industry by per employee coefficients of industrial water use. Water use was estimated for the production of meat products, preserved fruits and vegetables, and miscellaneous food and like products (including seafood processing). Water use by selected sectors of the food-processing industry in New Jersey in 1987 was estimated to be 3.75×10^9 gal.

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GLOSSARY

Actual evapotranspiration--evapotranspiration that is limited by available water; the actual loss of water from plant and soil surfaces.

Centroid of the plane region--the point that would be the location of the center of mass of a plane of constant density covering the region.

Consumptive water use--that part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment.

Evapotranspiration--water discharged to the atmosphere as a result of evaporation from the soil and surface-water bodies and by plant transpiration.

F statistic--a test statistic that indicates global model utility.

Field capacity--the soil moisture that exists when the maximum amount of water is held against the force of gravity in the soil profile.

Ground water--generally, all subsurface water, as distinct from surface water; specifically, that part of the subsurface water in the saturated zone (a zone in which all voids are filled with water) where the water is under pressure greater than atmospheric.

MCD--a minor civil division; the smallest political subdivision in New Jersey. Townships, boroughs, towns, and cities are examples of MCD's.

Naive estimator--an estimator which assumes that a pattern observed in the past will continue to happen in the same way in the future.

Nonconsumptive water use--that part of water withdrawn that is not removed from the water environment; water available for reuse.

Potential evapotranspiration--evapotranspiration that is not limited by a lack of available water.

Permanent wilting point--the soil moisture that exists when plants can no longer obtain sufficient moisture to satisfy transpiration requirements and the plants wilt and remain wilted.

R^2 (adj.)--the coefficient of determination adjusted for degrees of freedom; a test statistic that indicates how much variation in a dependent variable is explained by one or more independent variables.

Soil-moisture storage--moisture (commonly expressed as a depth) stored in the capillaries of the root zone of a soil against the force of gravity.

Soil series--a particular soil type in a particular area (for example, Freehold sandy loam is a series of sandy loam found in the Coastal Plain of New Jersey).

Soil type--the characteristics--such as texture or amount of organic matter--that define a particular kind of soil. Sandy loam is a soil type, for example.

Soil water deficit--the amount by which available soil moisture must be replenished to reach field capacity.

Soil water surplus--soil moisture over and above that needed for evapotranspiration, or soil-moisture recharge that is lost from the soil by subsurface flow.

Suburbanization--a process involving the direct conversion of farmland and vacant land near an urban center to residential, commercial, and transportation uses.

Surface water--an open body of water such as a stream, lake, reservoir, or pond.

T-statistic--a test statistic that indicates the significance of a predictor variable.

Transpiration--the act of giving off (vapor containing waste products) through the stomata of plant tissue.

Table 24.--Predicted harvested acreage in New Jersey in 1990, by minor civil division, before correction with the adjustment factor

[MCD, minor civil division; MS, "miscellaneous"; SR, southern rural; NI, northern irrigated; UF, urban fringe; * indicates outlier MCD's]

MCD name	MCD group	Predicted harvested acreage
	ATLANTIC COUNTY	
ABSECON CITY	MS	10.1
BUENA BOROUGH	SR	1,319.4
BUENA VISTA TOWNSHIP	SR	9,633.3
CORBIN CITY	MS	103.3
EGG HARBOR TOWNSHIP	MS	505.9
ESTELL MANOR CITY	MS	647.8
FOLSOM BOROUGH	MS	257.1
GALLOWAY TOWNSHIP	MS	886.7
HAMILTON TOWNSHIP	MS	2,052.4
HAMMONTON TOWN	SR	8,191.2
LINWOOD CITY	MS	38.7
MULLICA TOWNSHIP	MS	1,100.5
NORTHFIELD CITY	MS	38.7
PORT REPUBLIC CITY	MS	455.0
	BERGEN COUNTY	
FRANKLIN LAKES BOROUGH	NI	183.3
HILLSDALE BOROUGH	NI	18.4
* MAHWAH TOWNSHIP	NI	163.0
MONTVALE BOROUGH	NI	47.9
NEW MILFORD BOROUGH	NI	6.7
RIVERVALE TOWNSHIP	NI	44.1
SADDLE RIVER BOROUGH	NI	178.4
UPPER SADDLE RIVER BOROUGH	NI	74.9
WOODCLIFF LAKE BOROUGH	NI	56.5
WYCKOFF TOWNSHIP	NI	82.6
	BURLINGTON COUNTY	
BASS RIVER TOWNSHIP	MS	902.6
BORDENTOWN TOWNSHIP	UF	734.3
BURLINGTON CITY	SR	84.6
BURLINGTON TOWNSHIP	SR	1,630.0
CHESTERFIELD TOWNSHIP	SR	5,083.4
CINNAMINSON TOWNSHIP	UF	241.8
DELANCO TOWNSHIP	UF	118.4

Table 24.--Predicted harvested acreage in New Jersey in 1990, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
BURLINGTON COUNTY--Continued		
DELRAN TOWNSHIP	UF	195.4
EASTAMPTON TOWNSHIP	SR	768.8
EDGEWATER PARK TOWNSHIP	UF	28.9
EVESHAM TOWNSHIP	UF	3,888.0
FLORENCE TOWNSHIP	SR	994.6
HAINESPORT TOWNSHIP	SR	1,090.3
LUMBERTON TOWNSHIP	SR	2,294.6
MANSFIELD TOWNSHIP	SR	5,641.0
MAPLE SHADE TOWNSHIP	UF	7.7
MEDFORD TOWNSHIP	SR	6,349.3
MOORESTOWN TOWNSHIP	UF	1,779.5
MT HOLLY TOWNSHIP	SR	70.0
MT LAUREL TOWNSHIP	UF	2,321.7
NEW HANOVER TOWNSHIP	SR	2,907.1
NORTH HANOVER TOWNSHIP	SR	2,699.1
PEMBERTON BOROUGH	SR	44.4
PEMBERTON TOWNSHIP	SR	10,477.2
SHAMONG TOWNSHIP	MS	975.8
SOUTHAMPTON TOWNSHIP	SR	9,565.2
SPRINGFIELD TOWNSHIP	SR	7,604.1
TABERNACLE TOWNSHIP	MS	978.2
WASHINGTON TOWNSHIP	MS	1,022.1
WESTAMPTON TOWNSHIP	SR	1,730.6
WILLINGBORO TOWNSHIP	UF	20.3
WOODLAND TOWNSHIP	MS	1,169.2
WRIGHTSTOWN BOROUGH	SR	94.5
CAMDEN COUNTY		
BERLIN BOROUGH	UF	163.3
BERLIN TOWNSHIP	UF	169.7
CHERRY HILL TOWNSHIP	UF	330.7
* GIBBSBORO BOROUGH	UF	5.0
GLOUCESTER TOWNSHIP	UF	712.0
* HI-NELLA BOROUGH	UF	7.0
PINE HILL BOROUGH	UF	122.7
VORHEES TOWNSHIP	UF	534.9
WATERFORD TOWNSHIP	MS	463.4
WINSLOW TOWNSHIP	SR	9,877.3

Table 24.--Predicted harvested acreage in New Jersey in 1990, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
CAPE MAY COUNTY		
DENNIS TOWNSHIP	MS	1,083.6
* LOWER TOWNSHIP	MS	1,793.0
MIDDLE TOWNSHIP	MS	926.7
UPPER TOWNSHIP	MS	435.3
WEST CAPE MAY BOROUGH	UF	169.2
WOODBINE BOROUGH	MS	122.8
CUMBERLAND COUNTY		
BRIDGETON CITY	SR	282.6
COMMERCIAL TOWNSHIP	MS	1,193.3
DEERFIELD TOWNSHIP	SR	[illegible],018.6
DOWNE TOWNSHIP	MS	1,053.9
FAIRFIELD TOWNSHIP	SR	10,839.8
GREENWICH TOWNSHIP	SR	4,828.0
HOPEWELL TOWNSHIP	SR	7,869.6
LAWRENCE TOWNSHIP	MS	1,674.9
MAURICE RIVER TOWNSHIP	MS	1,315.3
MILVILLE CITY	SR	6,823.0
SHILOH BOROUGH	SR	251.2
STOW CREEK TOWNSHIP	SR	4,876.1
UPPER DEERFIELD TOWNSHIP	SR	5,817.3
VINELAND CITY	SR	8,243.8
ESSEX COUNTY		
CEDAR GROVE TOWNSHIP	NI	22.7
FAIRFIELD BOROUGH	NI	116.7
GLOUCESTER COUNTY		
CLAYTON BOROUGH	SR	992.8
DEPTFORD TOWNSHIP	UF	1,346.7
EAST GREENWICH TOWNSHIP	SR	2,152.1
ELK TOWNSHIP	SR	4,751.1
FRANKLIN TOWNSHIP	SR	11,291.6
GLASSBORO BOROUGH	UF	526.6
GREENWICH TOWNSHIP	SR	1,461.0
HARRISON TOWNSHIP	SR	4,502.2

Table 24.--Predicted harvested acreage in New Jersey in 1990, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
GLOUCESTER COUNTY--Continued		
LOGAN TOWNSHIP	SR	5,802.6
MANTUA TOWNSHIP	SR	3,077.7
MONROE TOWNSHIP	SR	7,391.1
NEWFIELD BOROUGH	SR	188.2
PITMAN BOROUGH	UF	13.2
SOUTH HARRISON TOWNSHIP	SR	3,983.7
SWEDESBORO TOWNSHIP	SR	30.6
WASHINGTON TOWNSHIP	UF	1,426.9
WEST DEPTFORD BOROUGH	UF	1,759.1
WOOLWICH TOWNSHIP	SR	5,575.0
HUNTERDON COUNTY		
ALEXANDRIA TOWNSHIP	NI	5,362.6
CLINTON TOWNSHIP	NI	2,853.6
DELAWARE TOWNSHIP	NI	6,135.5
FRANKLIN TOWNSHIP	NI	3,718.5
KINGWOOD TOWNSHIP	NI	7,534.8
LEBANON TOWNSHIP	NI	3,296.7
RARITAN TOWNSHIP	NI	2,603.3
READINGTON TOWNSHIP	NI	3,727.7
TEWKSBURY TOWNSHIP	NI	4,348.4
UNION TOWNSHIP	NI	2,757.8
WEST AMWELL TOWNSHIP	NI	3,281.9
MERCER COUNTY		
EAST WINDSOR TOWNSHIP	UF	1,101.9
EWING TOWNSHIP	UF	401.3
HAMILTON TOWNSHIP	UF	1,141.8
HIGHTSTOWN BOROUGH	UF	7.4
HOPEWELL BOROUGH	SR	27.5
HOPEWELL TOWNSHIP	SR	13,389.4
LAWRENCE TOWNSHIP	UF	2,495.5
PENNINGTON BOROUGH	SR	43.7
PRINCETON TOWNSHIP	UF	2,611.0
WASHINGTON TOWNSHIP	SR	4,162.4
WEST WINDSOR TOWNSHIP	UF	6,815.5

Table 24.--Predicted harvested acreage in New Jersey in 1990, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
MIDDLESEX COUNTY		
CRANBURY TOWNSHIP	SR	2,820.9
EAST BRUNSWICK TOWNSHIP	UF	887.9
*EDISON TOWNSHIP	UF	37.0
MIDDLESEX BOROUGH	UF	29.7
MILLTOWN BOROUGH	UF	6.5
MONROE TOWNSHIP	SR	6,551.1
NORTH BRUNSWICK TOWNSHIP	UF	242.8
OLD BRIDGE TOWNSHIP	UF	2,287.6
PISCATAWAY TOWNSHIP	UF	485.3
PLAINSBORO TOWNSHIP	UF	1,271.5
*SAYREVILLE BOROUGH	UF	14.0
SOUTH BRUNSWICK TOWNSHIP	UF	8,006.2
SOUTH PLAINFIELD BOROUGH	UF	205.7
SPOTSWOOD BOROUGH	UF	24.6
MONMOUTH COUNTY		
ABERDEEN TOWNSHIP	MS	24.7
ALLENTOWN BOROUGH	SR	34.6
COLTS NECK TOWNSHIP	SR	6,610.5
EATONTOWN BOROUGH	MS	37.5
ENGLISHTOWN BOROUGH	SR	23.7
FARMINGDALE BOROUGH	SR	15.9
FREEHOLD BOROUGH	SR	21.8
FREEHOLD TOWNSHIP	SR	5,209.3
HAZLET TOWNSHIP	MS	22.8
HOLMDEL TOWNSHIP	SR	2,299.8
HOWELL TOWNSHIP	SR	8,869.2
LITTLE SILVER BOROUGH	MS	61.1
LONG BRANCH CITY	MS	11.2
MANALAPAN TOWNSHIP	SR	3,369.1
MARLBORO TOWNSHIP	UF	3,950.7
MIDDLETOWN TOWNSHIP	MS	397.8
MILLSTONE TOWNSHIP	SR	9,230.7
NEPTUNE TOWNSHIP	MS	31.2
*OCEAN TOWNSHIP	MS	227.0
ROOSEVELT BOROUGH	SR	323.0
SHREWSBURY BOROUGH	MS	53.0
TINTON FALLS BOROUGH	MS	254.0

Table 24.--Predicted harvested acreage in New Jersey in 1990, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
MONMOUTH COUNTY--Continued		
UPPER FREEHOLD TOWNSHIP	SR	12,221.2
WALL TOWNSHIP	MS	672.2
WEST LONG BRANCH BOROUGH	MS	36.4
MORRIS COUNTY		
BOONTON TOWNSHIP	NI	445.8
CHATHAM TOWNSHIP	NI	184.6
CHESTER TOWNSHIP	NI	3,002.1
DENVILLE TOWNSHIP	NI	274.2
HARDING TOWNSHIP	NI	1,599.9
LINCOLN PARK BOROUGH	NI	88.3
MENDHAM BOROUGH	NI	179.8
MENDHAM TOWNSHIP	NI	1,352.2
MONTVILLE TOWNSHIP	NI	528.3
*MORRIS TOWNSHIP	NI	81.0
PARSIPPANY-TROY HILLS TOWNSHIP	NI	283.3
PASSAIC TOWNSHIP	NI	830.4
WASHINGTON TOWNSHIP	NI	2,727.4
OCEAN COUNTY		
BARNEGAT TOWNSHIP	MS	9.1
BERKELEY TOWNSHIP	MS	10.4
BRICK TOWNSHIP	MS	49.8
DOVER TOWNSHIP	MS	26.1
JACKSON TOWNSHIP	MS	204.6
LACEY TOWNSHIP	MS	131.0
LAKEWOOD TOWNSHIP	MS	81.5
LITTLE EGG HARBOR TOWNSHIP	MS	28.1
*MANCHESTER TOWNSHIP	MS	103.0
PLUMSTED TOWNSHIP	SR	9,141.3
STAFFORD TOWNSHIP	MS	72.6
PASSAIC COUNTY		
WAYNE TOWNSHIP	NI	278.7
*WEST MILFORD TOWNSHIP	NI	156.0

Table 24.--Predicted harvested acreage in New Jersey in 1990, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
SALEM COUNTY		
ALLOWAY TOWNSHIP	SR	8,664.6
CARNEYS POINT TOWNSHIP	SR	3,037.3
ELMER BOROUGH	SR	35.8
ELSINBORO TOWNSHIP	SR	3,358.4
LOWER ALLOWAYS CRK TOWNSHIP	SR	11,315.8
MANNINGTON BOROUGH	SR	10,223.4
OLDMANS TOWNSHIP	SR	4,979.7
PENNS GROVE BOROUGH	SR	8.2
PENNSVILLE TOWNSHIP	SR	3,622.5
PILESGROVE TOWNSHIP	SR	9,010.7
PITTSGROVE TOWNSHIP	SR	10,346.6
QUINTON TOWNSHIP	SR	6,188.3
SALEM CITY	SR	124.8
UPPER PITTSGROVE TOWNSHIP	SR	10,133.9
WOODSTOWN BOROUGH	SR	68.9
SOMERSET COUNTY		
BEDMINSTER TOWNSHIP	NI	2,880.0
BERNARDS TOWNSHIP	NI	804.5
BRANCHBURG TOWNSHIP	NI	1,043.2
BRIDGEWATER TOWNSHIP	NI	776.3
FRANKLIN TOWNSHIP	NI	1,174.3
HILLSBOROUGH TOWNSHIP	NI	2,665.5
MANVILLE BOROUGH	NI	13.2
MONTGOMERY TOWNSHIP	NI	2,181.2
WARREN TOWNSHIP	NI	786.6
SUSSEX COUNTY		
ANDOVER BOROUGH	NI	92.0
*BYRAM TOWNSHIP	NI	31.0
FRANKFORD TOWNSHIP	NI	4,056.3
FRANKLIN BOROUGH	NI	90.9
GREEN TOWNSHIP	NI	1,698.5
HAMPTON TOWNSHIP	NI	2,572.6
HARDYSTON TOWNSHIP	NI	3,623.0
LAFAYETTE TOWNSHIP	NI	2,986.8
*MONTAGUE TOWNSHIP	NI	949.0

Table 24.--Predicted harvested acreage in New Jersey in 1990, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
SUSSEX COUNTY--Continued		
SPARTA TOWNSHIP	NI	1,934.8
STILLWATER TOWNSHIP	NI	3,126.6
VERNON TOWNSHIP	NI	4,003.2
WANTAGE TOWNSHIP	NI	9,024.7
UNION COUNTY		
*CRANFORD TOWNSHIP	NI	5.0
SCOTCH PLAINS TOWNSHIP	NI	73.8
SPRINGFIELD TOWNSHIP	NI	34.1
*WESTFIELD TOWNSHIP	NI	27.0
WARREN COUNTY		
ALLAMUCHY TOWNSHIP	NI	1,967.0
BLAIRSTOWN TOWNSHIP	NI	3,457.2
FRELINGHUYSEN TOWNSHIP	NI	5,397.0
HARMONY TOWNSHIP	NI	3,892.7
HOPE TOWNSHIP	NI	3,650.9
INDEPENDENCE TOWNSHIP	NI	2,115.6
KNOWLTON TOWNSHIP	NI	5,156.7
LOPATCONG TOWNSHIP	NI	189.6
MANSFIELD TOWNSHIP	NI	2,970.6
OXFORD TOWNSHIP	NI	403.7
POHATCONG TOWNSHIP	NI	1,049.8
WASHINGTON TOWNSHIP	NI	1,385.3
WHITE TOWNSHIP	NI	4,825.5

Table 25.--Predicted harvested acreage in New Jersey in 2000, by minor civil division, before correction with the adjustment factor

[MCD, minor civil division; MS, "miscellaneous"; SR, southern rural; NI, northern irrigated; UF, urban fringe; * indicates outlier MCD's]

MCD name	MCD group	Predicted harvested acreage
ATLANTIC COUNTY		
ABSECON CITY	MS	7.1
BUENA BOROUGH	SR	1,301.4
BUENA VISTA TOWNSHIP	SR	9,377.0
CORBIN CITY	MS	102.3
EGG HARBOR TOWNSHIP	MS	355.0
ESTELL MANOR CITY	MS	614.7
FOLSOM BOROUGH	MS	247.1
GALLOWAY TOWNSHIP	MS	436.1
HAMILTON TOWNSHIP	MS	1,474.1
HAMMONTON TOWN	SR	8,142.0
LINWOOD CITY	MS	33.6
MULLICA TOWNSHIP	MS	1,068.0
NORTHFIELD CITY	MS	41.0
PORT REPUBLIC CITY	MS	447.2
BERGEN COUNTY		
FRANKLIN LAKES BOROUGH	NI	162.7
HILLSDALE BOROUGH	NI	17.9
*MAHWAH TOWNSHIP	NI	139.0
MONTVALE BOROUGH	NI	45.9
NEW MILFORD BOROUGH	NI	6.7
RIVERVALE TOWNSHIP	NI	41.4
SADDLE RIVER BOROUGH	NI	169.2
UPPER SADDLE RIVER BOROUGH	NI	71.8
WOODCLIFF LAKE BOROUGH	NI	53.8
WYCKOFF TOWNSHIP	NI	80.6
BURLINGTON COUNTY		
BASS RIVER TOWNSHIP	MS	884.0
BORDENTOWN TOWNSHIP	UF	550.0
BURLINGTON CITY	SR	88.6
BURLINGTON TOWNSHIP	SR	1,437.9
CHESTERFIELD TOWNSHIP	SR	4,936.4
CINNAMINSON TOWNSHIP	UF	229.3
DELANCO TOWNSHIP	UF	113.7

Table 25.--Predicted harvested acreage in New Jersey in 2000, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
BURLINGTON COUNTY--Continued		
DELRAN TOWNSHIP	UF	135.7
EASTAMPTON TOWNSHIP	SR	620.7
EDGEWATER PARK TOWNSHIP	UF	24.9
EVESHAM TOWNSHIP	UF	2,731.3
FLORENCE TOWNSHIP	SR	956.3
HAINESPORT TOWNSHIP	SR	1,046.1
LUMBERTON TOWNSHIP	SR	2,013.8
MANSFIELD TOWNSHIP	SR	5,443.9
MAPLE SHADE TOWNSHIP	UF	7.8
MEDFORD TOWNSHIP	SR	5,386.7
MOORESTOWN TOWNSHIP	UF	1,489.2
MT HOLLY TOWNSHIP	SR	71.2
MT LAUREL TOWNSHIP	UF	1,646.9
NEW HANOVER TOWNSHIP	SR	2,842.3
NORTH HANOVER TOWNSHIP	SR	2,435.0
PEMBERTON BOROUGH	SR	46.0
PEMBERTON TOWNSHIP	SR	9,962.0
SHAMONG TOWNSHIP	MS	857.8
SOUTHAMPTON TOWNSHIP	SR	9,033.4
SPRINGFIELD TOWNSHIP	SR	7,351.6
TABERNACLE TOWNSHIP	MS	819.2
WASHINGTON TOWNSHIP	MS	1,076.6
WESTAMPTON TOWNSHIP	SR	1,546.1
WILLINGBORO TOWNSHIP	UF	19.5
WOODLAND TOWNSHIP	MS	1,116.3
WRIGHTSTOWN BOROUGH	SR	87.8
CAMDEN COUNTY		
BERLIN BOROUGH	UF	102.0
BERLIN TOWNSHIP	UF	146.5
CHERRY HILL TOWNSHIP	UF	252.2
GLOUCESTER TOWNSHIP	UF	466.9
*HI-NELLA BOROUGH	UF	6.2
PINE HILL BOROUGH	UF	65.1
VORHEES TOWNSHIP	UF	263.9
WATERFORD TOWNSHIP	MS	286.9
WINSLOW TOWNSHIP	SR	8,899.8

Table 25.--Predicted harvested acreage in New Jersey in 2000, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
CAPE MAY COUNTY		
DENNIS TOWNSHIP	MS	842.2
*LOWER TOWNSHIP	MS	1,555.0
MIDDLE TOWNSHIP	MS	655.8
UPPER TOWNSHIP	MS	312.7
WEST CAPE MAY BOROUGH	UF	124.0
WOODBINE BOROUGH	MS	107.7
CUMBERLAND COUNTY		
BRIDGETON CITY	SR	327.0
COMMERCIAL TOWNSHIP	MS	1,219.0
DEERFIELD TOWNSHIP	SR	3,978.8
DOWNE TOWNSHIP	MS	1,043.0
FAIRFIELD TOWNSHIP	SR	10,814.8
GREENWICH TOWNSHIP	SR	4,785.6
HOPEWELL TOWNSHIP	SR	7,869.6
LAWRENCE TOWNSHIP	MS	1,656.3
MAURICE RIVER TOWNSHIP	MS	1,331.4
MILVILLE CITY	SR	6,519.0
SHILOH BOROUGH	SR	262.4
STOW CREEK TOWNSHIP	SR	4,879.3
UPPER DEERFIELD TOWNSHIP	SR	5,368.5
VINELAND CITY	SR	7,617.2
ESSEX COUNTY		
CEDAR GROVE TOWNSHIP	NI	21.4
FAIRFIELD BOROUGH	NI	87.4
GLOUCESTER COUNTY		
CLAYTON BOROUGH	SR	913.5
DEPTFORD TOWNSHIP	UF	1,184.3
EAST GREENWICH TOWNSHIP	SR	2,035.7
ELK TOWNSHIP	SR	4,358.7
FRANKLIN TOWNSHIP	SR	10,389.2
GLASSBORO BOROUGH	UF	482.4
GREENWICH TOWNSHIP	SR	1,477.9
HARRISON TOWNSHIP	SR	4,326.4

Table 25.--Predicted harvested acreage in New Jersey in 2000, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
GLOUCESTER COUNTY--Continued		
LOGAN TOWNSHIP	SR	5,342.9
MANTUA TOWNSHIP	SR	2,898.6
MONROE TOWNSHIP	SR	6,697.4
NEWFIELD BOROUGH	SR	185.6
PITMAN BOROUGH	UF	14.5
SOUTH HARRISON TOWNSHIP	SR	3,916.5
SWEDESBORO TOWNSHIP	SR	32.8
WASHINGTON TOWNSHIP	UF	907.7
WEST DEPTFORD BOROUGH	UF	1,302.8
WOOLWICH TOWNSHIP	SR	5,274.8
HUNTERDON COUNTY		
ALEXANDRIA TOWNSHIP	NI	5,124.6
CLINTON TOWNSHIP	NI	2,361.2
DELAWARE TOWNSHIP	NI	5,614.9
FRANKLIN TOWNSHIP	NI	3,438.5
KINGWOOD TOWNSHIP	NI	6,875.0
LEBANON TOWNSHIP	NI	2,716.0
RARITAN TOWNSHIP	NI	2,029.1
READINGTON TOWNSHIP	NI	2,972.8
TEWKSBURY TOWNSHIP	NI	3,610.6
UNION TOWNSHIP	NI	2,465.7
WEST AMWELL TOWNSHIP	NI	2,926.9
MERCER COUNTY		
EAST WINDSOR TOWNSHIP	UF	833.4
EWING TOWNSHIP	UF	393.0
HAMILTON TOWNSHIP	UF	892.2
HIGHTSTOWN BOROUGH	UF	7.4
HOPEWELL BOROUGH	SR	22.1
HOPEWELL TOWNSHIP	SR	12,530.1
LAWRENCE TOWNSHIP	UF	2,138.4
PENNINGTON BOROUGH	SR	39.4
PRINCETON TOWNSHIP	UF	1,791.0
WASHINGTON TOWNSHIP	UF	6,062.3
WEST WINDSOR TOWNSHIP	UF	4,814.9

Table 25.--Predicted harvested acreage in New Jersey in 2000, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
	MIDDLESEX COUNTY	
CRANBURY TOWNSHIP	SR	1,914.3
EAST BRUNSWICK TOWNSHIP	UF	787.3
*EDISON TOWNSHIP	UF	33.0
MIDDLESEX BOROUGH	UF	32.6
MILLTOWN BOROUGH	UF	7.1
MONROE TOWNSHIP	UF	7,612.3
NORTH BRUNSWICK TOWNSHIP	UF	159.2
OLD BRIDGE TOWNSHIP	UF	1,481.1
PISCATAWAY TOWNSHIP	UF	442.9
PLAINSBORO TOWNSHIP	UF	906.0
*SAYREVILLE BOROUGH	UF	12.4
SOUTH BRUNSWICK TOWNSHIP	UF	4,813.8
SOUTH PLAINFIELD BOROUGH	UF	220.0
SPOTSWOOD BOROUGH	UF	26.3
	MONMOUTH COUNTY	
ABERDEEN TOWNSHIP	MS	24.0
ALLENTOWN BOROUGH	UF	16.7
COLTS NECK TOWNSHIP	SR	6,313.7
EATONTOWN BOROUGH	MS	40.1
ENGLISHTOWN BOROUGH	SR	23.3
FARMINGDALE BOROUGH	SR	15.7
FREEHOLD BOROUGH	SR	21.7
FREEHOLD TOWNSHIP	SR	4,843.0
HAZLET TOWNSHIP	MS	22.2
HOLMDEL TOWNSHIP	SR	2,044.6
HOWELL TOWNSHIP	SR	8,386.0
LITTLE SILVER BOROUGH	MS	60.3
LONG BRANCH CITY	MS	11.0
MANALAPAN TOWNSHIP	SR	2,955.9
MARLBORO TOWNSHIP	UF	3,309.3
MIDDLETOWN TOWNSHIP	MS	402.5
MILLSTONE TOWNSHIP	SR	8,599.7
NEPTUNE TOWNSHIP	MS	33.2
*OCEAN TOWNSHIP	MS	197.0
ROOSEVELT BOROUGH	SR	294.7
SHREWSBURY BOROUGH	MS	49.7
TINTON FALLS BOROUGH	MS	180.8

Table 25.--Predicted harvested acreage in New Jersey in 2000, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
MONMOUTH COUNTY--Continued		
UPPER FREEHOLD TOWNSHIP	SR	11,826.6
WALL TOWNSHIP	MS	567.1
WEST LONG BRANCH B	MS	42.9
MORRIS COUNTY		
BOONTON TOWNSHIP	NI	402.8
CHATHAM TOWNSHIP	NI	160.2
CHESTER TOWNSHIP	NI	2,617.1
DENVILLE TOWNSHIP	NI	254.3
HARDING TOWNSHIP	NI	1,413.7
LINCOLN PARK BOROUGH	NI	77.6
MENDHAM BOROUGH	NI	144.8
MENDHAM TOWNSHIP	NI	1,148.1
MONTVILLE TOWNSHIP	NI	451.3
*MORRIS TOWNSHIP	NI	69.0
PARSIPPANY-TROY HILLS TOWNSHIP	NI	264.0
PASSAIC TOWNSHIP	NI	753.5
WASHINGTON TOWNSHIP	NI	2,147.5
OCEAN COUNTY		
BRICK TOWNSHIP	MS	41.2
DOVER TOWNSHIP	MS	18.1
JACKSON TOWNSHIP	MS	118.3
LACEY TOWNSHIP	MS	104.4
LAKEWOOD TOWNSHIP	MS	60.4
LITTLE EGG HARBOR TOWNSHIP	MS	15.2
*MANCHESTER TOWNSHIP	MS	89.0
PLUMSTED TOWNSHIP	SR	8,370.4
STAFFORD TOWNSHIP	MS	19.3
PASSAIC COUNTY		
WAYNE TOWNSHIP	NI	265.9
*WEST MILFORD TOWNSHIP	NI	133.0

Table 25.--Predicted harvested acreage in New Jersey in 2000, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
SALEM COUNTY		
ALLOWAY TOWNSHIP	SR	8,636.2
CARNEYS POINT TOWNSHIP	SR	2,974.9
ELMER BOROUGH	SR	32.4
ELSINBORO TOWNSHIP	SR	3,330.3
LOWER ALLOWAYS CRK TOWNSHIP	SR	11,385.2
MANNINGTON BOROUGH	SR	10,319.0
OLDMANS TOWNSHIP	SR	4,965.4
PENNS GROVE BOROUGH	SR	8.2
PENNSVILLE TOWNSHIP	SR	3,548.9
PILESGROVE TOWNSHIP	SR	8,973.1
PITTSGROVE TOWNSHIP	SR	10,128.9
QUINTON TOWNSHIP	SR	6,165.8
SALEM CITY	SR	124.8
UPPER PITTSGROVE TOWNSHIP	SR	10,028.4
WOODSTOWN BOROUGH	SR	64.5
SOMERSET COUNTY		
BEDMINSTER TOWNSHIP	NI	2,051.3
BERNARDS TOWNSHIP	NI	641.1
BRANCHBURG TOWNSHIP	NI	930.3
BRIDGEWATER TOWNSHIP	NI	768.1
FRANKLIN TOWNSHIP	NI	959.0
HILLSBOROUGH TOWNSHIP	NI	2,261.0
MANVILLE BOROUGH	NI	13.4
MONTGOMERY TOWNSHIP	NI	1,789.4
WARREN TOWNSHIP	NI	652.2
SUSSEX COUNTY		
ANDOVER BOROUGH	NI	81.5
*BYRAM TOWNSHIP	NI	26.0
FRANKFORD TOWNSHIP	NI	3,081.5
FRANKLIN BOROUGH	NI	81.4
GREEN TOWNSHIP	NI	1,237.9
HAMPTON TOWNSHIP	NI	2,014.2
HARDYSTON TOWNSHIP	NI	2,716.9
LAFAYETTE TOWNSHIP	NI	2,318.7
*MONTAGUE TOWNSHIP	NI	807.0

Table 25.--Predicted harvested acreage in New Jersey in 2000, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
SUSSEX COUNTY--Continued		
SPARTA TOWNSHIP	NI	1,443.7
STILLWATER TOWNSHIP	NI	2,339.0
VERNON TOWNSHIP	NI	2,512.3
WANTAGE TOWNSHIP	NI	6,527.3
UNION COUNTY		
SCOTCH PLAINS TOWNSHIP	NI	67.5
SPRINGFIELD TOWNSHIP	NI	32.0
*WESTFIELD TOWNSHIP	NI	23.0
WARREN COUNTY		
ALLAMUCHY TOWNSHIP	NI	1,579.9
BLAIRSTOWN TOWNSHIP	NI	3,237.8
FRELINGHUYSEN TOWNSHIP	NI	4,925.0
HARMONY TOWNSHIP	NI	4,337.2
HOPE TOWNSHIP	NI	3,186.5
INDEPENDENCE TOWNSHIP	NI	1,681.1
KNOWLTON TOWNSHIP	NI	4,949.5
LOPATCONG TOWNSHIP	NI	160.0
MANSFIELD TOWNSHIP	NI	2,624.2
OXFORD TOWNSHIP	NI	369.5
POHATCONG TOWNSHIP	NI	961.4
WASHINGTON TOWNSHIP	NI	1,218.6
WHITE TOWNSHIP	NI	4,330.5

Table 26.--Predicted harvested acreage in New Jersey in 2010, by minor civil division, before correction with the adjustment factor

[MCD, minor civil division; MS, "miscellaneous"; SR, southern rural; NI, northern irrigated; UF, urban fringe; * indicates outlier MCD's]

MCD name	MCD group	Predicted harvested acreage
ATLANTIC COUNTY		
ABSECON CITY	MS	5.2
BUENA BOROUGH	SR	1,284.1
BUENA VISTA TOWNSHIP	SR	9,127.3
CORBIN CITY	MS	101.4
EGG HARBOR TOWNSHIP	MS	256.4
ESTELL MANOR CITY	MS	573.0
FOLSOM BOROUGH	MS	237.2
GALLOWAY TOWNSHIP	MS	238.7
HAMILTON TOWNSHIP	MS	1,074.8
HAMMONTON TOWN	SR	8,093.5
LINWOOD CITY	MS	29.3
MULLICA TOWNSHIP	MS	1,037.1
NORTHFIELD CITY	MS	43.4
PORT REPUBLIC CITY	MS	438.2
BERGEN COUNTY		
FRANKLIN LAKES BOROUGH	NI	146.1
HILLSDALE BOROUGH	NI	17.4
*MAHWAH TOWNSHIP	NI	118.0
MONTVALE BOROUGH	NI	44.0
NEW MILFORD BOROUGH	NI	6.7
RIVERVALE TOWNSHIP	NI	39.1
SADDLE RIVER BOROUGH	NI	160.9
UPPER SADDLE RIVER BOROUGH	NI	68.9
WOODCLIFF LAKE BOROUGH	NI	51.4
WYCKOFF TOWNSHIP	NI	78.7
BURLINGTON COUNTY		
BASS RIVER TOWNSHIP	MS	862.46
BORDENTOWN TOWNSHIP	UF	525.2
BURLINGTON CITY	SR	83.2
BURLINGTON TOWNSHIP	SR	1,355.8
CHESTERFIELD TOWNSHIP	SR	4,780.4
CINNAMINSON TOWNSHIP	UF	224.3
DELANCO TOWNSHIP	UF	115.0

Table 26.--Predicted harvested acreage in New Jersey in 2010, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
BURLINGTON COUNTY--Continued		
DELRAN TOWNSHIP	UF	122.2
EASTAMPTON TOWNSHIP	SR	577.6
EDGEWATER PARK TOWNSHIP	UF	25.3
EVESHAM TOWNSHIP	UF	1,901.4
FLORENCE TOWNSHIP	SR	917.4
HAINESPORT TOWNSHIP	SR	997.2
LUMBERTON TOWNSHIP	SR	1,943.5
MANSFIELD TOWNSHIP	SR	5,365.8
MAPLE SHADE TOWNSHIP	UF	7.6
MEDFORD TOWNSHIP	SR	4,930.1
MOORESTOWN TOWNSHIP	UF	1,458.0
MT HOLLY TOWNSHIP	SR	69.9
MT LAUREL TOWNSHIP	UF	1,211.9
NEW HANOVER TOWNSHIP	SR	2,674.2
NORTH HANOVER TOWNSHIP	SR	2,225.2
PEMBERTON BOROUGH	SR	45.2
PEMBERTON TOWNSHIP	SR	9,477.6
SHAMONG TOWNSHIP	MS	760.6
SOUTHAMPTON TOWNSHIP	SR	8,650.5
SPRINGFIELD TOWNSHIP	SR	7,236.0
TABERNACLE TOWNSHIP	MS	711.9
WASHINGTON TOWNSHIP	MS	1,171.3
WESTAMPTON TOWNSHIP	SR	1,346.8
WILLINGBORO TOWNSHIP	UF	20.6
WOODLAND TOWNSHIP	MS	1,107.9
WRIGHTSTOWN BOROUGH	SR	78.7
CAMDEN COUNTY		
BERLIN BOROUGH	UF	75.6
BERLIN TOWNSHIP	UF	120.4
CHERRY HILL TOWNSHIP	UF	227.0
GLOUCESTER TOWNSHIP	UF	336.0
*HI-NELLA BOROUGH	UF	5.5
PINE HILL BOROUGH	UF	51.8
VORHEES TOWNSHIP	UF	162.9
WATERFORD TOWNSHIP	MS	208.5
WINSLOW TOWNSHIP	SR	7,907.7

Table 26.--Predicted harvested acreage in New Jersey in 2010, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
CAPE MAY COUNTY		
DENNIS TOWNSHIP	MS	648.7
*LOWER TOWNSHIP	MS	1,348.0
MIDDLE TOWNSHIP	MS	541.3
UPPER TOWNSHIP	MS	244.2
WEST CAPE MAY BOROUGH	UF	91.8
WOODBINE BOROUGH	MS	90.8
CUMBERLAND COUNTY		
BRIDGETON CITY	SR	375.7
COMMERCIAL TOWNSHIP	MS	1,243.1
DEERFIELD TOWNSHIP	SR	3,936.4
DOWNE TOWNSHIP	MS	1,022.2
FAIRFIELD TOWNSHIP	SR	10,788.6
GREENWICH TOWNSHIP	SR	4,736.6
HOPEWELL TOWNSHIP	SR	7,869.6
LAWRENCE TOWNSHIP	MS	1,633.0
MAURICE RIVER TOWNSHIP	MS	1,345.6
MILVILLE CITY	SR	6,214.0
SHILOH BOROUGH	SR	273.1
STOW CREEK TOWNSHIP	SR	4,882.2
UPPER DEERFIELD TOWNSHIP	SR	4,903.7
VINELAND CITY	SR	7,004.7
ESSEX COUNTY		
CEDAR GROVE TOWNSHIP	NI	20.1
FAIRFIELD BOROUGH	NI	65.3
GLOUCESTER COUNTY		
CLAYTON BOROUGH	SR	860.9
DEPTFORD TOWNSHIP	UF	1,038.4
EAST GREENWICH TOWNSHIP	SR	1,986.5
ELK TOWNSHIP	SR	4,133.8
FRANKLIN TOWNSHIP	SR	9,778.9
GLASSBORO BOROUGH	UF	446.8
GREENWICH TOWNSHIP	SR	1,462.6
HARRISON TOWNSHIP	SR	4,234.9

Table 26.--Predicted harvested acreage in New Jersey in 2010, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
GLOUCESTER COUNTY--Continued		
LOGAN TOWNSHIP	SR	5,073.8
MANTUA TOWNSHIP	SR	2,807.4
MONROE TOWNSHIP	SR	6,267.5
NEWFIELD BOROUGH	SR	176.5
PITMAN BOROUGH	UF	14.5
SOUTH HARRISON TOWNSHIP	SR	3,826.4
SWEDESBORO TOWNSHIP	SR	33.8
WASHINGTON TOWNSHIP	UF	665.1
WEST DEPTFORD BOROUGH	UF	1,130.5
WOOLWICH TOWNSHIP	SR	4,732.7
HUNTERDON COUNTY		
ALEXANDRIA TOWNSHIP	NI	4,889.4
CLINTON TOWNSHIP	NI	1,946.9
DELAWARE TOWNSHIP	NI	5,125.6
FRANKLIN TOWNSHIP	NI	3,176.1
KINGWOOD TOWNSHIP	NI	6,244.7
LEBANON TOWNSHIP	NI	2,226.3
RARITAN TOWNSHIP	NI	1,572.5
READINGTON TOWNSHIP	NI	2,357.4
TEWKSBURY TOWNSHIP	NI	2,972.2
UNION TOWNSHIP	NI	2,197.9
WEST AMWELL TOWNSHIP	NI	2,601.1
MERCER COUNTY		
EAST WINDSOR TOWNSHIP	UF	511.4
EWING TOWNSHIP	UF	330.1
HAMILTON TOWNSHIP	UF	839.5
HIGHTSTOWN BOROUGH	UF	7.4
HOPEWELL BOROUGH	SR	21.5
HOPEWELL TOWNSHIP	SR	11,989.1
LAWRENCE TOWNSHIP	UF	1,785.0
PENNINGTON BOROUGH	SR	36.0
PRINCETON TOWNSHIP	UF	1,346.1
WASHINGTON TOWNSHIP	UF	5,731.9
WEST WINDSOR TOWNSHIP	UF	3,970.2

Table 26.--Predicted harvested acreage in New Jersey in 2010, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
MIDDLESEX COUNTY		
CRANBURY TOWNSHIP	UF	1,013.6
EAST BRUNSWICK TOWNSHIP	UF	695.5
*EDISON TOWNSHIP	UF	29.0
MIDDLESEX BOROUGH	UF	35.8
MILLTOWN BOROUGH	UF	7.7
MONROE TOWNSHIP	UF	4,181.4
NORTH BRUNSWICK TOWNSHIP	UF	101.4
OLD BRIDGE TOWNSHIP	UF	910.9
PISCATAWAY TOWNSHIP	UF	403.7
PLAINSBORO TOWNSHIP	UF	613.2
*SAYREVILLE BOROUGH	UF	11.0
SOUTH BRUNSWICK TOWNSHIP	UF	2,351.5
SOUTH PLAINFIELD BOROUGH	UF	235.0
SPOTSWOOD BOROUGH	UF	28.1
MONMOUTH COUNTY		
ABERDEEN TOWNSHIP	MS	23.2
ALLENTOWN BOROUGH	UF	16.3
COLTS NECK TOWNSHIP	SR	6,036.2
EATONTOWN BOROUGH	MS	42.8
ENGLISHTOWN BOROUGH	UF	11.2
FARMINGDALE BOROUGH	SR	15.5
FREEHOLD BOROUGH	SR	21.6
FREEHOLD TOWNSHIP	SR	4,516.8
HAZLET TOWNSHIP	MS	21.5
HOLMDEL TOWNSHIP	SR	1,831.9
HOWELL TOWNSHIP	SR	7,944.3
LITTLE SILVER BOROUGH	MS	59.5
LONG BRANCH CITY	MS	10.9
MANALAPAN TOWNSHIP	UF	2,962.0
MARLBORO TOWNSHIP	UF	2,777.2
MIDDLETOWN TOWNSHIP	MS	407.6
MILLSTONE TOWNSHIP	SR	7,992.0
NEPTUNE TOWNSHIP	MS	35.4
*OCEAN TOWNSHIP	MS	171.0
ROOSEVELT BOROUGH	SR	270.1
SHREWSBURY BOROUGH	MS	46.6
TINTON FALLS BOROUGH	MS	132.2

Table 26.--Predicted harvested acreage in New Jersey in 2010, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
MONMOUTH COUNTY--Continued		
UPPER FREEHOLD TOWNSHIP	SR	10,977.6
WALL TOWNSHIP	MS	481.6
WEST LONG BRANCH BOROUGH	MS	50.9
MORRIS COUNTY		
BOONTON TOWNSHIP	NI	363.3
CHATHAM TOWNSHIP	NI	139.1
CHESTER TOWNSHIP	NI	2,276.2
DENVILLE TOWNSHIP	NI	236.0
HARDING TOWNSHIP	NI	1,246.2
LINCOLN PARK BOROUGH	NI	68.2
MENDHAM BOROUGH	NI	116.4
MENDHAM TOWNSHIP	NI	971.8
MONTVILLE TOWNSHIP	NI	384.9
*MORRIS TOWNSHIP	NI	59.0
PARSIPPANY-TROY HILLS TOWNSHIP	NI	245.9
PASSAIC TOWNSHIP	NI	683.3
WASHINGTON TOWNSHIP	NI	1,682.9
OCEAN COUNTY		
BRICK TOWNSHIP	MS	34.0
DOVER TOWNSHIP	MS	12.4
JACKSON TOWNSHIP	MS	64.7
LACEY TOWNSHIP	MS	82.4
LAKEWOOD TOWNSHIP	MS	44.2
LITTLE EGG HARBOR TOWNSHIP	MS	7.8
*MANCHESTER TOWNSHIP	MS	77.0
PLUMSTED TOWNSHIP	SR	7,477.4
PASSAIC COUNTY		
WAYNE TOWNSHIP	NI	253.6
*WEST MILFORD TOWNSHIP	NI	119.0

Table 26.--Predicted harvested acreage in New Jersey in 2010, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
SALEM COUNTY		
ALLOWAY TOWNSHIP	SR	8,613.5
CARNEYS POINT TOWNSHIP	SR	2,939.5
ELMER BOROUGH	SR	31.0
ELSINBORO TOWNSHIP	SR	3,319.3
LOWER ALLOWAYS CRK TOWNSHIP	SR	11,439.5
MANNINGTON BOROUGH	SR	10,376.6
OLDMANS TOWNSHIP	SR	4,952.6
PENNS GROVE BOROUGH	SR	8.2
PENNSVILLE TOWNSHIP	SR	3,505.7
PILESGROVE TOWNSHIP	SR	8,938.8
PITTSGROVE TOWNSHIP	SR	9,995.5
QUINTON TOWNSHIP	SR	6,150.4
SALEM CITY	SR	124.8
UPPER PITTSGROVE TOWNSHIP	SR	9,950.2
WOODSTOWN BOROUGH	SR	64.5
SOMERSET COUNTY		
BEDMINSTER TOWNSHIP	NI	1,571.3
BERNARDS TOWNSHIP	NI	531.9
BRANCHBURG TOWNSHIP	NI	831.1
BRIDGEWATER TOWNSHIP	NI	713.1
FRANKLIN TOWNSHIP	NI	805.3
HILLSBOROUGH TOWNSHIP	NI	1,956.3
MANVILLE BOROUGH	NI	13.3
MONTGOMERY TOWNSHIP	NI	1,509.2
WARREN TOWNSHIP	NI	553.2
SUSSEX COUNTY		
ANDOVER BOROUGH	NI	72.1
*BYRAM TOWNSHIP	NI	22.0
FRANKFORD TOWNSHIP	NI	2,313.3
FRANKLIN BOROUGH	NI	72.9
GREEN TOWNSHIP	NI	889.6
HAMPTON TOWNSHIP	NI	1,564.1
HARDYSTON TOWNSHIP	NI	2,011.1
LAFAYETTE TOWNSHIP	NI	1,768.2
*MONTAGUE TOWNSHIP	NI	807.0

Table 26.--Predicted harvested acreage in New Jersey in 2010, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
SUSSEX COUNTY--Continued		
SPARTA TOWNSHIP	NI	1,070.4
STILLWATER TOWNSHIP	NI	1,726.7
VERNON TOWNSHIP	NI	1,554.7
WANTAGE TOWNSHIP	NI	4,628.1
UNION COUNTY		
SCOTCH PLAINS TOWNSHIP	NI	61.7
SPRINGFIELD TOWNSHIP	NI	30.1
*WESTFIELD TOWNSHIP	NI	20.0
WARREN COUNTY		
ALLAMUCHY TOWNSHIP	NI	1,259.1
BLAIRSTOWN TOWNSHIP	NI	3,029.8
FRELINGHUYSEN TOWNSHIP	NI	4,472.1
HARMONY TOWNSHIP	NI	4,811.5
HOPE TOWNSHIP	NI	2,763.8
INDEPENDENCE TOWNSHIP	NI	1,322.9
KNOWLTON TOWNSHIP	NI	4,750.5
LOPATCONG TOWNSHIP	NI	134.7
MANSFIELD TOWNSHIP	NI	2,312.5
OXFORD TOWNSHIP	NI	337.9
POHATCONG TOWNSHIP	NI	879.6
WASHINGTON TOWNSHIP	NI	1,069.8
WHITE TOWNSHIP	NI	3,871.3

Table 27.--Predicted harvested acreage in New Jersey in 2020, by minor civil division, before correction with the adjustment factor

[MCD, minor civil division; MS, "miscellaneous"; SR, southern rural; NI, northern irrigated; UF, urban fringe; * indicates outlier MCD's]

MCD name	MCD group	Predicted harvested acreage
ATLANTIC COUNTY		
BUENA BOROUGH	SR	1,266.6
BUENA VISTA TOWNSHIP	SR	8,886.2
CORBIN CITY	MS	100.4
EGG HARBOR TOWNSHIP	MS	180.1
ESTELL MANOR CITY	MS	520.0
FOLSOM BOROUGH	MS	227.3
GALLOWAY TOWNSHIP	MS	119.9
HAMILTON TOWNSHIP	MS	737.7
HAMMONTON TOWN	SR	8,045.1
LINWOOD CITY	MS	25.4
MULLICA TOWNSHIP	MS	1,006.1
NORTHFIELD CITY	MS	46.0
PORT REPUBLIC CITY	MS	428.3
BERGEN COUNTY		
FRANKLIN LAKES BOROUGH	NI	132.7
HILLSDALE BOROUGH	NI	17.0
*MAHWAH TOWNSHIP	NI	100.0
MONTVALE BOROUGH	NI	42.2
NEW MILFORD BOROUGH	NI	6.7
RIVERVALE TOWNSHIP	NI	36.9
SADDLE RIVER BOROUGH	NI	153.5
UPPER SADDLE RIVER BOROUGH	NI	66.4
WOODCLIFF LAKE BOROUGH	NI	49.2
WYCKOFF TOWNSHIP	NI	76.9
BURLINGTON COUNTY		
BASS RIVER TOWNSHIP	MS	834.3
BORDENTOWN TOWNSHIP	UF	500.5
BURLINGTON CITY	SR	78.1
BURLINGTON TOWNSHIP	SR	1,275.6
CHESTERFIELD TOWNSHIP	SR	4,613.4
CINNAMINSON TOWNSHIP	UF	219.2
DELANCO TOWNSHIP	UF	116.3
DELRAN TOWNSHIP	UF	109.8

Table 27.--Predicted harvested acreage in New Jersey in 2020, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
BURLINGTON COUNTY--Continued		
EASTAMPTON TOWNSHIP	SR	535.6
EDGEWATER PARK TOWNSHIP	UF	25.7
EVESHAM TOWNSHIP	UF	1,258.1
FLORENCE TOWNSHIP	SR	879.2
HAINESPORT TOWNSHIP	SR	948.1
LUMBERTON TOWNSHIP	SR	1,873.2
MANSFIELD TOWNSHIP	SR	5,281.8
MAPLE SHADE TOWNSHIP	UF	7.4
MEDFORD TOWNSHIP	SR	4,481.3
MOORESTOWN TOWNSHIP	UF	1,427.3
MT HOLLY TOWNSHIP	SR	68.6
MT LAUREL TOWNSHIP	UF	864.8
NEW HANOVER TOWNSHIP	SR	2,507.9
NORTH HANOVER TOWNSHIP	SR	2,017.8
PEMBERTON BOROUGH	SR	44.4
PEMBERTON TOWNSHIP	SR	8,990.9
SHAMONG TOWNSHIP	MS	664.0
SOUTHAMPTON TOWNSHIP	SR	8,243.5
SPRINGFIELD TOWNSHIP	SR	7,103.7
TABERNACLE TOWNSHIP	MS	609.3
WASHINGTON TOWNSHIP	MS	1,216.5
WESTAMPTON TOWNSHIP	SR	1,152.8
WILLINGBORO TOWNSHIP	UF	21.7
WOODLAND TOWNSHIP	MS	1,098.8
WRIGHTSTOWN BOROUGH	SR	70.2
CAMDEN COUNTY		
BERLIN BOROUGH	UF	55.1
BERLIN TOWNSHIP	UF	98.1
CHERRY HILL TOWNSHIP	UF	204.1
GLOUCESTER TOWNSHIP	UF	237.6
PINE HILL BOROUGH	UF	40.9
VORHEES TOWNSHIP	UF	97.0
WATERFORD TOWNSHIP	MS	146.7
WINSLOW TOWNSHIP	SR	6,921.2

Table 27.--Predicted harvested acreage in New Jersey in 2020, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
CAPE MAY COUNTY		
DENNIS TOWNSHIP	MS	504.7
*LOWER TOWNSHIP	MS	1,169.0
MIDDLE TOWNSHIP	MS	479.0
UPPER TOWNSHIP	MS	216.8
WEST CAPE MAY BOROUGH	UF	68.8
WOODBINE BOROUGH	MS	78.8
CUMBERLAND COUNTY		
BRIDGETON CITY	SR	428.7
COMMERCIAL TOWNSHIP	MS	1,262.9
DEERFIELD TOWNSHIP	SR	3,892.5
DOWNE TOWNSHIP	MS	992.0
FAIRFIELD TOWNSHIP	SR	10,761.0
GREENWICH TOWNSHIP	SR	4,681.3
HOPEWELL TOWNSHIP	SR	7,869.6
LAWRENCE TOWNSHIP	MS	1,603.9
MAURICE RIVER TOWNSHIP	MS	1,359.9
MILVILLE CITY	SR	5,909.0
SHILOH BOROUGH	SR	283.1
STOW CREEK TOWNSHIP	SR	4,884.8
UPPER DEERFIELD TOWNSHIP	SR	4,431.4
VINELAND CITY	SR	6,410.9
ESSEX COUNTY		
CEDAR GROVE TOWNSHIP	NI	18.9
FAIRFIELD BOROUGH	NI	48.8
GLOUCESTER COUNTY		
CLAYTON BOROUGH	SR	809.3
DEPTFORD TOWNSHIP	UF	904.7
EAST GREENWICH TOWNSHIP	SR	1,936.7
ELK TOWNSHIP	SR	3,889.9
FRANKLIN TOWNSHIP	SR	9,142.9
GLASSBORO BOROUGH	UF	413.4
GREENWICH TOWNSHIP	SR	1,447.1
HARRISON TOWNSHIP	SR	4,139.2

Table 27.--Predicted harvested acreage in New Jersey in 2020, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
GLOUCESTER COUNTY--Continued		
LOGAN TOWNSHIP	SR	4,777.8
MANTUA TOWNSHIP	SR	2,716.3
MONROE TOWNSHIP	SR	5,839.5
NEWFIELD BOROUGH	SR	167.7
PITMAN BOROUGH	UF	14.5
SOUTH HARRISON TOWNSHIP	SR	3,720.4
SWEDESBORO TOWNSHIP	SR	34.9
WASHINGTON TOWNSHIP	UF	477.0
WEST DEPTFORD BOROUGH	UF	973.3
WOOLWICH TOWNSHIP	SR	3,970.9
HUNTERDON COUNTY		
ALEXANDRIA TOWNSHIP	NI	4,664.6
CLINTON TOWNSHIP	NI	1,597.8
DELAWARE TOWNSHIP	NI	4,667.9
FRANKLIN TOWNSHIP	NI	2,926.2
KINGWOOD TOWNSHIP	NI	5,656.0
LEBANON TOWNSHIP	NI	1,815.9
RARITAN TOWNSHIP	NI	1,211.9
READINGTON TOWNSHIP	NI	1,859.0
TEWKSBURY TOWNSHIP	NI	2,430.3
UNION TOWNSHIP	NI	1,953.8
WEST AMWELL TOWNSHIP	NI	2,303.9
MERCER COUNTY		
EAST WINDSOR TOWNSHIP	UF	295.8
EWING TOWNSHIP	UF	275.9
HAMILTON TOWNSHIP	UF	789.1
HIGHTSTOWN BOROUGH	UF	7.4
HOPEWELL BOROUGH	SR	20.9
HOPEWELL TOWNSHIP	SR	11,408.3
LAWRENCE TOWNSHIP	UF	1,468.2
PENNINGTON BOROUGH	SR	32.8
PRINCETON TOWNSHIP	UF	972.9
WASHINGTON TOWNSHIP	UF	5,370.8
WEST WINDSOR TOWNSHIP	UF	3,169.7

Table 27.--Predicted harvested acreage in New Jersey in 2020, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
MIDDLESEX COUNTY		
CRANBURY TOWNSHIP	UF	116.3
EAST BRUNSWICK TOWNSHIP	UF	612.2
*EDISON TOWNSHIP	UF	27.0
MIDDLESEX BOROUGH	UF	39.3
MILLTOWN BOROUGH	UF	8.4
MONROE TOWNSHIP	UF	1,785.2
NORTH BRUNSWICK TOWNSHIP	UF	62.8
OLD BRIDGE TOWNSHIP	UF	533.5
PISCATAWAY TOWNSHIP	UF	367.2
PLAINSBORO TOWNSHIP	UF	394.6
*SAYREVILLE BOROUGH	UF	10.0
SOUTH BRUNSWICK TOWNSHIP	UF	934.3
SOUTH PLAINFIELD BOROUGH	UF	251.0
SPOTSWOOD BOROUGH	UF	30.0
MONMOUTH COUNTY		
ABERDEEN TOWNSHIP	MS	22.5
ALLENTOWN BOROUGH	UF	16.0
COLTS NECK TOWNSHIP	SR	5,746.5
EATONTOWN BOROUGH	MS	45.7
ENGLISHTOWN BOROUGH	UF	10.8
FARMINGDALE BOROUGH	SR	15.3
FREEHOLD BOROUGH	SR	21.4
FREEHOLD TOWNSHIP	SR	4,195.6
HAZLET TOWNSHIP	MS	20.9
HOLMDEL TOWNSHIP	SR	1,627.6
HOWELL TOWNSHIP	SR	7,505.7
LITTLE SILVER BOROUGH	MS	58.7
LONG BRANCH CITY	MS	10.8
MANALAPAN TOWNSHIP	UF	2,293.7
MARLBORO TOWNSHIP	UF	2,297.9
MIDDLETOWN TOWNSHIP	MS	412.4
MILLSTONE TOWNSHIP	SR	7,279.4
NEPTUNE TOWNSHIP	MS	37.7
*OCEAN TOWNSHIP	MS	148.0
ROOSEVELT BOROUGH	SR	245.5
SHREWSBURY BOROUGH	MS	43.8
TINTON FALLS BOROUGH	MS	94.3

Table 27.--Predicted harvested acreage in New Jersey in 2020, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
MONMOUTH COUNTY--Continued		
UPPER FREEHOLD TOWNSHIP	SR	9,728.1
WALL TOWNSHIP	MS	405.3
WEST LONG BRANCH BOROUGH	MS	60.1
MORRIS TWP		
BOONTON TOWNSHIP	NI	327.7
CHATHAM TOWNSHIP	NI	120.7
CHESTER TOWNSHIP	NI	1,974.1
DENVILLE TOWNSHIP	NI	218.7
HARDING TOWNSHIP	NI	1,096.3
LINCOLN PARK BOROUGH	NI	59.9
MENDHAM BOROUGH	NI	93.5
MENDHAM TOWNSHIP	NI	820.4
MONTVILLE TOWNSHIP	NI	328.2
*MORRIS TOWNSHIP	NI	50.0
PARSIPPANY-TROY HILLS TOWNSHIP	NI	228.8
PASSAIC TOWNSHIP	NI	618.6
WASHINGTON TOWNSHIP	NI	1,313.9
OCEAN TWP		
BRICK TOWNSHIP	MS	28.0
DOVER TOWNSHIP	MS	8.4
JACKSON TOWNSHIP	MS	33.5
LACEY TOWNSHIP	MS	64.3
LAKEWOOD TOWNSHIP	MS	32.0
LITTLE EGG HARBOR TOWNSHIP	MS	3.8
*MANCHESTER TOWNSHIP	MS	67.0
PLUMSTED TOWNSHIP	SR	6,500.3
STAFFORD TOWNSHIP	MS	.6
PASSAIC COUNTY		
WAYNE TOWNSHIP	NI	241.9
*WEST MILFORD TOWNSHIP	NI	101.0

Table 27.--Predicted harvested acreage in New Jersey in 2020, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
SALEM COUNTY		
ALLOWAY TOWNSHIP	SR	8,588.7
CARNEYS POINT TOWNSHIP	SR	2,903.8
ELMER BOROUGH	SR	29.5
ELSINBORO TOWNSHIP	SR	3,307.1
LOWER ALLOWAYS CRK TOWNSHIP	SR	11,490.4
MANNINGTON BOROUGH	SR	10,420.6
OLDMANS TOWNSHIP	SR	4,938.9
PENNS GROVE BOROUGH	SR	8.2
PENNSVILLE TOWNSHIP	SR	3,462.6
PILESGROVE TOWNSHIP	SR	8,900.7
PITTSGROVE TOWNSHIP	SR	9,857.1
QUINTON TOWNSHIP	SR	6,134.3
SALEM CITY	SR	124.8
UPPER PITTSGROVE TOWNSHIP	SR	9,857.9
WOODSTOWN BOROUGH	SR	64.5
SOMERSET COUNTY		
BEDMINSTER TOWNSHIP	NI	1,390.3
BERNARDS TOWNSHIP	NI	486.1
BRANCHBURG TOWNSHIP	NI	778.3
BRIDGEWATER TOWNSHIP	NI	680.8
FRANKLIN TOWNSHIP	NI	738.5
HILLSBOROUGH TOWNSHIP	NI	1,806.8
MANVILLE BOROUGH	NI	13.0
MONTGOMERY TOWNSHIP	NI	1,385.5
WARREN TOWNSHIP	NI	508.5
SUSSEX COUNTY		
ANDOVER BOROUGH	NI	63.8
*BYRAM TOWNSHIP	NI	19.0
FRANKFORD TOWNSHIP	NI	1,719.4
FRANKLIN BOROUGH	NI	65.3
GREEN TOWNSHIP	NI	632.7
HAMPTON TOWNSHIP	NI	1,205.8
HARDYSTON TOWNSHIP	NI	1,473.7
LAFAYETTE TOWNSHIP	NI	1,329.9
*MONTAGUE TOWNSHIP	NI	686.0

Table 27.--Predicted harvested acreage in New Jersey in 2020, by minor civil division, before correction with the adjustment factor--Continued

MCD name	MCD group	Predicted harvested acreage
SUSSEX COUNTY--Continued		
SPARTA TOWNSHIP	NI	791.2
STILLWATER TOWNSHIP	NI	1,260.5
VERNON TOWNSHIP	NI	952.7
WANTAGE TOWNSHIP	NI	3,230.1
UNION COUNTY		
SCOTCH PLAINS TOWNSHIP	NI	56.3
SPRINGFIELD TOWNSHIP	NI	28.3
*WESTFIELD TOWNSHIP	NI	17.0
WARREN COUNTY		
ALLAMUCHY TOWNSHIP	NI	998.6
BLAIRSTOWN TOWNSHIP	NI	2,832.8
FRELINGHUYSEN TOWNSHIP	NI	4,044.3
HARMONY TOWNSHIP	NI	5,316.7
HOPE TOWNSHIP	NI	2,380.1
INDEPENDENCE TOWNSHIP	NI	1,033.6
KNOWLTON TOWNSHIP	NI	4,553.1
LOPATCONG TOWNSHIP	NI	113.4
MANSFIELD TOWNSHIP	NI	2,031.5
OXFORD TOWNSHIP	NI	308.7
POHATCONG TOWNSHIP	NI	804.1
WASHINGTON TOWNSHIP	NI	937.5
WHITE TOWNSHIP	NI	3,445.8

Table 39.--Predicted annual water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county

[Values may not add to totals because of independent rounding]

Wet-year scenario				
	Water demand (million gallons)			
County	1990	2000	2010	2020
Atlantic	1,362.79	1,313.89	1,283.64	1,257.52
Bergen	20.98	18.98	16.79	14.96
Burlington	137.38	127.93	122.30	116.67
Camden	206.14	183.62	165.82	148.15
Cape May	53.09	43.88	37.46	32.78
Cumberland	1,042.75	1,048.83	1,052.50	1,053.47
Essex	2.53	1.87	1.32	.66
Gloucester	479.59	450.74	428.36	403.67
Hunterdon	65.21	57.65	50.86	44.86
Mercer	75.07	69.44	62.81	56.77
Middlesex	144.09	117.87	66.54	28.70
Monmouth	96.86	91.16	85.59	77.64
Morris	20.07	17.20	14.73	12.63
Ocean	48.65	44.70	40.46	35.90
Passaic	.15	.15	.15	.07
Salem	709.56	729.92	751.61	772.62
Somerset	22.67	18.49	15.52	14.06
Sussex	11.46	9.16	7.37	5.99
Union	.82	.65	.65	.38
Warren	27.42	25.73	24.14	22.62
Total	4,527.28	4,371.85	4,228.61	4,100.08

Table 39.--Predicted annual water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

Average-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	2,439.40	2,352.77	2,300.01	2,254.92
Bergen	41.34	36.88	32.04	28.12
Burlington	389.20	363.82	348.95	333.93
Camden	371.83	330.45	297.97	265.61
Cape May	141.79	117.09	100.01	87.52
Cumberland	2,403.34	2,420.90	2,432.58	2,438.00
Essex	6.54	4.82	3.37	1.72
Gloucester	938.98	883.34	840.47	792.87
Hunterdon	293.39	261.42	232.37	206.61
Mercer	269.63	250.67	228.12	207.16
Middlesex	412.24	338.07	189.76	79.93
Monmouth	238.33	225.02	211.94	192.74
Morris	87.88	77.06	67.51	59.09
Ocean	96.39	88.60	80.18	71.13
Passaic	15.88	14.68	14.16	12.84
Salem	1,994.36	2,059.10	2,127.46	2,193.90
Somerset	82.55	68.95	59.17	53.77
Sussex	163.10	127.35	100.24	79.27
Union	2.12	1.68	1.68	1.06
Warren	216.06	201.37	188.39	176.56
Total	10,604.36	10,224.01	9,856.36	9,536.72

Table 39.--Predicted annual water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

Drought-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	3,747.53	3,615.42	3,535.60	3,467.60
Bergen	65.59	58.28	50.35	43.98
Burlington	663.09	620.46	595.93	571.01
Camden	593.91	527.16	474.97	422.92
Cape May	223.92	184.88	157.92	138.18
Cumberland	3,597.34	3,625.63	3,644.98	3,654.90
Essex	11.33	8.34	5.83	2.99
Gloucester	1,365.78	1,285.05	1,223.54	1,154.92
Hunterdon	572.44	510.29	453.75	403.66
Mercer	472.18	439.24	400.18	363.68
Middlesex	669.08	548.97	308.00	129.45
Monmouth	391.31	369.84	348.71	317.41
Morris	167.31	147.01	129.01	113.12
Ocean	149.71	137.74	124.74	110.67
Passaic	33.27	30.80	29.69	26.92
Salem	3,219.37	3,326.41	3,439.24	3,548.95
Somerset	159.93	134.03	115.39	104.96
Sussex	293.55	230.71	183.07	145.96
Union	3.70	2.96	2.96	1.89
Warren	419.56	391.65	367.14	344.74
Total	16,819.90	16,194.86	15,590.98	15,067.87

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county

[Values may not add to totals because of independent rounding]

JUNE

Wet-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	12.81	12.02	11.25	10.46
Bergen	.00	.00	.00	.00
Burlington	.00	.00	.00	.00
Camden	.00	.00	.00	.00
Cape May	.15	.11	.08	.07
Cumberland	6.80	6.85	6.89	6.90
Essex	.00	.00	.00	.00
Gloucester	27.45	25.67	24.00	22.31
Hunterdon	.00	.00	.00	.00
Mercer	.00	.00	.00	.00
Middlesex	1.96	1.61	.98	.53
Monmouth	.00	.00	.00	.00
Morris	.00	.00	.00	.00
Ocean	.68	.63	.57	.53
Passaic	.00	.00	.00	.00
Salem	.09	.07	.07	.06
Somerset	.00	.00	.00	.00
Sussex	.00	.00	.00	.00
Union	.00	.00	.00	.00
Warren	.00	.00	.00	.00
Total	49.94	46.96	43.84	40.86

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JULY

Wet-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	115.71	111.70	109.38	107.43
Bergen	.00	.00	.00	.00
Burlington	14.40	13.30	12.57	11.86
Camden	15.52	14.07	12.84	11.62
Cape May	5.84	4.76	4.00	3.45
Cumberland	219.93	221.09	221.75	221.84
Essex	.00	.00	.00	.00
Gloucester	50.34	47.17	44.75	42.09
Hunterdon	.03	.03	.03	.03
Mercer	1.92	1.75	1.56	1.38
Middlesex	12.91	10.40	5.69	2.31
Monmouth	6.09	5.48	4.91	4.23
Morris	.00	.00	.00	.00
Ocean	5.18	4.70	4.22	3.73
Passaic	.00	.00	.00	.00
Salem	44.10	45.15	46.29	47.40
Somerset	.00	.00	.00	.00
Sussex	.00	.00	.00	.00
Union	.00	.00	.00	.00
Warren	.00	.00	.00	.00
Total	491.96	479.59	467.98	457.37

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

AUGUST

Wet-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	78.07	75.75	74.63	73.79
Bergen	.00	.00	.00	.00
Burlington	5.33	4.76	4.39	4.05
Camden	.70	.55	.44	.35
Cape May	.82	.66	.55	.47
Cumberland	78.25	77.40	76.44	75.32
Essex	.00	.00	.00	.00
Gloucester	50.34	47.17	44.75	42.09
Hunterdon	.00	.00	.00	.00
Mercer	7.63	6.95	6.20	5.51
Middlesex	11.17	9.06	4.98	2.01
Monmouth	6.01	5.41	4.85	4.18
Morris	.00	.00	.00	.00
Ocean	1.67	1.48	1.30	1.12
Passaic	.00	.00	.00	.00
Salem	73.61	75.93	78.38	80.75
Somerset	.00	.00	.00	.00
Sussex	.00	.00	.00	.00
Union	.00	.00	.00	.00
Warren	.00	.00	.00	.00
Total	313.59	305.12	296.92	289.63

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

SEPTEMBER

Wet-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	0.00	0.00	0.00	0.00
Bergen	.00	.00	.00	.00
Burlington	.00	.00	.00	.00
Camden	.00	.00	.00	.00
Cape May	.00	.00	.00	.00
Cumberland	9.59	9.00	8.43	7.86
Essex	.00	.00	.00	.00
Gloucester	.00	.00	.00	.00
Hunterdon	.00	.00	.00	.00
Mercer	.00	.00	.00	.00
Middlesex	.00	.00	.00	.00
Monmouth	.00	.00	.00	.00
Morris	.00	.00	.00	.00
Ocean	.00	.00	.00	.00
Passaic	.00	.00	.00	.00
Salem	.00	.00	.00	.00
Somerset	.00	.00	.00	.00
Sussex	.00	.00	.00	.00
Union	.00	.00	.00	.00
Warren	.00	.00	.00	.00
Total	9.59	9.00	8.43	7.86

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

APRIL

Average-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	14.06	13.38	12.79	12.22
Bergen	.39	.36	.34	.32
Burlington	2.19	2.07	1.96	1.86
Camden	4.95	4.62	4.30	3.99
Cape May	.26	.22	.19	.17
Cumberland	13.28	13.01	12.73	12.42
Essex	.00	.00	.00	.00
Gloucester	13.78	12.95	12.14	11.33
Hunterdon	.13	.13	.12	.11
Mercer	.17	.17	.15	.15
Middlesex	.66	.59	.46	.35
Monmouth	.41	.38	.36	.34
Morris	.08	.08	.07	.07
Ocean	.54	.50	.46	.41
Passaic	.00	.00	.00	.00
Salem	3.71	3.85	4.01	4.16
Somerset	.08	.07	.07	.06
Sussex	.14	.13	.12	.12
Union	.00	.00	.00	.00
Warren	.21	.20	.18	.17
Total	55.02	52.69	50.46	48.23

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

MAY

Average-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	185.89	178.55	173.42	168.74
Bergen	3.58	3.30	3.00	2.75
Burlington	28.19	26.49	25.42	24.32
Camden	31.48	28.52	26.05	23.59
Cape May	8.87	7.36	6.32	5.56
Cumberland	154.42	154.79	154.82	154.45
Essex	.22	.17	.12	.06
Gloucester	96.67	90.98	86.16	80.99
Hunterdon	12.80	11.69	10.63	9.67
Mercer	11.77	11.05	10.14	9.30
Middlesex	21.93	18.22	10.75	5.15
Monmouth	15.05	14.26	13.48	12.33
Morris	2.74	2.51	2.29	2.07
Ocean	7.46	6.89	6.26	5.58
Passaic	.14	.13	.12	.11
Salem	129.52	134.18	139.10	143.87
Somerset	3.21	2.89	2.63	2.42
Sussex	5.25	4.85	4.44	4.09
Union	.05	.04	.04	.03
Warren	8.80	8.26	7.76	7.28
Total	728.06	705.10	682.95	662.35

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JUNE

Average-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	547.25	527.36	515.21	504.77
Bergen	10.27	9.19	8.05	7.10
Burlington	77.59	72.68	69.81	66.88
Camden	82.41	73.38	66.25	59.13
Cape May	29.20	24.15	20.65	18.08
Cumberland	489.38	493.12	495.66	496.90
Essex	1.47	1.08	.76	.39
Gloucester	208.10	195.86	186.28	175.69
Hunterdon	61.34	55.00	49.17	43.97
Mercer	57.59	53.68	48.97	44.60
Middlesex	84.87	69.79	39.46	16.94
Monmouth	47.10	44.53	41.99	38.22
Morris	19.83	17.49	15.41	13.56
Ocean	19.73	18.18	16.48	14.64
Passaic	3.12	2.88	2.78	2.53
Salem	412.74	426.59	441.20	455.40
Somerset	18.61	15.80	13.74	12.51
Sussex	29.58	23.71	19.18	15.65
Union	.50	.40	.40	.26
Warren	46.04	43.04	40.39	37.92
Total	2,246.72	2,167.90	2,091.81	2,025.15

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JULY

Average-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	730.98	704.94	689.44	676.34
Bergen	12.81	11.36	9.79	8.53
Burlington	121.96	113.97	109.34	104.65
Camden	118.06	104.64	94.19	83.76
Cape May	47.75	39.45	33.69	29.49
Cumberland	773.66	780.13	784.65	787.14
Essex	2.19	1.61	1.13	.58
Gloucester	263.58	248.01	236.31	223.19
Hunterdon	101.05	89.86	79.69	70.70
Mercer	95.51	88.82	80.89	73.49
Middlesex	142.33	116.65	65.18	27.07
Monmouth	79.92	75.50	71.14	64.70
Morris	32.08	28.13	24.63	21.56
Ocean	29.17	26.80	24.25	21.50
Passaic	6.64	6.14	5.92	5.37
Salem	649.84	671.03	693.38	715.12
Somerset	30.16	25.15	21.54	19.56
Sussex	61.10	47.76	37.67	29.83
Union	.70	.55	.55	.35
Warren	75.87	70.86	66.46	62.43
Total	3,375.34	3,251.34	3,129.84	3,025.35

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

AUGUST

Average-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	570.82	550.96	539.13	529.17
Bergen	9.65	8.55	7.32	6.35
Burlington	99.35	92.71	88.85	84.96
Camden	88.03	77.85	69.98	62.13
Cape May	33.20	27.34	23.29	20.34
Cumberland	589.19	593.81	596.97	598.60
Essex	1.74	1.28	.89	.46
Gloucester	207.05	194.70	185.52	175.19
Hunterdon	82.18	72.78	64.32	56.85
Mercer	75.84	70.29	63.79	57.74
Middlesex	100.53	82.19	45.72	18.80
Monmouth	60.11	56.68	53.32	48.43
Morris	20.79	18.14	15.82	13.79
Ocean	24.82	22.80	20.63	18.28
Passaic	3.72	3.44	3.31	3.00
Salem	507.86	523.87	540.77	557.20
Somerset	22.76	18.77	15.93	14.44
Sussex	46.28	35.08	26.69	20.28
Union	.58	.45	.45	.28
Warren	52.57	48.91	45.69	42.78
Total	2,597.05	2,500.59	2,408.39	2,329.08

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

SEPTEMBER

Average-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	327.08	316.03	309.49	304.03
Bergen	3.69	3.28	2.80	2.42
Burlington	58.19	54.28	51.99	49.69
Camden	44.32	39.20	35.24	31.31
Cape May	19.71	16.22	13.82	12.07
Cumberland	335.42	337.90	339.56	340.35
Essex	.68	.50	.35	.18
Gloucester	119.47	112.30	106.99	101.02
Hunterdon	31.06	27.22	23.82	20.84
Mercer	33.52	31.01	28.08	25.36
Middlesex	49.70	40.51	22.37	9.02
Monmouth	31.84	30.00	28.21	25.62
Morris	7.37	6.37	5.50	4.75
Ocean	14.34	13.16	11.89	10.53
Passaic	.72	.67	.65	.58
Salem	261.72	269.68	278.09	286.27
Somerset	9.03	7.38	6.21	5.63
Sussex	13.38	9.91	7.32	5.37
Union	.24	.19	.19	.12
Warren	24.05	22.34	20.82	19.48
Total	1,385.53	1,338.14	1,293.40	1,254.63

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

OCTOBER

Average-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	26.70	25.72	25.07	24.50
Bergen	.04	.03	.02	.02
Burlington	3.72	3.47	3.32	3.18
Camden	4.22	3.71	3.32	2.93
Cape May	1.34	1.10	.94	.82
Cumberland	26.11	26.19	26.22	26.18
Essex	.01	.01	.01	.00
Gloucester	15.45	14.50	13.73	12.90
Hunterdon	.34	.30	.26	.23
Mercer	1.99	1.83	1.65	1.48
Middlesex	2.94	2.39	1.31	.53
Monmouth	1.99	1.86	1.75	1.58
Morris	.00	.00	.00	.00
Ocean	1.67	1.52	1.37	1.21
Passaic	.00	.00	.00	.00
Salem	16.56	17.00	17.47	17.92
Somerset	.04	.03	.02	.02
Sussex	.04	.03	.02	.01
Union	.00	.00	.00	.00
Warren	.38	.35	.32	.30
Total	103.52	100.03	96.79	93.81

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

APRIL

Drought-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	171.27	164.04	158.62	153.55
Bergen	1.60	1.50	1.41	1.32
Burlington	30.56	28.98	27.94	26.86
Camden	35.36	32.47	29.95	27.43
Cape May	3.38	2.82	2.43	2.14
Cumberland	218.55	219.79	220.53	220.67
Essex	.00	.00	.00	.00
Gloucester	114.45	107.70	101.79	95.53
Hunterdon	1.93	1.81	1.70	1.58
Mercer	3.51	3.37	3.14	2.97
Middlesex	7.52	6.60	4.88	3.49
Monmouth	3.27	3.07	2.88	2.69
Morris	2.32	2.19	2.05	1.89
Ocean	11.24	10.41	9.47	8.45
Passaic	.00	.00	.00	.00
Salem	106.81	111.21	115.87	120.36
Somerset	1.90	1.77	1.66	1.52
Sussex	3.65	3.44	3.20	2.98
Union	.00	.00	.00	.00
Warren	2.09	1.96	1.85	1.72
Total	719.41	703.13	689.33	675.15

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

MAY

Drought-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	673.67	648.18	631.58	616.91
Bergen	16.86	14.94	12.94	11.29
Burlington	122.52	114.93	110.40	105.77
Camden	110.72	99.15	89.86	80.59
Cape May	42.23	35.00	29.99	26.31
Cumberland	659.64	664.27	667.28	668.58
Essex	3.13	2.30	1.61	.83
Gloucester	321.39	302.45	287.07	270.33
Hunterdon	104.62	93.98	84.13	75.39
Mercer	87.97	82.26	75.31	68.82
Middlesex	128.82	106.24	60.55	26.51
Monmouth	73.97	70.11	66.28	60.49
Morris	35.52	31.46	27.87	24.58
Ocean	30.95	28.57	25.93	23.08
Passaic	3.45	3.17	3.07	2.79
Salem	689.11	713.43	739.03	763.91
Somerset	26.25	22.37	19.50	17.85
Sussex	33.37	29.06	25.45	22.51
Union	1.04	.82	.82	.52
Warren	104.63	98.23	92.59	87.38
Total	3,269.86	3,160.90	3,051.25	2,954.44

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JUNE

Drought-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	1,109.91	1,071.21	1,048.26	1,028.82
Bergen	26.72	23.81	20.71	18.18
Burlington	165.21	154.41	148.12	141.74
Camden	179.24	159.09	143.34	127.59
Cape May	63.05	52.10	44.51	38.98
Cumberland	1,183.85	1,195.36	1,203.79	1,209.08
Essex	4.22	3.10	2.16	1.12
Gloucester	411.06	386.99	368.68	348.19
Hunterdon	215.62	192.28	171.00	152.14
Mercer	159.67	149.15	136.43	124.49
Middlesex	175.27	143.88	80.92	34.28
Monmouth	98.35	92.84	87.40	79.38
Morris	61.35	54.16	47.72	42.04
Ocean	38.01	34.97	31.66	28.11
Passaic	15.05	13.95	13.44	12.24
Salem	1,073.49	1,109.07	1,146.61	1,183.11
Somerset	44.41	37.69	32.75	29.85
Sussex	108.04	85.12	67.79	54.21
Union	1.29	1.01	1.01	.64
Warren	136.82	128.02	120.31	113.18
Total	5,270.63	5,088.20	4,916.62	4,767.35

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JULY

Drought-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	1,422.12	1,372.18	1,342.72	1,317.93
Bergen	25.98	22.89	19.52	16.82
Burlington	269.59	252.30	242.42	232.34
Camden	262.74	232.76	209.43	186.14
Cape May	82.67	68.30	58.39	51.16
Cumberland	1,271.21	1,281.17	1,287.95	1,291.42
Essex	4.96	3.66	2.56	1.30
Gloucester	447.95	421.88	403.25	381.85
Hunterdon	333.17	296.59	263.29	233.89
Mercer	215.19	200.27	182.49	165.91
Middlesex	276.49	226.56	126.38	52.21
Monmouth	179.68	169.94	160.33	146.02
Morris	82.37	72.15	63.03	55.16
Ocean	57.76	53.17	48.16	42.73
Passaic	18.16	16.82	16.21	14.69
Salem	1,263.09	1,304.94	1,349.06	1,392.00
Somerset	63.43	53.16	45.75	41.60
Sussex	157.26	121.82	95.17	74.52
Union	1.79	1.39	1.39	.85
Warren	176.82	165.15	154.96	145.61
Total	6,612.43	6,337.10	6,072.45	5,844.12

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

AUGUST

Drought-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	1,220.18	1,177.75	1,152.90	1,132.06
Bergen	20.72	18.12	15.27	13.04
Burlington	204.68	191.25	183.53	175.73
Camden	164.12	145.10	130.38	115.72
Cape May	74.78	61.63	52.56	45.96
Cumberland	1,161.20	1,171.89	1,179.58	1,184.22
Essex	4.31	3.17	2.21	1.14
Gloucester	373.18	351.04	334.61	316.10
Hunterdon	196.43	174.21	153.99	136.29
Mercer	189.88	176.47	160.60	145.78
Middlesex	231.24	189.41	105.54	43.46
Monmouth	131.75	124.24	116.88	106.18
Morris	64.08	56.11	48.98	42.84
Ocean	47.21	43.41	39.30	34.86
Passaic	15.06	13.97	13.46	12.19
Salem	1,000.52	1,032.73	1,066.72	1,099.77
Somerset	59.15	48.73	41.34	37.47
Sussex	156.66	120.46	93.31	72.34
Union	1.36	1.08	1.08	.71
Warren	188.10	174.97	163.48	153.08
Total	5,504.59	5,275.74	5,055.71	4,868.93

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

SEPTEMBER

Drought-year scenario

County	Water demand (million gallons) 1990	2000	2010	2020
Atlantic	821.05	793.60	777.79	764.69
Bergen	14.03	12.46	10.69	9.34
Burlington	119.81	112.02	107.58	103.07
Camden	113.81	101.47	91.68	81.94
Cape May	51.82	42.61	36.28	31.66
Cumberland	857.50	864.21	868.77	871.09
Essex	2.54	1.88	1.31	.66
Gloucester	248.87	234.01	223.06	210.72
Hunterdon	120.08	105.67	92.86	81.61
Mercer	94.14	87.49	79.65	72.30
Middlesex	140.55	114.95	63.82	26.07
Monmouth	88.67	83.88	79.16	72.09
Morris	47.21	41.29	36.07	31.45
Ocean	29.77	27.37	24.78	21.98
Passaic	9.43	8.69	8.38	7.58
Salem	721.56	746.85	773.41	799.23
Somerset	35.65	29.57	25.25	22.93
Sussex	88.92	68.07	52.38	40.39
Union	.84	.69	.69	.46
Warren	126.17	117.79	110.40	103.68
Total	3,732.43	3,594.57	3,463.98	3,352.93

Table 40.--Predicted monthly water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

OCTOBER

Drought-year scenario

County	Water demand (million gallons)			
	1990	2000	2010	2020
Atlantic	273.52	262.66	255.26	248.67
Bergen	.97	.81	.63	.47
Burlington	48.53	45.40	43.59	41.76
Camden	57.19	51.07	46.22	41.41
Cape May	22.93	18.92	16.15	14.10
Cumberland	288.38	290.15	291.24	291.59
Essex	.31	.23	.16	.08
Gloucester	131.98	124.04	118.01	111.29
Hunterdon	5.97	5.21	4.55	3.97
Mercer	22.65	20.96	18.99	17.15
Middlesex	52.65	42.83	23.43	9.19
Monmouth	37.96	35.72	33.55	30.47
Morris	.08	.07	.06	.05
Ocean	13.13	12.03	10.87	9.61
Passaic	.00	.00	.00	.00
Salem	161.42	165.24	169.34	173.31
Somerset	1.02	.82	.68	.61
Sussex	.61	.44	.32	.23
Union	.05	.04	.04	.02
Warren	6.19	5.76	5.38	5.04
Total	1,125.53	1,082.39	1,038.45	999.01

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county

[Values may not add to totals because of independent rounding]

JUNE

Wet-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	0.427	0.401	0.375	0.349
Bergen	.000	.000	.000	.000
Burlington	.000	.000	.000	.000
Camden	.000	.000	.000	.000
Cape May	.005	.004	.003	.002
Cumberland	.227	.228	.230	.230
Essex	.000	.000	.000	.000
Gloucester	.915	.856	.800	.744
Hunterdon	.000	.000	.000	.000
Mercer	.000	.000	.000	.000
Middlesex	.065	.054	.033	.018
Monmouth	.000	.000	.000	.000
Morris	.000	.000	.000	.000
Ocean	.023	.021	.019	.018
Passaic	.000	.000	.000	.000
Salem	.003	.002	.002	.002
Somerset	.000	.000	.000	.000
Sussex	.000	.000	.000	.000
Union	.000	.000	.000	.000
Warren	.000	.000	.000	.000
Total	1.670	1.570	1.460	1.360

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JULY

Wet-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	3.732	3.603	3.528	3.465
Bergen	.000	.000	.000	.000
Burlington	.465	.429	.406	.383
Camden	.501	.454	.414	.375
Cape May	.188	.153	.129	.111
Cumberland	7.094	7.132	7.153	7.156
Essex	.000	.000	.000	.000
Gloucester	1.624	1.522	1.443	1.358
Hunterdon	.001	.001	.001	.001
Mercer	.062	.056	.050	.045
Middlesex	.416	.336	.184	.074
Monmouth	.196	.177	.158	.137
Morris	.000	.000	.000	.000
Ocean	.167	.152	.136	.120
Passaic	.000	.000	.000	.000
Salem	1.423	1.457	1.493	1.529
Somerset	.000	.000	.000	.000
Sussex	.000	.000	.000	.000
Union	.000	.000	.000	.000
Warren	.000	.000	.000	.000
Total	15.870	15.470	151.100	14.750

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

AUGUST

Wet-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	2.518	2.444	2.408	2.380
Bergen	.000	.000	.000	.000
Burlington	.172	.153	.142	.131
Camden	.023	.018	.014	.011
Cape May	.026	.021	.018	.015
Cumberland	2.524	2.497	2.466	2.430
Essex	.000	.000	.000	.000
Gloucester	1.624	1.522	1.443	1.358
Hunterdon	.000	.000	.000	.000
Mercer	.246	.224	.200	.178
Middlesex	.360	.292	.161	.065
Monmouth	.194	.174	.156	.135
Morris	.000	.000	.000	.000
Ocean	.054	.048	.042	.036
Passaic	.000	.000	.000	.000
Salem	2.374	2.449	2.528	2.605
Somerset	.000	.000	.000	.000
Sussex	.000	.000	.000	.000
Union	.000	.000	.000	.000
Warren	.000	.000	.000	.000
Total	10.120	9.840	9.580	9.340

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

SEPTEMBER

Wet-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	0.000	0.000	0.000	0.000
Bergen	.000	.000	.000	.000
Burlington	.000	.000	.000	.000
Camden	.000	.000	.000	.000
Cape May	.000	.000	.000	.000
Cumberland	.320	.300	.281	.262
Essex	.000	.000	.000	.000
Gloucester	.000	.000	.000	.000
Hunterdon	.000	.000	.000	.000
Mercer	.000	.000	.000	.000
Middlesex	.000	.000	.000	.000
Monmouth	.000	.000	.000	.000
Morris	.000	.000	.000	.000
Ocean	.000	.000	.000	.000
Passaic	.000	.000	.000	.000
Salem	.000	.000	.000	.000
Somerset	.000	.000	.000	.000
Sussex	.000	.000	.000	.000
Union	.000	.000	.000	.000
Warren	.000	.000	.000	.000
Total	.320	.300	.280	.260

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

APRIL

Average-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	0.469	0.446	0.426	0.407
Bergen	.013	.012	.011	.011
Burlington	.073	.069	.065	.062
Camden	.165	.154	.143	.133
Cape May	.009	.007	.006	.006
Cumberland	.443	.434	.424	.414
Essex	.000	.000	.000	.000
Gloucester	.459	.432	.405	.378
Hunterdon	.004	.004	.004	.004
Mercer	.006	.006	.005	.005
Middlesex	.022	.020	.015	.012
Monmouth	.014	.013	.012	.011
Morris	.003	.003	.002	.002
Ocean	.018	.017	.015	.014
Passaic	.000	.000	.000	.000
Salem	.124	.128	.134	.139
Somerset	.003	.002	.002	.002
Sussex	.005	.004	.004	.004
Union	.000	.000	.000	.000
Warren	.007	.007	.006	.006
Total	1.840	1.760	1.680	1.610

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

MAY

Average-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	5.997	5.760	5.594	5.443
Bergen	.115	.106	.097	.089
Burlington	.909	.855	.820	.785
Camden	1.016	.920	.840	.761
Cape May	.286	.238	.204	.179
Cumberland	4.981	4.993	4.994	4.982
Essex	.007	.005	.004	.002
Gloucester	3.118	2.935	2.779	2.612
Hunterdon	.413	.377	.343	.312
Mercer	.380	.356	.327	.300
Middlesex	.707	.588	.347	.166
Monmouth	.485	.460	.435	.398
Morris	.088	.081	.074	.067
Ocean	.241	.222	.202	.180
Passaic	.005	.004	.004	.004
Salem	4.178	4.328	4.487	4.641
Somerset	.104	.093	.085	.078
Sussex	.169	.156	.143	.132
Union	.002	.001	.001	.001
Warren	.284	.267	.250	.235
Total	23.490	22.750	22.030	21.370

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JUNE

Average-year scenario

County	Water demand (million gallons per day) 1990	2000	2010	2020
Atlantic	18.242	17.579	17.174	16.826
Bergen	.342	.306	.268	.237
Burlington	2.586	2.423	2.327	2.229
Camden	2.747	2.446	2.208	1.971
Cape May	.973	.805	.688	.603
Cumberland	16.313	16.437	16.522	16.563
Essex	.049	.036	.025	.013
Gloucester	6.937	6.529	6.209	5.856
Hunterdon	2.045	1.833	1.639	1.466
Mercer	1.920	1.789	1.632	1.487
Middlesex	2.829	2.326	1.315	.565
Monmouth	1.570	1.484	1.400	1.274
Morris	.661	.583	.514	.452
Ocean	.658	.606	.549	.488
Passaic	.104	.096	.093	.084
Salem	13.758	14.220	14.707	15.180
Somerset	.620	.527	.458	.417
Sussex	.986	.790	.639	.522
Union	.017	.013	.013	.009
Warren	1.535	1.435	1.346	1.264
Total	74.890	72.260	69.730	67.510

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JULY

Average-year scenario				
	Water demand (million gallons per day)			
County	1990	2000	2010	2020
Atlantic	23.580	22.740	22.240	21.817
Bergen	.413	.366	.316	.275
Burlington	3.934	3.676	3.527	3.376
Camden	3.808	3.376	3.038	2.702
Cape May	1.540	1.272	1.087	.951
Cumberland	24.957	25.165	25.311	25.392
Essex	.071	.052	.036	.019
Gloucester	8.502	8.000	7.623	7.200
Hunterdon	3.260	2.899	2.571	2.281
Mercer	3.081	2.865	2.609	2.371
Middlesex	4.591	3.763	2.102	.873
Monmouth	2.578	2.435	2.295	2.087
Morris	1.035	.907	.794	.696
Ocean	.941	.865	.782	.693
Passaic	.214	.198	.191	.173
Salem	20.963	21.646	22.367	23.068
Somerset	.973	.811	.695	.631
Sussex	1.971	1.541	1.215	.962
Union	.023	.018	.018	.011
Warren	2.447	2.286	2.144	2.014
Total	108.880	104.880	100.960	97.590

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

AUGUST

Average-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	18.413	17.773	17.391	17.070
Bergen	.311	.276	.236	.205
Burlington	3.205	2.991	2.866	2.741
Camden	2.840	2.511	2.257	2.004
Cape May	1.071	.882	.751	.656
Cumberland	19.006	19.155	19.257	19.310
Essex	.056	.041	.029	.015
Gloucester	6.679	6.281	5.984	5.651
Hunterdon	2.651	2.348	2.075	1.834
Mercer	2.446	2.267	2.058	1.863
Middlesex	3.243	2.651	1.475	.606
Monmouth	1.939	1.828	1.720	1.562
Morris	.671	.585	.510	.445
Ocean	.801	.736	.665	.590
Passaic	.120	.111	.107	.097
Salem	16.383	16.899	17.444	17.974
Somerset	.734	.605	.514	.466
Sussex	1.493	1.131	.861	.654
Union	.019	.015	.015	.009
Warren	1.696	1.578	1.474	1.380
Total	83.780	80.660	77.690	75.130

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

SEPTEMBER

Average-year scenario				
	Water demand (million gallons per day)			
County	1990	2000	2010	2020
Atlantic	10.903	10.534	10.316	10.134
Bergen	.123	.109	.093	.081
Burlington	1.940	1.809	1.733	1.656
Camden	1.477	1.307	1.175	1.044
Cape May	.657	.541	.461	.402
Cumberland	11.181	11.263	11.319	11.345
Essex	.023	.017	.012	.006
Gloucester	3.982	3.743	3.566	3.367
Hunterdon	1.035	.907	.794	.695
Mercer	1.117	1.034	.936	.845
Middlesex	1.657	1.350	.746	.301
Monmouth	1.061	1.000	.940	.854
Morris	.246	.212	.183	.158
Ocean	.478	.439	.396	.351
Passaic	.024	.022	.022	.019
Salem	8.724	8.989	9.270	9.542
Somerset	.301	.246	.207	.188
Sussex	.446	.330	.244	.179
Union	.008	.006	.006	.004
Warren	.802	.745	.694	.649
Total	46.190	44.600	43.110	41.820

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

OCTOBER

Average-year scenario

County	Water demand (million gallons per day) 1990	2000	2010	2020
Atlantic	0.861	0.830	0.809	0.790
Bergen	.001	.001	.001	.001
Burlington	.120	.112	.107	.102
Camden	.136	.120	.107	.095
Cape May	.043	.035	.030	.026
Cumberland	.842	.845	.846	.845
Essex	.000	.000	.000	.000
Gloucester	.498	.468	.443	.416
Hunterdon	.011	.010	.008	.007
Mercer	.064	.059	.053	.048
Middlesex	.095	.077	.042	.017
Monmouth	.064	.060	.056	.051
Morris	.000	.000	.000	.000
Ocean	.054	.049	.044	.039
Passaic	.000	.000	.000	.000
Salem	.534	.548	.563	.578
Somerset	.001	.001	.001	.001
Sussex	.001	.001	.001	.000
Union	.000	.000	.000	.000
Warren	.012	.011	.010	.010
Total	3.340	3.230	3.120	3.030

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

APRIL

Drought-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	5.709	5.468	5.287	5.118
Bergen	.053	.050	.047	.044
Burlington	1.019	.966	.931	.895
Camden	1.179	1.082	.998	.914
Cape May	.113	.094	.081	.071
Cumberland	7.285	7.326	7.351	7.356
Essex	.000	.000	.000	.000
Gloucester	3.815	3.590	3.393	3.184
Hunterdon	.064	.060	.057	.053
Mercer	.117	.112	.105	.099
Middlesex	.251	.220	.163	.116
Monmouth	.109	.102	.096	.090
Morris	.077	.073	.068	.063
Ocean	.375	.347	.316	.282
Passaic	.000	.000	.000	.000
Salem	3.560	3.707	3.862	4.012
Somerset	.063	.059	.055	.051
Sussex	.122	.115	.107	.099
Union	.000	.000	.000	.000
Warren	.070	.065	.062	.057
Total	23.980	23.440	22.980	22.500

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

MAY

Drought-year scenario

County	Water demand (million gallons per day) 1990	2000	2010	2020
Atlantic	21.731	20.909	20.374	19.900
Bergen	.544	.482	.417	.364
Burlington	3.952	3.707	3.561	3.412
Camden	3.572	3.198	2.899	2.600
Cape May	1.362	1.129	.967	.849
Cumberland	21.279	21.428	21.525	21.567
Essex	.101	.074	.052	.027
Gloucester	10.367	9.757	9.260	8.720
Hunterdon	3.375	3.032	2.714	2.432
Mercer	2.838	2.653	2.429	2.220
Middlesex	4.155	3.427	1.953	.855
Monmouth	2.386	2.261	2.138	1.951
Morris	1.146	1.015	.899	.793
Ocean	.998	.922	.837	.745
Passaic	.111	.102	.099	.090
Salem	22.229	23.014	23.840	24.642
Somerset	.847	.722	.629	.576
Sussex	1.076	.937	.821	.726
Union	.034	.026	.026	.017
Warren	3.375	3.169	2.987	2.819
Total	105.480	101.960	98.430	95.310

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JUNE

Drought-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	36.997	35.707	34.942	34.294
Bergen	.891	.794	.690	.606
Burlington	5.507	5.147	4.937	4.725
Camden	5.975	5.303	4.778	4.253
Cape May	2.102	1.737	1.484	1.299
Cumberland	39.462	39.845	40.126	40.303
Essex	.141	.103	.072	.037
Gloucester	13.702	12.900	12.289	11.606
Hunterdon	7.187	6.409	5.700	5.071
Mercer	5.322	4.972	4.548	4.150
Middlesex	5.842	4.796	2.697	1.143
Monmouth	3.278	3.095	2.913	2.646
Morris	2.045	1.805	1.591	1.401
Ocean	1.267	1.166	1.055	.937
Passaic	.502	.465	.448	.408
Salem	35.783	36.969	38.220	39.437
Somerset	1.480	1.256	1.092	.995
Sussex	3.601	2.837	2.260	1.807
Union	.043	.034	.034	.021
Warren	4.561	4.267	4.010	3.773
Total	175.690	169.610	163.890	158.910

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

JULY

Drought-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	45.875	44.264	43.314	42.514
Bergen	.838	.738	.630	.543
Burlington	8.697	8.139	7.820	7.495
Camden	8.476	7.508	6.756	6.004
Cape May	2.667	2.203	1.884	1.650
Cumberland	41.007	41.328	41.547	41.659
Essex	.160	.118	.083	.042
Gloucester	14.450	13.609	13.008	12.318
Hunterdon	10.747	9.567	8.493	7.545
Mercer	6.942	6.460	5.887	5.352
Middlesex	8.919	7.308	4.077	1.684
Monmouth	5.796	5.482	5.172	4.710
Morris	2.657	2.327	2.033	1.779
Ocean	1.863	1.715	1.553	1.378
Passaic	.586	.543	.523	.474
Salem	40.745	42.095	43.518	44.903
Somerset	2.046	1.715	1.476	1.342
Sussex	5.073	3.930	3.070	2.404
Union	.058	.045	.045	.027
Warren	5.704	5.327	4.999	4.697
Total	213.310	204.420	195.890	188.520

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

AUGUST

Drought-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	39.361	37.992	37.190	36.518
Bergen	.668	.585	.493	.420
Burlington	6.602	6.169	5.920	5.669
Camden	5.294	4.681	4.206	3.733
Cape May	2.412	1.988	1.695	1.482
Cumberland	37.458	37.803	38.051	38.201
Essex	.139	.102	.071	.037
Gloucester	12.038	11.324	10.794	10.197
Hunterdon	6.337	5.620	4.968	4.396
Mercer	6.125	5.693	5.181	4.703
Middlesex	7.459	6.110	3.404	1.402
Monmouth	4.250	4.008	3.770	3.425
Morris	2.067	1.810	1.580	1.382
Ocean	1.523	1.400	1.268	1.124
Passaic	.486	.451	.434	.393
Salem	32.275	33.314	34.410	35.477
Somerset	1.908	1.572	1.333	1.209
Sussex	5.053	3.886	3.010	2.334
Union	.044	.035	.035	.023
Warren	6.068	5.644	5.273	4.938
Total	177.570	170.190	163.090	157.060

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

SEPTEMBER

Drought-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	27.368	26.453	25.926	25.490
Bergen	.468	.415	.356	.311
Burlington	3.994	3.734	3.586	3.436
Camden	3.794	3.382	3.056	2.731
Cape May	1.727	1.420	1.209	1.055
Cumberland	28.583	28.807	28.959	29.036
Essex	.085	.063	.044	.022
Gloucester	8.296	7.800	7.435	7.024
Hunterdon	4.003	3.522	3.095	2.720
Mercer	3.138	2.916	2.655	2.410
Middlesex	4.685	3.832	2.127	.869
Monmouth	2.956	2.796	2.639	2.403
Morris	1.574	1.376	1.202	1.048
Ocean	.992	.912	.826	.733
Passaic	.314	.290	.279	.253
Salem	24.052	24.895	25.780	26.641
Somerset	1.188	.986	.842	.764
Sussex	2.964	2.269	1.746	1.346
Union	.028	.023	.023	.015
Warren	4.206	3.926	3.680	3.456
Total	124.420	119.820	115.470	111.760

Table 41.--Predicted daily water demand for field-grown crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

OCTOBER

Drought-year scenario

County	Water demand (million gallons per day)			
	1990	2000	2010	2020
Atlantic	8.823	8.473	8.234	8.022
Bergen	.031	.026	.020	.015
Burlington	1.566	1.465	1.406	1.347
Camden	1.845	1.647	1.491	1.336
Cape May	.740	.610	.521	.455
Cumberland	9.303	9.360	9.395	9.406
Essex	.010	.007	.005	.003
Gloucester	4.257	4.001	3.807	3.590
Hunterdon	.192	.168	.147	.128
Mercer	.731	.676	.613	.553
Middlesex	1.698	1.382	.756	.296
Monmouth	1.224	1.152	1.082	.983
Morris	.003	.002	.002	.002
Ocean	.423	.388	.350	.310
Passaic	.000	.000	.000	.000
Salem	5.207	5.330	5.462	5.591
Somerset	.033	.026	.022	.020
Sussex	.020	.014	.010	.007
Union	.002	.001	.001	.001
Warren	.200	.186	.173	.163
Total	36.310	34.910	33.500	32.230

Table 44.--Predicted water demand for container-grown nursery crops in New Jersey in 1990, 2000, 2010, and 2020, by county

	Wet-year scenario			
	Water demand (million gallons)			
County	1990	2000	2010	2020
Atlantic	48.90	55.69	62.48	67.91
Bergen	32.60	36.67	40.75	44.82
Burlington	148.06	165.71	184.73	202.39
Camden	14.94	16.30	17.65	20.37
Cape May	9.50	10.86	12.22	13.58
Cumberland	188.81	211.90	234.99	259.44
Essex	4.07	4.07	4.07	5.43
Gloucester	239.07	268.95	298.83	328.72
Hunterdon	130.40	146.70	163.00	179.30
Mercer	65.20	73.35	81.50	89.65
Middlesex	161.64	182.01	202.39	221.41
Monmouth	618.04	695.47	772.90	848.96
Morris	29.88	32.60	36.67	40.75
Ocean	13.58	16.30	17.65	19.01
Passaic	5.43	6.79	6.79	8.15
Salem	62.48	70.63	78.78	86.93
Somerset	61.12	67.91	76.06	82.85
Sussex	31.24	35.31	39.39	43.46
Union	5.43	6.79	6.79	8.15
Warren	17.65	20.37	21.73	24.45
Total	1,888.11	2,124.46	2,359.50	2,595.80

Table 44.--Predicted water demand for container-grown nursery crops in New Jersey in 1990, 2000, 2010, and 2020, by county --Continued

Average-year scenario				
	Water demand (million gallons)			
County	1990	2000	2010	2020
Atlantic	58.68	66.83	74.98	81.50
Bergen	39.12	44.01	48.90	53.79
Burlington	177.67	198.86	221.68	242.87
Camden	17.93	19.56	21.19	24.45
Cape May	11.41	13.04	14.67	16.30
Cumberland	226.57	254.28	281.99	311.33
Essex	4.89	4.89	4.89	6.52
Gloucester	286.88	322.74	358.60	394.46
Hunterdon	156.48	176.04	195.60	215.16
Mercer	78.24	88.02	97.80	107.58
Middlesex	193.97	218.42	242.87	265.69
Monmouth	741.65	834.57	927.48	1,018.76
Morris	35.86	39.12	44.01	48.90
Ocean	16.30	19.56	21.19	22.82
Passaic	6.52	8.15	8.15	9.78
Salem	74.98	84.76	94.54	104.32
Somerset	73.35	81.50	91.28	99.43
Sussex	37.49	42.38	47.27	52.16
Union	6.52	8.15	8.15	9.78
Warren	21.19	24.45	26.08	29.34
Total	2,265.73	2,549.35	2,831.34	3,114.94

Table 44.--Predicted water demand for container-grown nursery crops in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

	Drought-year scenario			
	Water demand (million gallons)			
County	1990	2000	2010	2020
Atlantic	68.46	77.96	87.48	95.08
Bergen	45.64	51.34	57.05	62.76
Burlington	207.28	232.00	258.63	283.35
Camden	20.91	22.82	24.72	28.53
Cape May	13.31	15.21	17.12	19.02
Cumberland	264.33	296.66	328.99	363.22
Essex	5.70	5.70	5.71	7.61
Gloucester	334.69	376.53	418.37	460.21
Hunterdon	182.56	205.38	228.20	251.02
Mercer	91.28	102.69	114.10	125.51
Middlesex	226.30	254.82	283.35	309.98
Monmouth	865.26	973.66	1,082.06	1,188.56
Morris	41.83	45.64	51.35	57.05
Ocean	19.01	22.82	24.72	26.62
Passaic	7.60	9.50	9.51	11.41
Salem	87.47	98.88	110.30	121.71
Somerset	85.57	95.08	106.49	116.00
Sussex	43.73	49.44	55.15	60.85
Union	7.60	9.50	9.51	11.41
Warren	24.72	28.52	30.43	34.23
Total	2,643.25	2,974.15	3,303.24	3,634.13

Table 45.--Predicted water demand for all crop uses in New Jersey in 1990, 2000, 2010, and 2020, by county

	Wet-year scenario			
	Water demand (million gallons)			
County	1990	2000	2010	2020
Atlantic	1,527.75	1,485.64	1,462.18	1,441.49
Bergen	53.58	55.65	57.54	59.78
Burlington	4,382.61	4,390.81	4,404.20	4,416.23
Camden	221.08	199.92	183.47	168.52
Cape May	62.59	54.74	49.68	46.36
Cumberland	1,231.56	1,260.73	1,287.49	1,312.91
Essex	6.60	5.94	5.39	6.09
Gloucester	718.66	719.69	727.19	732.39
Hunterdon	195.61	204.35	213.86	224.16
Mercer	140.27	142.79	144.31	146.42
Middlesex	305.73	299.88	268.93	250.11
Monmouth	714.90	786.63	858.49	926.60
Morris	49.95	49.80	51.40	53.38
Ocean	282.61	281.38	278.49	275.29
Passaic	5.58	6.94	6.94	8.22
Salem	772.04	800.55	830.39	859.55
Somerset	83.79	86.40	91.58	96.91
Sussex	42.70	44.47	46.76	49.45
Union	6.25	7.44	7.44	8.53
Warren	45.07	46.10	45.87	47.07
Total	10,849.00	10,929.92	11,021.72	11,129.49

Table 45.--Predicted water demand for all crop uses in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

	Average-year scenario			
	Water demand (million gallons)			
County	1990	2000	2010	2020
Atlantic	2,614.14	2,535.66	2,491.05	2,452.48
Bergen	80.46	80.89	80.94	81.91
Burlington	4,664.04	4,659.85	4,667.80	4,673.97
Camden	389.76	350.01	319.16	290.06
Cape May	153.20	130.13	114.68	103.82
Cumberland	2,629.91	2,675.18	2,714.57	2,749.33
Essex	11.43	9.71	8.26	8.24
Gloucester	1,225.86	1,206.08	1,199.07	1,187.33
Hunterdon	449.87	437.46	427.97	421.77
Mercer	347.87	338.69	325.92	314.74
Middlesex	606.21	556.49	432.63	345.62
Monmouth	979.98	1,059.59	1,139.42	1,211.50
Morris	123.74	116.18	111.52	107.99
Ocean	333.07	328.54	321.75	314.33
Passaic	22.40	22.83	22.31	22.62
Salem	2,069.34	2,143.86	2,222.00	2,298.22
Somerset	155.90	150.45	150.45	153.20
Sussex	200.59	169.73	147.51	131.43
Union	8.64	9.83	9.83	10.84
Warren	237.25	225.82	214.47	205.90
Total	17,303.70	17,206.97	17,121.31	17,085.27

Table 45.--Predicted water demand for all crop uses in New Jersey in 1990, 2000, 2010, and 2020, by county--Continued

	Drought-year scenario			
	Water demand (million gallons)			
County	1990	2000	2010	2020
Atlantic	3,932.05	3,809.44	3,739.14	3,678.74
Bergen	111.23	109.62	107.40	106.74
Burlington	4,967.54	4,949.63	4,951.73	4,951.53
Camden	614.82	549.98	499.69	451.45
Cape May	237.23	200.09	175.04	157.20
Cumberland	3,861.67	3,922.29	3,973.97	3,018.12
Essex	17.03	14.04	11.54	10.60
Gloucester	1,700.47	1,661.58	1,641.91	1,615.13
Hunterdon	755.00	715.67	681.95	654.68
Mercer	563.46	541.93	514.28	489.19
Middlesex	895.38	803.79	591.35	439.43
Monmouth	1,256.57	1,343.50	1,430.77	1,505.97
Morris	209.14	192.65	180.36	170.17
Ocean	389.10	380.94	369.84	357.67
Passaic	40.87	40.30	39.20	38.33
Salem	3,306.84	3,425.29	3,549.54	3,670.66
Somerset	245.50	229.11	221.88	220.96
Sussex	337.28	280.15	238.22	206.81
Union	11.30	12.46	12.47	13.30
Warren	444.28	420.17	397.57	378.97
Total	23,896.76	23,602.62	23,327.83	23,135.61

APPENDIXES

Appendix 1.--List of minor civil divisions in the southern rural group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
ATLANTIC COUNTY			
Buena Borough	2,073	5,056	3,762
Buena Vista Township	2,998	26,451	7,237
Hammonton Town	6,566	25,907	12,316
Burlington City	23	1,958	10,578
Eastampton Township	1,452	3,667	3,877
Evesham Township	3,126	18,976	25,293
Florence Township	2,000	6,195	9,254
Hainesport Township	942	4,275	3,384
Lumberton Township	4,632	8,506	5,262
Mansfield Township	7,014	14,534	2,584
Medford Township	4,154	25,805	19,502
Moorestown Township	3,033	9,715	15,814
Mt. Holly Township	47	1,862	10,987
Mt. Laurel Township	4,430	14,112	21,491
New Hanover Township	710	13,984	15,549
North Hanover Township	5,119	11,078	9,228
Pemberton Borough	47	454	1,202
Pemberton Township	6,929	41,286	30,866
Southampton Township	9,097	27,270	8,995
Springfield Township	8,813	18,931	2,798
Westampton Township	2,643	7,066	4,092
Willingboro Township	15	5,030	39,389
Wrightstown Borough	48	1,120	3,291
CAMDEN COUNTY			
Winslow Township	6,468	37,165	23,020

Appendix 1.--List of minor civil divisions in the southern rural group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984--Continued

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
CUMBERLAND COUNTY			
Bridgeton City	139	4,160	18,688
Deerfield Township	3,837	10,688	2,618
Fairfield Township	3,166	27,520	5,777
Greenwich Township	4,411	12,160	948
Hopewell Township	10,972	20,096	4,385
Millville City	1,791	28,352	25,205
Shiloh Borough	488	832	607
Stow Creek Township	6,369	12,032	1,429
Upper Deerfield Township	11,390	20,352	6,933
Vineland City	6,508	44,480	53,326
GLOUCESTER COUNTY			
Clayton Borough	709	5,133	6,101
Elk Township	4,355	12,922	3,380
Franklin Township	9,261	34,643	13,530
Glassboro Borough	639	5,907	14,415
Greenwich Township	864	6,144	5,345
Harrison Township	9,287	12,570	3,664
Logan Township	5,352	15,430	3,447
Mantua Township	3,026	12,346	9,657
Monroe Township	4,083	29,760	22,511
Newfield Borough	172	1,114	1,589
Pitman Borough	38	1,504	9,572
South Harrison Township	5,333	10,118	1,654
Swedesboro Borough	71	493	2,113
Washington Township	3,874	14,266	30,484
Woolwich Township	9,526	13,728	1,203
MERCER COUNTY			
East Windsor Township	3,401	9,984	22,257
Hightstown Borough	21	787	4,496
Hopewell Borough	18	480	1,985
Hopewell Township	10,566	37,120	10,947
Lawrence Township	2,287	13,997	21,375
Pennington Borough	49	634	2,104
Washington Township	6,193	13,248	3,523
West Windsor Township	6,370	17,178	9,290

Appendix 1.--List of minor civil divisions in the southern rural group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984--Continued

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
MIDDLESEX COUNTY			
Cranbury Township	4,788	8,384	2,117
Monroe Township	8,904	26,752	18,148
South Brunswick Township	6,128	26,496	18,443
MONMOUTH COUNTY			
Allentown Borough	51	576	1,954
Colts Neck Township	4,798	20,224	7,969
Englishtown Borough	60	384	985
Farmingdale Borough	25	320	1,353
Freehold Borough	36	1,088	10,050
Freehold Township	5,448	24,512	19,933
Holmdel Township	2,428	11,456	9,057
Howell Township	3,804	40,448	28,374
Manalapan Township	5,530	20,544	22,564
Marlboro Township	3,817	19,328	22,266
Millstone Township	8,567	23,910	4,115
Roosevelt Borough	384	1,242	865
Shrewsbury Borough	133	1,472	2,909
Upper Freehold Township	15,160	30,144	2,809
OCEAN COUNTY			
Plumsted Township	4,505	26,048	4,829

Appendix 1.--List of minor civil divisions in the southern rural group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984--Continued

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
	SALEM COUNTY		
Alloway Township	6,990	21,453	2,733
Carneys Point Township	3,429	11,616	8,728
Elmer Borough	88	461	1,580
Elsinboro Township	2,592	8,346	1,286
Lower Alloway Creek Township	5,222	29,248	1,592
Mannington Township	12,159	25,741	1,695
Oldmans Township	4,946	12,416	1,866
Penns Grove Borough	23	499	5,418
Pennsville Township	2,068	15,328	13,741
Pilesgrove Township	11,579	22,342	2,858
Pittsgrove Township	8,803	28,480	7,708
Quinton Township	4,486	15,750	2,879
Salem City	212	1,824	6,996
Upper Pittsgrove Township	14,326	25,082	3,226
Woodstown Borough	187	947	3,275

Appendix 2.--List of minor civil divisions in the urban fringe group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
BURLINGTON COUNTY			
Bordentown Township	1,225	4,742	7,166
Burlington Township	2,145	8,973	11,723
Chesterfield Township	7,261	14,157	4,219
Cinnaminson Township	254	4,730	15,908
Delanco Township	417	1,382	3,683
Delran Township	610	4,384	14,631
Edgewater Park Township	238	1,830	9,328
Maple Shade Township	6	2,381	20,284
CAMDEN COUNTY			
Berlin Borough	523	2,278	5,922
Berlin Township	71	2,093	5,480
Cherry Hill Township	740	15,686	69,848
Gibbsboro Borough	6	1,376	2,632
Gloucester Township	1,246	15,027	48,841
Hi Nella Borough	8	141	1,254
Pine Hill Borough	17	2,360	9,111
Vorhees Township	461	7,622	18,130
CAPE MAY			
West Cape May Borough	159	832	1,223
GLOUCESTER COUNTY			
Deptford Township	1,607	11,110	24,018
East Greenwich Township	5,140	7,539	4,285
West Deptford Township	1,632	10,189	18,137

Appendix 2.--List of minor civil divisions in the urban fringe group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984--Continued

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
MERCER COUNTY			
Ewing Township	243	9,683	35,101
Hamilton Township	4,502	25,203	84,576
Princeton Township	864	10,400	14,094
MIDDLESEX COUNTY			
East Brunswick Township	1,230	13,760	39,125
Edison Township	42	19,323	76,087
Middlesex Borough	26	2,304	13,323
Milltown Borough	5	1,024	7,022
North Brunswick Township	358	7,232	24,869
Old Bridge Township	1,595	24,122	54,212
Piscataway Township	461	12,096	43,262
Plainsboro Township	3,823	7,488	8,778
Sayreville Borough	16	10,432	30,822
South Plainfield Borough	42	5,248	20,301
Spotswood Borough	10	1,472	8,616

Appendix 3.--List of minor civil divisions in the "miscellaneous" group by county, with corresponding values of the percentage of total acreage that was arable in 1973, and harvested acreage, total minor civil division acreage, and population in 1984

[*, arable percentage of total acreage unavailable]

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984	Arable percentage of total acreage, 1973
		ATLANTIC COUNTY		
Absecon City	12	3,757	7,222	31.5
Corbin City City	30	5,709	264	7.5
Egg Harbor Township	692	42,586	20,875	20.9
Estell Manor City	337	33,997	995	7.4
Folsom Borough	243	5,626	1,944	28.6
Galloway Township	2,929	58,720	16,401	18.8
Hamilton Township	2,133	73,632	11,140	17.2
Linwood City	21	2,650	6,264	57.9
Mullica Township	905	35,021	5,335	16.3
Northfield City	13	2,278	7,625	74.9
Port Republic City	34	5,210	885	*
		BURLINGTON COUNTY		
Bass River Township	776	50,976	1,397	6.8
Shamong Township	2,970	29,830	4,934	17.7
Tabernacle Township	3,349	30,970	6,806	19.2
Washington Township	1,493	68,557	807	6.8
Woodland Township	1,290	61,043	2,026	7.4
		CAMDEN COUNTY		
Waterford Township	1,680	22,003	9,252	23.6
		CAPE MAY COUNTY		
Dennis Township	1,719	41,664	4,444	13.7
Lower Township	2,068	18,731	19,066	23.7
Middle Township	1,736	47,290	12,479	18.4
Upper Township	447	41,299	7,875	11.8
Woodbine Borough	58	5,120	2,722	28.9

Appendix 3.--List of minor civil divisions in the "miscellaneous" group by county, with corresponding values of the percentage of total acreage that was arable in 1973, and harvested acreage, total minor civil division acreage, and population in 1984--Continued

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984	Arable percentage of total acreage; 1973
		CUMBERLAND COUNTY		
Commercial Township	732	21,760	4,843	23.1
Downe Township	393	35,712	1,834	11.3
Lawrence Township	2,364	22,784	2,304	28.4
Maurice River Township	765	60,608	5,002	9.1
		MONMOUTH COUNTY		
Aberdeen Township	55	3,488	18,486	81.3
Eatontown Borough	19	3,776	13,010	70.9
Hazlet Township	68	3,571	22,973	87.0
Little Silver Borough	58	1,792	5,463	90.9
Long Branch City	9	3,264	29,254	99.8
Middletown Township	538	24,448	66,882	64.8
Neptune Township	21	5,120	28,996	81.1
Ocean Township	262	23,593	1,984	73.6
Tinton Falls Borough	528	10,374	8,344	43.4
Wall Township	1,319	19,846	19,480	47.6
West Long Branch Borough	68	1,856	7,486	92.9
		OCEAN COUNTY		
Barnegat Township	83	23,232	9,420	6.8
Berkeley Township	51	25,702	27,345	13.9
Brick Township	6	16,896	57,627	52.1
Dover Township	105	28,179	68,301	27.7
Jackson Township	1,042	64,512	26,563	13.9
Lacey Township	74	55,341	15,777	9.5
Lakewood Township	175	16,512	39,390	46.3
Little Egg Harbor Township	7	30,848	9,849	7.1
Manchester Township	119	52,672	31,831	48.5
Stafford Township	180	29,376	11,766	12.5

Appendix 4.--List of minor civil divisions in the northern irrigated group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
BERGEN COUNTY			
Dumont Borough	7	1,152	18,162
Franklin Lakes Borough	58	6,016	9,523
Hillsdale Borough	24	1,856	10,367
Mahwah Township	198	16,064	13,300
Montvale Borough	108	2,560	7,545
New Milford Borough	7	1,408	16,626
Rivervale Township	10	2,816	9,799
Saddle River Borough	87	3,136	2,864
Upper Saddle River Borough	75	3,264	8,009
Woodcliff Lake Borough	110	2,400	5,585
Wyckoff Township	39	4,806	15,777
ESSEX COUNTY			
Cedar Grove Township	14	2,880	12,400
Fairfield Township	116	6,656	8,241
HUNTERDON COUNTY			
Alexandria Township	6,341	18,048	2,998
Clinton Township	4,532	21,837	8,863
Delaware Township	9,533	23,616	3,871
Franklin Township	6,698	14,912	2,410
Kingwood Township	8,134	22,784	2,902
Lebanon Township	3,229	20,480	5,537
Raritan Township	8,780	24,576	9,465
Readington Township	8,981	30,592	11,283
Tewksbury Township	5,431	20,352	4,200
Union Township	2,710	13,030	3,853
West Amwell Township	4,025	14,016	2,321

Appendix 4.--List of minor civil divisions in the northern irrigated group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984--Continued

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
MORRIS COUNTY			
Boonton Township	155	5,434	3,373
Chatham Township	29	5,760	8,878
Chester Township	2,033	18,355	5,344
Denville Township	263	8,192	14,296
Harding Township	1,245	10,688	3,399
Lincoln Park Borough	159	4,115	8,992
Mendham Borough	328	4,288	5,116
Mendham Township	635	11,264	4,554
Montville Township	1,576	12,115	14,830
Morris Township	95	1,600	19,684
Parsippany-Troy Hills Township	81	16,192	50,217
Passaic Township	252	10,560	7,460
Washington Township	5,848	28,864	13,394
PASSAIC COUNTY			
Wayne Township	123	15,680	48,126
West Milford Township	183	50,240	23,919
SOMERSET COUNTY			
Bedminster Township	3,374	17,088	2,762
Bernards Township	827	15,616	13,347
Branchburg Township	3,966	12,928	8,292
Bridgewater Township	824	21,018	29,260
Franklin Township	7,198	29,696	33,626
Hillsboro Township	10,424	35,008	21,240
Manville Bcrough	46	1,600	11,182
Montgomery Township	6,850	20,646	7,769
Warren Township	947	12,352	9,937

Appendix 4.--List of minor civil divisions in the northern irrigated group by county, with corresponding values of harvested acreage, total minor civil division acreage, and population in 1984--Continued

Minor civil division	Harvested acreage, 1984	Total acreage, 1984	Population, 1984
SUSSEX COUNTY			
Andover Borough	200	1,280	864
Byram Township	37	13,184	7,685
Frankford Township	3,505	22,272	5,012
Franklin Borough	323	2,816	4,469
Green Township	2,461	10,560	2,485
Hampton Township	1,860	15,808	4,146
Hardyston Township	1,804	20,864	4,646
Lafayette Township	3,384	11,712	1,748
Montague Township	1,116	28,544	2,280
Sparta Township	1,603	24,832	13,738
Stillwater Township	1,123	17,946	4,054
Vernon Township	3,713	43,456	17,613
Wantage Township	10,496	43,456	7,656
UNION COUNTY			
Cranford Township	6	448	24,214
Scotch Plains Township	99	6,022	22,414
Springfield Township	72	3,328	13,919
Westfield Township	6	4,096	30,440
WARREN COUNTY			
Allamuchy Township	2,337	12,864	2,760
Blairstown Township	2,969	19,648	4,607
Frelinghuysen Township	2,998	15,104	1,547
Harmony Township	5,295	15,552	2,641
Hope Township	2,503	12,032	1,568
Independence Township	2,514	12,224	2,957
Knowlton Township	3,875	16,576	2,226
Lopatcong Township	1,612	4,416	4,888
Mansfield Township	3,927	19,264	5,849
Oxford Township	518	3,648	1,650
Pohatcong Township	4,257	9,011	3,788
Wahington Township	4,278	11,200	4,273
White Township	4,928	18,048	2,922

Appendix 5.--List of minor civil divisions in the southern rural and urban fringe groups in 1984 after application of the classification procedure

[* indicates MCD's that were reclassified after application of the classification procedure]

Minor civil divisions in southern rural group

ATLANTIC COUNTY

Buena Borough
Buena Vista Township
Hammonton Town

BURLINGTON COUNTY

Burlington City
Burlington Township *
Chesterfield Township *
Eastampton Township
Evesham Township
Florence Township
Hainesport Township
Lumberton Township
Mansfield Township
Medford Township
Mt. Holly Township
New Hanover Township
North Hanover Township
Pemberton Borough
Pemberton Township
Southampton Township
Springfield Township
Westampton Township
Wrightstown Borough

CAMDEN COUNTY

Winslow Township

CUMBERLAND COUNTY

Bridgeton City
Deerfield Township
Fairfield Township
Greenwich Township
Hopewell Township
Millville City
Shiloh Borough
Stow Creek Township
Upper Deerfield Township
Vineland City

Appendix 5.--List of minor civil divisions in the southern rural and urban fringe groups in 1984 after application of the classification procedure--Continued

Minor civil divisions in southern rural group--Continued	
GLOUCESTER COUNTY	
Clayton Borough	Mantua Township
East Greenwich Township *	Monroe Township
Elk Township	Newfield Borough
Franklin Township	South Harrison Township
Greenwich Township	Swedesboro Borough
Harrison Township	Woolwich Township
Logan Township	
MERCER COUNTY	
Hopewell Borough	Pennington Borough
Hopewell Township	Washington Township
MIDDLESEX COUNTY	
Cranbury Township	Monroe Township
MONMOUTH COUNTY	
Allentown Borough	Howell Township
Colts Neck Township	Manalapan Township
Englishtown Borough	Marlboro Township
Farmingdale Borough	Millstone Township
Freehold Borough	Roosevelt Borough
Freehold Township	Shrewsbury Borough
Holmdel Township	Upper Freehold Township
OCEAN COUNTY	
Plumsted Township	

Appendix 5.--List of minor civil divisions in the southern rural and urban fringe groups in 1984 after application of the classification procedure--Continued

Minor civil divisions in southern rural group--Continued	
SALEM COUNTY	
Alloway Township	Pennsville Township
Carneys Point Township	Pilesgrove Township
Elmer Borough	Pittsgrove Township
Elsinboro Township	Quinton Township
Lower Alloway Creek Township	Salem City
Mannington Township	Upper Pittsgrove Township
Oldmans Township	Woodstown Borough
Penns Grove Borough	
MCD's in urban fringe group	
BURLINGTON COUNTY	
Bordentown Township	Maple Shade Township
Cinnaminson Township	Moorestown Township *
Delanco Township	Mount Laurel Township *
Delran Township	Willingboro Township *
Edgewater Park Township	
CAMDEN COUNTY	
Berlin Borough	Gloucester Township
Berlin Township	Hi Nella Borough
Cherry Hill Township	Pine Hill Borough
Gibbsboro Borough	Vorhees Township
CAPE MAY	
West Cape May Borough	

Appendix 5.--List of minor civil divisions in the southern rural and urban fringe groups in 1984 after application of the classification procedure--Continued

Minor civil divisions in urban fringe group--Continued	
GLOUCESTER COUNTY	
Deptford Township	Washington Township *
Glassboro Borough *	West Deptford Township
Pitman Borough *	
MERCER COUNTY	
East Windsor Township *	Lawrence Township *
Ewing Township	Princeton Township
Hamilton Township	West Windsor Township *
Hightstown Borough *	
MIDDLESEX COUNTY	
East Brunswick Township	Piscataway Township
Edison Township	Plainsboro Township
Middlesex Borough	Sayreville Borough
Milltown Borough	South Brunswick Township *
North Brunswick Township	South Plainfield Borough
Old Bridge Township	Spotswood Borough

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations

[An asterisk over a column indicates that the data in the column were extrapolated from projections for other years and, in some cases, actual 1980 value]

Minor civil division	1990	2000	2010	2020
ATLANTIC COUNTY[1]				
				*
Absecon City	8,046	9,183	10,320	11,587
Buena Borough	3,801	3,904	4,006	4,111
Buena Vista Township	7,863	8,791	9,719	10,640
Corbin City	262	269	276	283
Egg Harbor Township	24,590	30,052	35,515	41,971
Estell Manor City	1,171	1,479	1,787	2,159
Folsom Borough	1,965	2,055	2,146	2,241
Galloway Township	24,430	37,460	50,491	68,055
Hamilton Township	15,220	21,094	26,967	34,475
Hammonton Town	12,494	12,701	12,908	13,118
Linwood City	6,528	6,979	7,430	7,910
Mullica Township	5,476	5,713	5,950	6,197
Northfield City	7,630	7,429	7,228	7,032
Port Republic City	921	991	1,062	1,138
BERGEN COUNTY[1]				
	*	*		*
Dumont Borough	17,972	18,236	18,500	18,764
Franklin Lakes Borough	11,325	12,750	14,175	15,600
Hillsdale Borough	10,505	10,790	11,075	11,360
Mahwah Township	18,076	21,413	24,750	28,087
Montvale Borough	7,802	8,141	8,480	8,819
New Milford Borough	16,137	16,131	16,125	16,119
Rivervale Township	10,208	10,854	11,500	12,146
Saddle River Borough	3,152	3,326	3,500	3,674
Upper Saddle River Borough	8,139	8,482	8,825	9,168
Woodcliff Lake Borough	5,836	6,118	6,400	6,682
Wyckoff Township	15,905	16,290	16,675	17,060

Footnotes at end of appendix

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
BURLINGTON COUNTY[2]				*
Bass River Township	1,460	1,710	1,910	2,133
Bordentown Township	9,480	11,110	11,380	11,657
Burlington City	10,690	10,320	10,820	11,344
Burlington Township	12,140	14,300	15,370	16,520
Chesterfield Township	4,470	5,010	5,600	6,260
Cinnaminson Township	16,120	16,470	16,620	16,771
Delanco Township	3,760	3,830	3,810	3,790
Delran Township	15,790	18,170	18,890	19,639
Eastampton Township	4,030	5,450	5,970	6,540
Edgewater Park Township	9,620	10,110	10,060	10,010
Evesham Township	31,790	39,560	47,880	57,950
Florence Township	9,850	10,340	10,870	11,427
Hainesport Township	3,360	3,630	3,950	4,298
Lumberton Township	5,980	7,660	8,140	8,650
Mansfield Township	3,060	3,780	4,060	4,361
Maple Shade Township	20,440	20,330	20,470	20,611
Medford Township	21,690	28,550	32,540	37,088
Moorestown Township	17,520	19,540	19,780	20,023
Mt Holly Township	11,270	11,130	11,280	11,432
Mt Laurel Township	27,210	32,960	38,330	44,575
New Hanover Township	15,570	16,110	17,610	19,250
North Hanover Township	9,480	11,300	12,990	14,933
Pemberton Borough	1,240	1,200	1,220	1,240
Pemberton Township	32,760	35,950	39,200	42,744
Shamong Township	5,380	6,330	7,210	8,212
Southampton Township	9,440	11,470	13,030	14,802
Springfield Township	2,900	3,970	4,400	4,877
Tabernacle Township	7,020	8,490	9,660	10,991
Washington Township	840	940	1,220	1,583
Westampton Township	5,990	7,260	8,940	11,009
Willingboro Township	40,460	40,910	40,300	39,699
Woodland Township	2,020	2,550	2,620	2,692
Wrightstown Borough	3,520	3,760	4,140	4,558

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
CAMDEN COUNTY[2]				*
Berlin Borough	6,720	8,190	9,200	10,332
Berlin Township	5,840	6,240	6,790	7,388
Cherry Hill Township	74,670	81,980	84,910	87,967
Gibbsboro Borough	2,650	2,860	2,950	3,041
Gloucester Township	52,820	62,190	70,080	78,980
Hi-Nella Borough	1,240	1,340	1,420	1,505
Pine Hill Borough	9,300	11,830	12,820	13,897
Vorhees Township	22,700	30,290	36,110	43,043
Waterford Township	10,660	14,590	17,470	20,912
Winslow Township	26,940	32,800	39,920	48,583
CAPE MAY COUNTY[1]				
Dennis Township	5,600	7,600	9,700	11,800
Lower Township	23,000	26,500	2,900	31,000
Middle Township	15,600	20,100	22,750	24,500
Upper Township	10,000	12,500	14,500	15,500
West Cape May Borough	1,400	1,700	2,000	2,300
Woodbine Borough	3,200	3,500	3,900	4,250
CUMBERLAND COUNTY[3]			*	*
Bridgeton City	15,821	13,932	12,269	10,804
Commercial Township	3,220	3,021	2,834	2,659
Deerfield Township	2,725	2,868	3,019	3,177
Downe Township	1,394	1,236	1,096	972
Fairfield Township	5,176	5,278	5,382	5,488
Greenwich Township	820	757	699	645
Hopewell Township	3,963	3,963	3,963	3,963
Lawrence Township	2,005	1,863	1,731	1,608
Maurice River Township	3,486	3,367	3,252	3,141
Milville City	24,804	26,845	29,054	31,445
Shiloh Borough	453	404	360	321
Stow Creek Township	1,085	1,105	1,125	1,146
Upper Deerfield Township	12,625	14,977	17,767	21,077
Vineland City	58,537	65,117	72,437	80,579

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
ESSEX COUNTY[3]				
			*	*
Cedar Grove Township	20,367	21,627	22,965	24,386
Fairfield Borough	21,604	28,676	38,063	50,523
GLOUCESTER COUNTY[2]				
				*
Clayton Borough	6,360	7,140	7,720	8,347
Deptford Township	25,440	27,180	29,000	30,942
East Greenwich Township	4,690	5,290	5,560	5,844
Elk Township	3,680	5,130	6,030	7,088
Franklin Township	15,310	19,180	22,100	25,465
Glassboro Borough	15,770	16,430	17,010	17,611
Greenwich Township	5,490	5,380	5,480	5,582
Harrison Township	4,010	4,660	5,010	5,386
Logan Township	3,930	5,600	6,640	7,873
Mantua Township	10,130	11,280	11,910	12,575
Monroe Township	24,590	29,210	32,480	36,116
Newfield Borough	1,660	1,690	1,800	1,917
Pitman Borough	9,560	9,280	9,280	9,280
South Harrison Township	1,910	2,170	2,500	2,880
Swedesboro Township	2,020	1,910	1,860	1,811
Washington Township	36,020	44,340	50,470	57,448
West Deptford Borough	19,080	22,680	24,430	26,315
Woolwich Township	1,320	3,090	5,060	8,286
HUNTERDON COUNTY[3]				
			*	*
Alexandria Township	2,784	2,962	3,151	3,353
Clinton Township	9,118	11,208	13,777	16,935
Delaware Township	4,359	4,883	5,470	6,128
Franklin Township	2,900	3,202	3,535	3,904
Kingwood Township	3,024	3,442	3,918	4,459

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
HUNTERDON COUNTY[3]--Continued			*	*
Lebanon Township	6,761	8,406	10,451	12,994
Raritan Township	12,899	16,812	21,912	28,559
Readington Township	13,789	17,613	22,498	28,737
Tewksbury Township	4,804	6,004	7,504	9,378
Union Township	3,113	3,562	4,076	4,664
West Amwell Township	2,953	3,402	3,919	4,515
MERCER COUNTY[1]				*
East Windsor Township	24,000	27,482	34,000	42,064
Ewing Township	35,900	36,200	38,700	41,373
Hamilton Township	90,210	99,300	101,630	104,015
Hightstown Borough	4,900	4,900	4,900	4,900
Hopewell Borough	2,100	2,495	2,550	2,606
Hopewell Borough	11,500	14,700	16,850	19,314
Lawrence Township	25,690	28,200	31,200	34,519
Pennington Borough	2,380	2,600	2,800	3,015
Princeton Township	15,000	19,500	23,000	27,128
Washington Township	6,500	9,500	10,500	11,605
West Windsor Township	15,511	22,600	26,400	30,839
MIDDLESEX COUNTY[1]			*	*
Cranbury Township	3,356	8,033	19,228	46,025
East Brunswick Township	42,507	44,753	47,118	49,607
Edison Township	82,190	82,668	83,149	83,632
Middlesex Borough	12,961	12,564	12,179	11,806
Milltown Borough	7,214	7,018	6,827	6,642
Monroe Township	22,684	34,737	53,194	81,459
North Brunswick Township	29,073	33,916	39,566	46,157
Old Bridge Township	62,502	76,124	92,715	112,922
Piscataway Township	45,413	47,048	48,742	50,497
Plainsboro Township	14,162	17,161	20,795	25,199
Sayreville Borough	34,582	41,600	50,042	60,198
South Brunswick Township	32,566	48,042	70,873	104,552
South Plainfield Borough	19,883	19,368	18,866	18,378
Spotswood Borough	7,590	7,421	7,256	7,094

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
		MONMOUTH COUNTY[1]		
	*	*		*
Aberdeen Township	19,092	19,332	19,573	19,817
Allentown Borough	2,430	2,448	2,466	2,484
Colts Neck Township	8,862	10,096	11,329	12,713
Eatontown Borough	14,839	14,429	14,020	13,622
Englishtown Borough	1,583	1,605	1,627	1,649
Farmingdale Borough	1,572	1,588	1,604	1,620
Freehold Borough	10,127	10,165	10,204	10,243
Freehold Township	26,377	29,447	32,516	35,905
Hazlet Township	22,374	22,620	22,866	23,115
Holmdel Township	13,444	15,874	18,304	21,106
Howell Township	41,419	45,219	49,020	53,140
Little Silver Borough	5,682	5,722	5,762	5,802
Long Branch City	31,038	31,166	31,295	31,424
Manalapan Township	31,799	37,295	42,792	49,099
Marlboro Township	32,420	36,376	40,334	44,972
Middletown Township	67,553	67,163	66,772	66,384
Millstone Township	5,220	7,498	9,776	12,746
Neptune Township	29,621	28,915	28,208	27,519
Ocean Township	25,528	26,174	26,821	27,484
Roosevelt Borough	940	1,114	1,289	1,491
Shrewsbury Borough	3,079	3,196	3,312	3,429
Tinton Falls Borough	12,499	15,147	17,794	20,904
Upper Freehold Township	2,751	5,857	8,963	13,716
Wall Township	22,673	25,251	27,828	30,668
West Long Branch Borough	7,974	7,384	6,793	6,250
		MORRIS COUNTY[1]		
			*	*
Boonton Township	3,740	4,160	4,627	5,147
Chatham Township	10,320	11,870	13,653	15,703
Chester Township	5,950	6,950	8,118	9,482
Denville Township	14,050	15,140	16,315	17,580
Harding Township	3,830	4,400	5,055	5,807
Lincoln Park Borough	10,960	12,440	14,120	16,027
Mendham Borough	5,870	7,290	9,054	11,244

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
MORRIS COUNTY[1]			*	*
Mendham Township	5,160	6,160	7,354	8,779
Montville Township	15,950	18,680	21,877	25,622
Morris Township	21,350	25,070	29,438	34,567
Parsippany-Troy Hills Township	52,650	56,450	60,524	64,893
Passaic Township	7,600	8,410	9,306	10,298
Washington Township	17,120	22,010	28,297	36,379
OCEAN COUNTY[1]			*	*
Barnegat Township	12,450	18,000	26,024	37,625
Berkeley Township	36,000	48,000	64,000	85,333
Brick Township	70,000	75,000	80,357	86,097
Dover Township	75,000	85,000	96,333	109,178
Jackson Township	40,000	51,000	65,025	82,907
Lacey Township	22,500	25,000	27,778	30,864
Lakewood Township	47,500	53,500	60,258	67,869
Little Egg Harbor Township	12,600	16,100	20,572	26,287
Manchester Township	46,000	53,000	61,065	70,358
Plumsted Township	9,000	12,000	16,000	21,333
Stafford Township	17,500	30,000	51,429	88,163
PASSAIC COUNTY[1]			*	*
Wayne Township	50,209	52,583	55,069	57,673
West Milford Township	25,206	27,007	28,937	31,004

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
SALEM COUNTY[1]				
				*
Alloway Township	3,015	3,185	3,305	3,430
Carnesy Point Township	8,698	9,058	9,268	9,483
Elmer Borough	1,561	1,701	1,771	1,844
Elsinboro Township	1,246	1,386	1,436	1,488
Lower Alloways Creek Township	1,603	1,673	1,733	1,795
Mannington Borough	1,741	1,931	2,091	2,264
Oldmans Township	1,940	2,010	2,070	2,132
Penns Grove Borough	5,255	5,255	5,255	5,255
Pennsville Township	13,845	14,345	14,645	14,951
Pilesgrove Township	3,219	3,429	3,599	3,777
Pittsgrove Township	8,557	9,347	9,837	10,353
Quinton Township	3,024	3,114	3,174	3,235
Salem City	6,896	6,896	6,896	6,896
Upper Pittsgrove Township	3,504	4,074	4,424	4,804
Woodstown Borough	3,396	3,596	3,596	3,596
SOMERSET COUNTY[1]				
Bedminster Township	5,350	7,830	10,430	11,870
Bernards Township	17,370	21,830	26,310	28,800
Branchburg Township	9,060	10,210	11,470	12,270
Bridgewater Township	32,680	33,010	35,580	37,250
Franklin Township	43,100	52,790	62,790	68,350
Hillsboro Township	26,070	30,900	35,850	38,860
Manville Borough	10,860	10,670	10,770	10,970
Montgomery Township	10,870	13,420	16,030	17,520
Warren Township	11,060	13,400	15,820	17,230

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
		SUSSEX COUNTY[1]		
			*	*
Andover Borough	1,011	1,146	1,299	1,472
Byram Township	10,217	13,915	18,950	25,808
Frankford Township	6,371	8,722	11,939	16,344
Franklin Borough	5,005	5,584	6,230	6,951
Green Township	3,488	4,966	7,070	10,065
Hampton Township	5,154	6,783	8,928	11,750
Hardyston Township	6,310	8,745	12,120	16,797
Lafayette Township	2,213	3,034	4,160	5,704
Montague Township	2,625	3,335	4,238	5,384
Sparta Township	18,045	24,422	33,053	44,735
Stillwater Township	5,404	7,513	10,445	14,522
Vernon Township	26,467	42,970	69,764	113,265
Wantage Township	10,622	15,524	22,688	33,157
		UNION COUNTY[3]		
			*	*
Cranford Township	26,774	26,535	26,298	26,063
Scotch Plains Township	27,717	30,266	33,049	36,089
Springfield Township	18,275	19,409	20,613	21,892
Westfield Township	33,505	33,419	33,333	33,248

Appendix 6.--Minor civil division population projections used as input data to the predictive regression equations--Continued

Minor civil division	1990	2000	2010	2020
WARREN COUNTY[1]				
			*	*
Allamuchy Township	4,500	5,750	7,347	9,388
Blairstown Township	5,850	6,313	6,813	7,352
Frelinghuysen Township	1,789	2,047	2,342	2,680
Harmony Township	3,011	2,613	2,268	1,968
Hope Township	1,804	2,165	2,598	3,118
Independence Township	3,709	4,822	6,269	8,150
Knowlton Township	2,399	2,539	2,687	2,844
Lopatcong Township	5,900	7,000	8,305	9,853
Mansfield Township	6,677	7,679	8,831	10,157
Oxford Township	1,826	2,009	2,210	2,432
Pohatcong Township	4,265	4,692	5,162	5,679
Washington Township	4,966	5,710	6,566	7,549
White Township	3,208	3,689	4,242	4,878

[1] Data from applicable county planning agency.

[2] Data from the Delaware Valley Regional Planning Commission (1982).

[3] Data from Greenburg and Neuman (1977).