

**INVENTORY AND ANALYSIS OF
ADJACENT LAND USES:
As of July 1989**

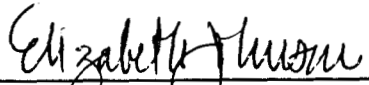
**Delaware Water Gap
National Recreation Area**

USDI National Park Service

**Office of Research and Resource Planning
Delaware Water Gap National Recreation Area**

November 1991

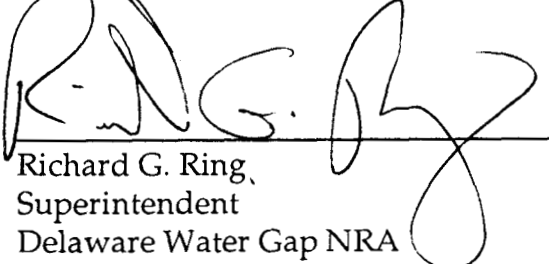
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INTRODUCTION

Rapid residential, resort and commercial development in lands adjacent to Delaware Water Gap National Recreation Area is changing the region's rural character and generating concern about possible point and non-point source pollution impacts to the Middle Delaware Scenic and Recreational River and its tributary streams. In response to potential water quality concerns accompanying the increasing urbanization, the National Park Service (NPS) has been working with the Delaware River Basin Commission (DRBC: a basin-wide planning and regulatory agency that establishes policy and sets standards for the river) to develop a resource management plan for the waters of Delaware Water Gap National Recreation Area. As part of the planning process, a study of land uses in townships bordering the National Recreation Area was undertaken in order to document current land use and trends, assess their immediate and long-term impacts on water quality, and assist with developing strategies for providing increased protection to ambient water quality. Data were gathered from local sources between 1986 and 1989 and then entered into a geographic information system (GIS) and a relational dBASE III database system for analysis.

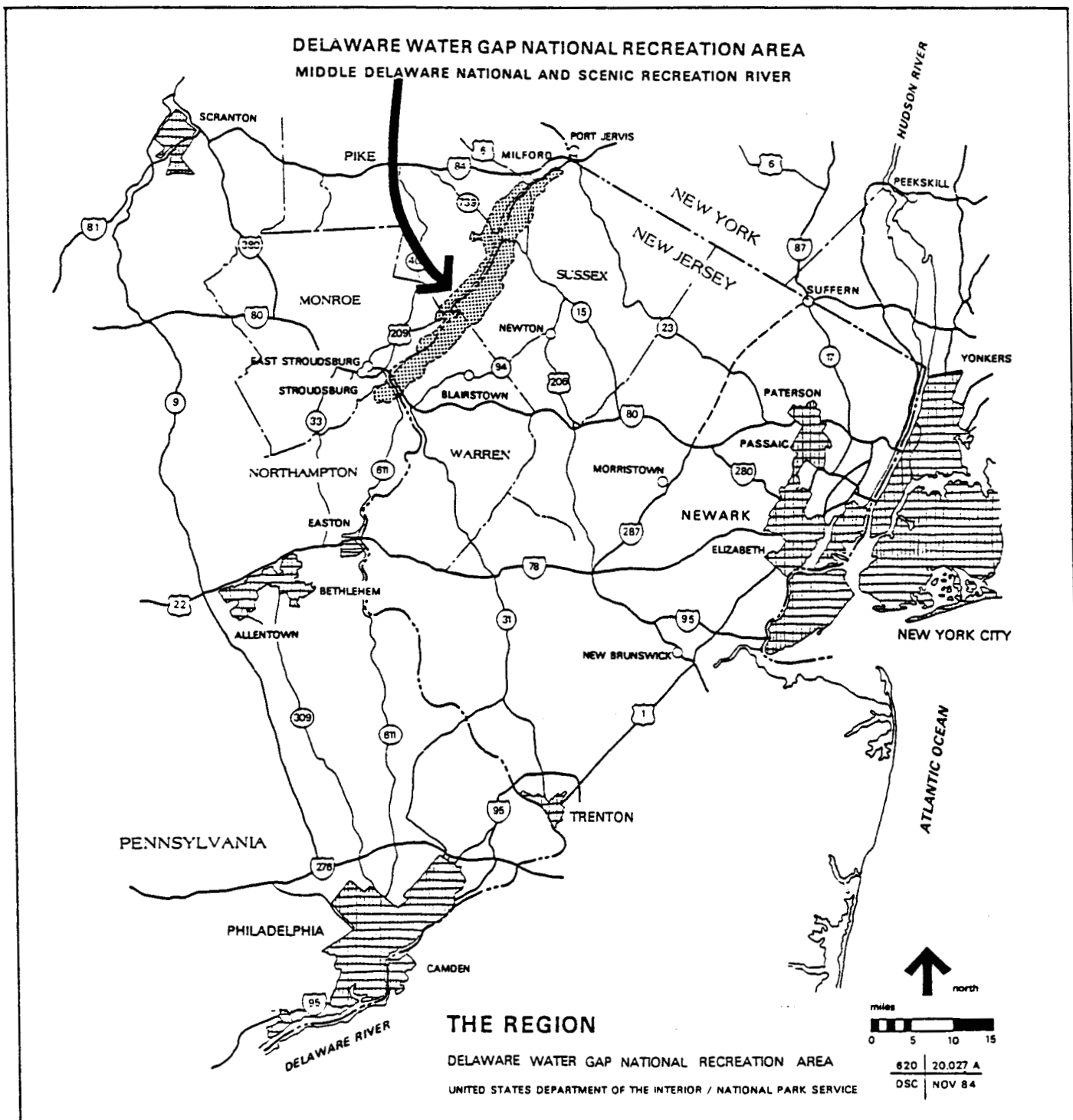
BACKGROUND AND STUDY OBJECTIVES

Regional Context: Delaware Water Gap National Recreation Area is a 69,000 acre unit of the National Park system located along the Delaware River between New Jersey and Pennsylvania (Figure 1). It is located less than one hundred miles from metropolitan New York and Philadelphia, and it is highly accessible to the ever-growing numbers of vacationers and new residents being drawn to the Pocono region.

The Delaware River is the only major free-flowing river on the Eastern Seaboard. It is one of the smallest and most intensively used of America's rivers, draining just 0.4 percent of the nation's land area yet supplying water to almost 10% of its population. In 1978, thirty-seven miles of the river between Port Jervis, NY, and the Delaware Water Gap were made a part of the National Wild and Scenic Rivers system. This segment, which flows through the National Recreation Area, was designated the Middle Delaware Scenic and Recreational River. The enhanced aesthetics and recreational opportunities that it provides are a major contributor to the region's economic vitality.

Water quality in the Middle Delaware and its tributaries is now uniformly good to excellent, in many cases far exceeding the levels of protection provided by current standards (see Breidt and Boes 1989, and DRBC Summer Program Reports, multiple years). Maintaining this exceptional water quality is vital to the continued use and enjoyment of Recreation Area waters, which are a regionally- and nationally-recognized recreation and fisheries resource.

FIGURE 1: Locator Map, Delaware Water Gap National Recreation Area

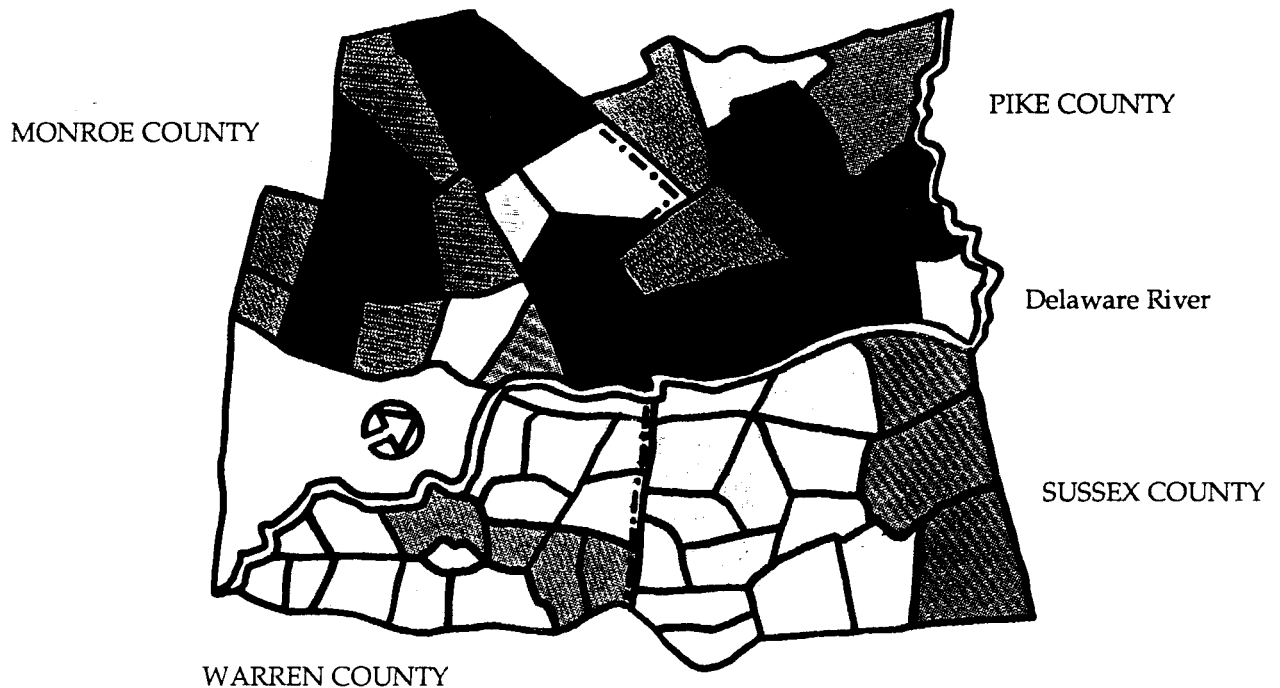


The Middle Delaware's status as a Scenic and Recreational River under the federal Wild and Scenic Rivers Act provides the National Recreation Area with strong legislative mandates to preserve and, where possible, enhance the exceptional water quality. This task is proving increasingly difficult, since the upper reaches of nearly all of the tributaries draining into the Middle Delaware lie outside of National Recreation Area boundaries, and so are outside National Park Service management jurisdiction. Activities in these adjacent lands are of concern because of their increasing potential to impact water quality within the National Recreation Area.

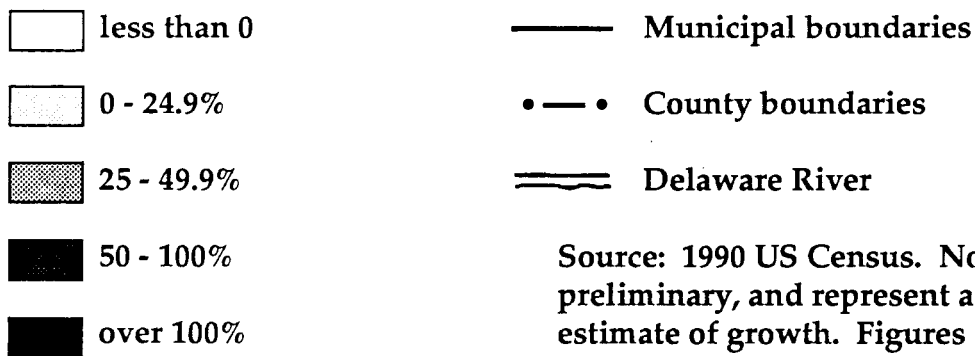
When the National Recreation Area was established in 1965, a series of population projections were developed for preliminary planning in the Tock's Island region (Raymond and May Associates 1966). The report suggested that build-out populations for the Pennsylvania townships adjacent to the new recreation area would be quite low, with a total of 175,000 to 200,000 people residing in what was termed the "primary impact area" by the turn of the century. In fact, current population figures far exceed those early estimates, and the potential for further growth remains very strong.

In the 1970's a wave of development began moving westward into the Poconos along the Interstate 80 transportation corridor. Commuters and retirees were attracted to the area by its close proximity to metropolitan New York/New Jersey, affordable housing, lower taxes, and rural amenities. Development impacts were felt first in Monroe County, which experienced a growth rate of 114% between 1970 and 1988 (Monroe County Planning Commission, 1989). In the 1980's the focus shifted to Pike County, with populations moving in both from the south and along the Route 15/23 and Route 206 corridors, which carry traffic into the Poconos from northwestern New Jersey. Current growth rates for the counties adjacent to the National Recreation Area are among the highest in New Jersey and Pennsylvania. Pike and Monroe Counties are presently the two fastest-growing counties in Pennsylvania, with population increases between 1980 and 1990 of 53% and 35%, and Sussex County is one of New Jersey's fastest-growing commuter counties. Immediately above the park in New York, Orange County is the fastest growing county in that state. This growth trend is rapidly changing the region's rural character. Many vacation and seasonal homes are now being converted to year-round residences, permanent residential and commercial developments have rapidly expanded, and land has been changing hands at record levels. In addition, the increasing proliferation of time-share units - officially listed as seasonal dwellings - are actually occupied throughout the year. Figure 2 summarizes growth rates for the park-adjacent counties.

**FIGURE 2: Population Growth Rates in Park-adjacent Counties:
1980-1990**



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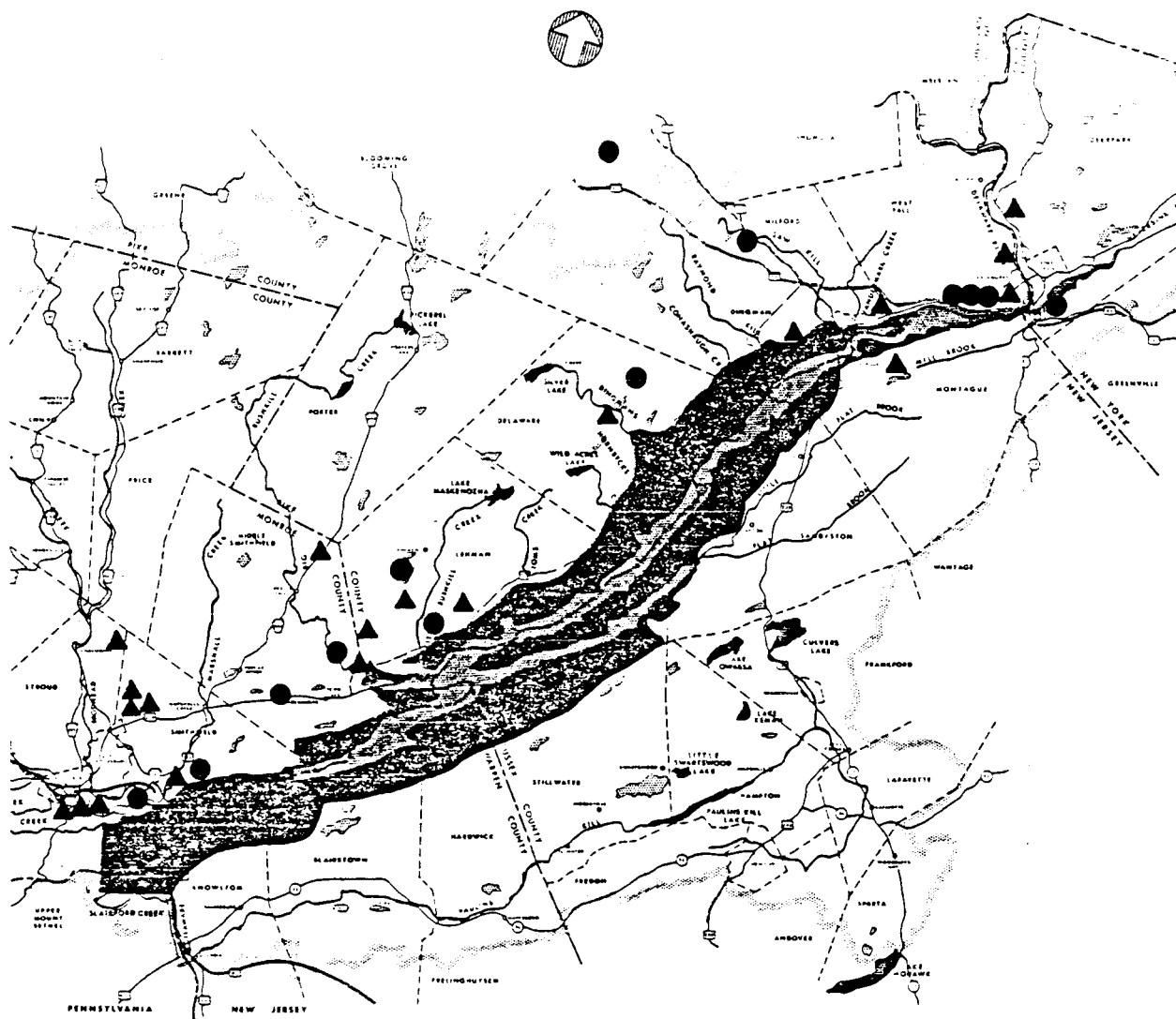
Source: 1990 US Census. Note: figures are preliminary, and represent a conservative estimate of growth. Figures are presently being adjusted upwards by counties.

Water Quality: A number of potential water quality problems accompany the conversion of field and forest lands to urban and suburban land uses. Potential non-point source pollution impacts include erosion and sedimentation from construction activities; increased stormwater runoff, which carries with it road salts, oil, and tar residues; and the failure of on-lot septic systems that are inadequate to handle increased loadings from year-round use. Severe constraints to on-lot wastewater disposal presented by local soils have led to the increased use of elevated sand mound systems, which have limited life spans and frequent operational problems when not properly installed or maintained. Other resource problems include reduced infiltration and groundwater recharge.

Intensifying development has also led to the proliferation of wastewater treatment facilities in the Middle Delaware watershed which discharge to the Middle Delaware and its tributary streams. Many of these facilities provide only minimum treatment, and a number have experienced compliance problems. Many more applications for new or expanding - in some cases up to fifteen times - facilities are currently under review (Figure 3). In addition, state water quality protection designations on several tributaries, and limited assimilative capacity in those tributaries, are forcing many potential dischargers to look to the mainstem Delaware. Delaware Water Gap National Recreation Area has received requests from development interests for rights-of-way to cross National Park Service lands in order to discharge treated wastewaters into the Delaware River. To date the National Recreation Area has denied these requests because dischargers could not meet ambient water quality and because discharges were proposed not simply to alleviate existing water quality problems, but also to promote significant future growth. Water quality standards now in place for this stretch of the Delaware River will permit degradation of the existing high water quality. This growth pressure presents a major management challenge to agencies charged with protection of the region's land and water resources.

In response to this pressure, Delaware Water Gap National Recreation Area initiated a water resources planning effort in 1987 to develop a water quality protection strategy for the waters of the National Recreation Area. This work was undertaken in cooperation with staff from DRBC and the National Park Service's Water Resources Division in Denver. As part of this planning effort, the National Recreation Area completed a study of land uses in townships adjacent to the park. The study was used in conjunction with water quality monitoring data from the eight-year NPS/DRBC cooperative water quality monitoring program to assess the immediate and long-term effects of the accelerating development, and to develop revised standards for the river that better reflect ambient water quality. Maps and a supporting database developed for the study describe existing land use and ownership patterns in the Pennsylvania and New Jersey townships adjacent to the National Recreation Area. This information was used to produce projections of future point and non-point source pollution loadings in the Middle Delaware watershed. This report presents a description of study methodology, maps and tabular data generated during the study, and projections of growth trends and pollution potential developed from the database.

FIGURE 3: Location of Wastewater Treatment Facilities in the Middle Delaware Watershed



KEY



Delaware Water Gap NRA



Existing wastewater treatment facilities



New/expanding wastewater treatment facilities (proposed or in progress)

Base map after Roy F. Weston (1970).

METHODS

Study Area: The study area for this project was defined as the townships immediately adjacent to Delaware Water Gap National Recreation Area, excluding the land contained within the boundaries of the National Recreation Area (Figure 4). This geographic area represents almost all of the land within each of the watersheds draining into the Middle Delaware, with the exception of the Bushkill and Brodhead watersheds. Figure 5 compares watershed extent with study area coverage. Potential impacts to water quality will most likely originate within this geographic area. Data was collected for the following nine townships: Westfall, Milford, Dingmans, Delaware, and Lehman in Pike County; Smithfield and Middle Smithfield in Monroe County; and Montague and Sandyston Townships in Sussex County. Information was not mapped or tabulated for the boroughs of Matamoras, Milford and Delaware Water Gap because they represent development densities and land uses that are, for all intents and purposes, not subject to change. The two New Jersey townships of Walpack (Sussex County) and Pahaquarry Township (Warren County) were also excluded from analysis because both consist exclusively of either National Recreation Area or state conservation lands; these two townships are therefore not subject to the pressures of urbanization experienced by the other adjacent townships.

FIGURE 4: Study Area Townships

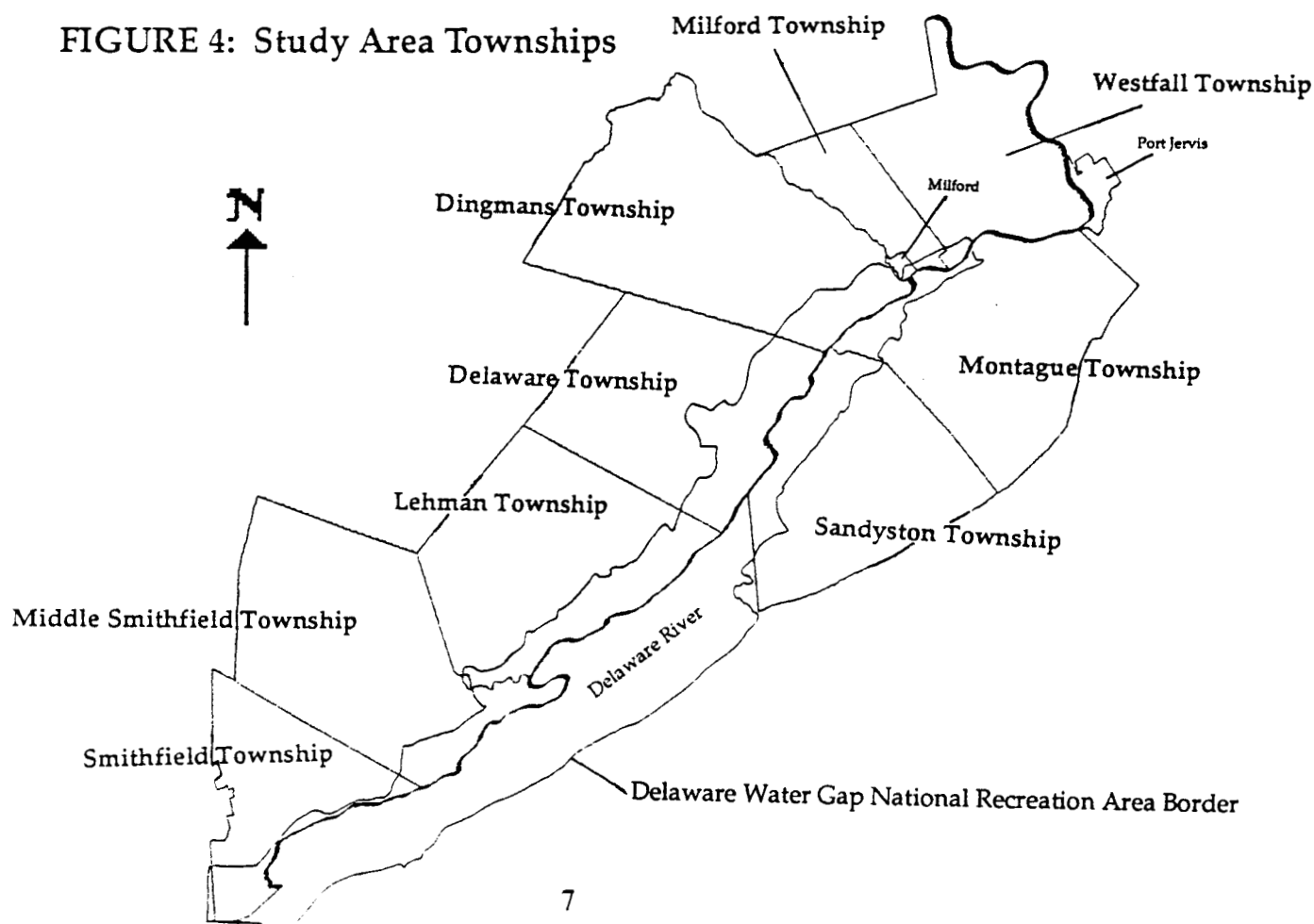
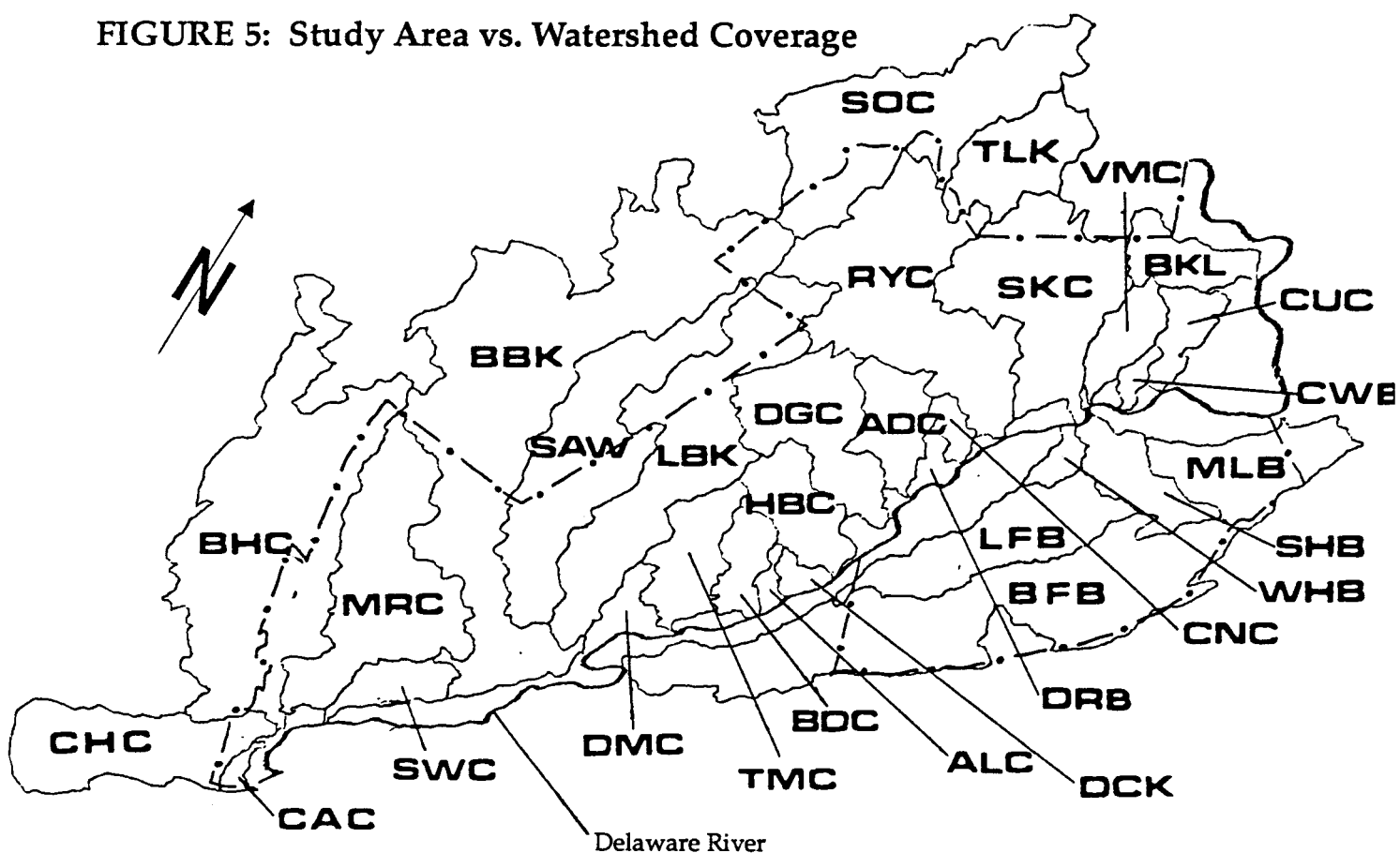


FIGURE 5: Study Area vs. Watershed Coverage



KEY

ADC	Adams Creek	HBC	Hornbecks Creek
ALC	Alicia's Creek	LBK	Little Bushkill
BBK	Big Bushkill	LFB	Little Flatbrook
BDC	Brodhead-Hellers Creek	MLB	Mill Brook
BFB	Big Flatbrook	MRC	Marshalls Creek
BHC	Brodhead Creek	RYC	Raymondskill Creek
BKL	Bushkill Creek (Milford/Westfall Tsp.)	SAW	Saw Creek
CAC	Caledonia Creek	SHB	Shimers Brook
CHC	Cherry Creek	SKC	Sawkill Creek
CNC	Conashaugh Creek	SOC	Shohola Creek
CUC	Cummins Creek	SWC	Shawnee Creek
CWB	Crawford Branch	TLK	Twin Lakes Creek
DCK	Deckers Creek	TMC	Toms Creek
DGC	Dingmans Creek	VMC	Vandermark Creek
DMC	Denmark Creek	WHB	White Brook
DRB	Dry Brook	•—•	Study Area Border
		Unlabeled	Direct Drainage

Information for the land use inventory was gathered from a variety of sources, including county tax assessment offices and planning commissions, township municipal offices (zoning maps, ordinances, and wastewater management plans), local zoning and sewage enforcement officers, conservation district offices, and state environmental agencies. The information was transcribed onto a series of maps which could relay a quick and graphic image of the urbanizing lands surrounding the National Recreation Area.

Seventeen USGS 7.5 minute topographic maps serve as base maps for manually-drafted mylar overlays that describe watersheds, property lines, existing and proposed development, zoning, open areas, public lands, wetlands, and erosion/sedimentation problem areas. A description of how the various overlays were created is available in an operations manual being prepared to describe the study (USDI/National Park Service, in progress). The mapped information is supported by a 4219-record computerized database containing detailed information for each mapped parcel on parcel size, use, watershed location, number of subdivided lots, number of dwelling units, and township zoning classes. A supporting database, with approximately 250 records, includes information specific to named developments and subdivisions over ten acres in size. A third data file provides documentation on area wastewater treatment facilities, both existing and proposed, with information on owner/operator, permits, discharge volumes and location, and level of treatment.

Mapped and computerized parcels information was obtained from county tax maps and tax map record books. Parcels were color-coded by acreage, thus presenting a quick overview of development density, and clearly contrasting thickly settled residential areas with large parcels of as-yet undeveloped land lying outside of park boundaries (see Figure 7, page 14). All parcels contained within a named development were treated as a single unit for mapping purposes, and assigned a color code according to the minimum lot size found within that development.

Land Use Classes: Seventeen categories were used to describe and quantify land use in the study area. The following uses are included: (1) residential lands, (2) vacant lands, (3) farm lands, (4) commercial lands, (5) industrial lands, (6) hunting and fishing clubs, (7) camps, (8) campgrounds, (9) golfcourses, (10) state forest and gamelands/federal lands, (11) other quasi-public lands, (12) existing developments, (13) proposed or in-progress developments, (14) resorts, (15) reserved open spaces within developments, (16) developer-owned lands that are not yet subdivided, (17) lands with use unknown. The Appendix provides a detailed description of the various land use categories. These categories were selected to reflect principal land use activities in the region having water quality implications. The list was developed after examining land use categories developed by each of the study area townships, and consulting agencies and individuals with local land use expertise. Contacts included Delaware River Basin Commission staff, the USDA Soil Conservation Service, the US Army Corps of Engineers, the US Environmental Protection Agency, the US Geological Survey, state water quality and land use planning agencies, county planning offices and conservation districts, and township offices.

Residential development constitutes one of the largest land use activities in the study area. Associated impacts (such as construction-related erosion and sedimentation, increased stormwater runoff, and an increase in the volume of sewage wastes to be disposed of either on-lot or at centralized wastewater treatment facilities) are seen as significant threats to area water quality. The current pattern of constructing large-scale developments - often associated with resorts - is expected to continue since population figures and real estate values have soared in recent years. The **Developments** categories describe this activity; they include all residential subdivisions over ten acres in size and containing more than ten lots. Developments have a "community" orientation, with an official name (e.g., Pocono Ranchlands, Birchwood Lakes) and some form of homeowners' association, and they frequently offer amenities such as a community recreation/meeting center, swimming pool or beach, and other "common" facilities. **Development - Existing** includes properties that have approvals for subdivision, where houses are already built or under construction; **Development - Proposed** includes properties where subdivision plans were under review, but where approvals had not yet been obtained, at the time that data was entered into the land use study database. **Developer-owned** lands are considered separately as undeveloped lands subject to development at some point in the near future, and **Reserved Open Areas** within a development are parcels, usually of larger than average lot size, where development will not occur because of environmental constraints (e.g., wetlands) or because they have been set aside. These parcels have been separated out in order to obtain accurate density figures. **Resorts** are listed separately because of the intensity of use and development activities associated with this land use.

Open areas in the study area represent varying levels of protection from development. **State Forests and Federal Lands** will not, for the most part, be subject to development at any time in the future. The **Hunting and Fishing Clubs, Camps, and Campgrounds** categories represent lands that are theoretically free from development pressure, and will generally remain in their present, largely undeveloped, state. **Golf courses** form a separate category because of the potential water quality impacts associated with intensive turf management involving heavy fertilizer and pesticide applications. A **Farm** category is included among the use codes. However, it should be noted that most of the farming activity in the study area occurs within the boundaries of the National Recreation Area, where agricultural operations are managed under a permitting program that requires the use of Best Management Practices. Farms are therefore not seen as a significant water quality threat. The remaining land use categories include **Residential, Commercial, Industrial, and Quasi-public**, all representing urbanized/urbanizing land use activities. A more detailed description of the seventeen land use categories can be found in the Appendix.

Geographic Information System Technology: In 1988, the Land Use Study was expanded to adapt to new Geographic Information System (GIS) capabilities being developed at the National Recreation Area. The intent of the original, manually-mapped, overlays was to provide a visual overview of development impacts. When GIS capabilities were acquired, it became apparent that the maps would need to be redrafted, both to provide greater precision and to meet the technical requirements of the digitizing process. In the process of refining the maps and database in 1989, Land Use Study information was updated. Digitization is in progress now; as of mid-1991, base hypsographic and hydrographic information has been digitized, as have political boundaries, zoning, parcels, and watersheds. The GIS-formatted land use information has been integrated with computerized database information and water quality data from the cooperative NPS/DRBC summer program to perform analyses of present conditions, project future trends, and develop recommendations for maintaining existing water quality in the Middle Delaware watershed.

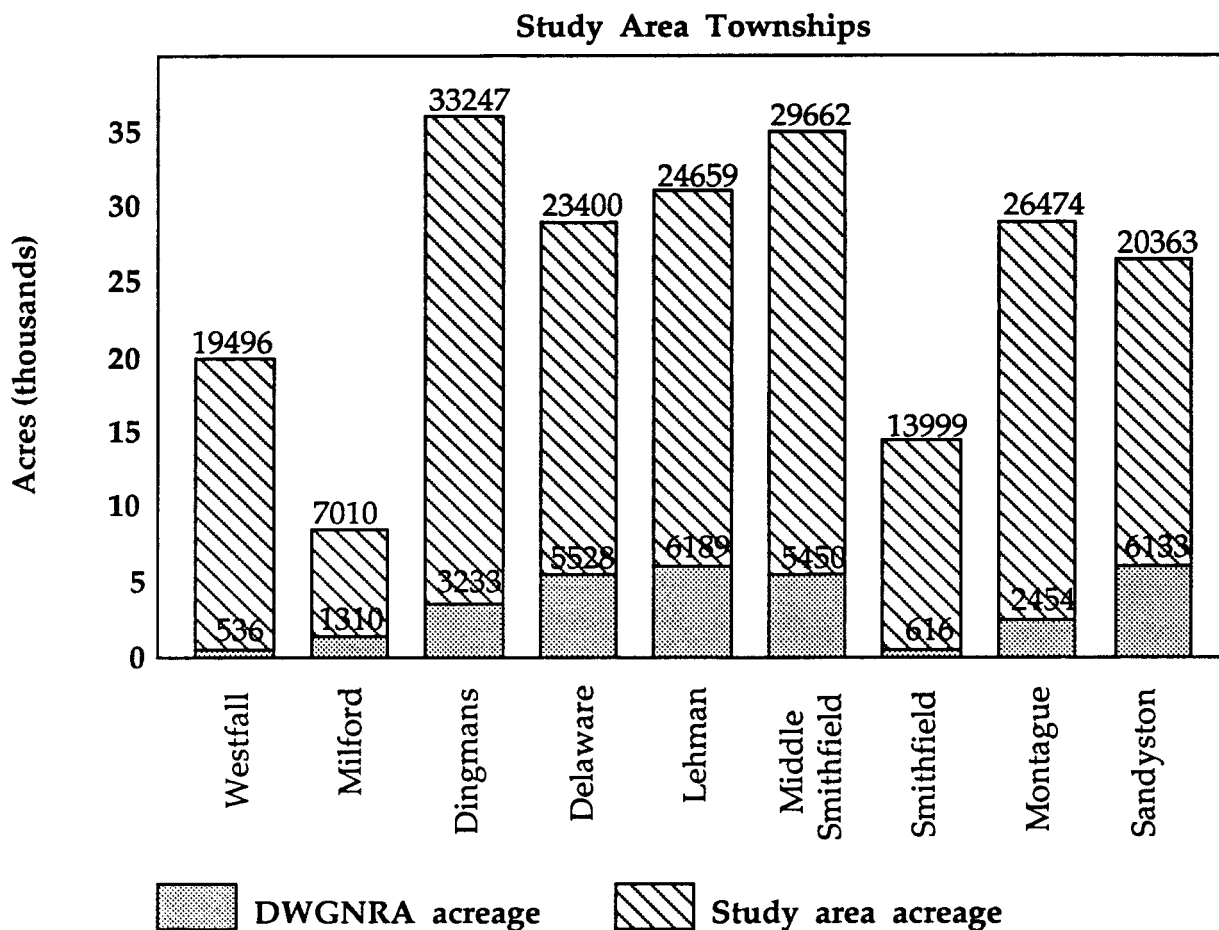
Numerous analyses can be performed using the dBase III databases, either alone or in combination with mapped information. Information on parcel classes and land use can be mapped or tabulated by county, township, or watershed in order to assess the type and intensity of human activity within the specified geographic unit, and each unit can be analyzed individually for any combination of parameters contained in the database. It is important to remember, when reviewing the data and projections presented below, that the mapped study area includes only the townships immediately adjacent to the National Recreation Area. National Recreation Area lands were excluded, as were lands contained within the boroughs of Matamoras, Milford, Delaware Water Gap, Stroudsburg, and East Stroudsburg; these borough lands were considered to be 100% developed. While this may not be strictly true, it was assumed for study purposes that they would not contribute further to water quality impacts generated by intensifying land use. In some cases, National Recreation Area acreage was calculated and entered into charts and tables for reference purposes; this has been done where specified only. Figure 6 presents National Recreation Area acreage as a percentage of township total for each of the study areas townships.

MAPS AND DATABASE

Mapped and tabular information from the land use database is presented below. Figures 7 through 16 present mapped information on parcel size for the study area as a whole and then for individual townships. Figures 17 through 36 and Tables 2 through 10 describe land use, first by study area and county, then by individual township. Table 11 lists land uses by combined categories (see below) for the twenty-nine watersheds that surround and contain the study area; Figures 37 through 90 provide mapped and tabular land use information by individual watershed. Bar graphs of township and watershed land use include Delaware Water Gap National Recreation Area acreage for comparative purposes. The seventeen land use categories were combined for some analyses in order to present an overview of impacts anticipated for various activity

types. The combined categories are described in Table 1; see the Appendix for a complete numerical listing of land use categories. All mapped and database information is valid as of July 1989.

FIGURE 6: Federal Acreage vs. Total Township Acreage



Note: assumes federal ownership of all land within the DWGNRA boundary; in reality, 19% of this land remains in private ownership.

TABLE 1: Combined Land Use Categories

DWGNRA	acres within Delaware Water Gap NRA
Conservation lands:	Category 10 All other state and federal lands
Other open lands:	Category 2 Vacant lands
	Category 3 Farm lands
	Category 6 Private hunting and fishing clubs
	Category 7 Camps
	Category 8 Campgrounds
	Category 9 Golf courses
	Category 15 Reserved open space within a development
Development-owned:	Category 12 Development - existing
	Category 13 Development - proposed or in progress
	Category 14 Resorts
	Category 16 Developer-owned but not subdivided
Other built-up lands:	Category 1 Residential lands
	Category 4 Commerical lands
	Category 5 Industrial lands
	Category 11 Other Quasi-public lands
Unknown:	Category 17 Use unknown

Note: "DWGNRA acres" includes most acres lying inside the National Recreation Area boundary, exclusive of ownership. State lands and all private inholdings are included, with the exception of one 500-acre tract which was acquired by the federal government after data analysis was completed.

FIGURE 7: Study Area Parcels

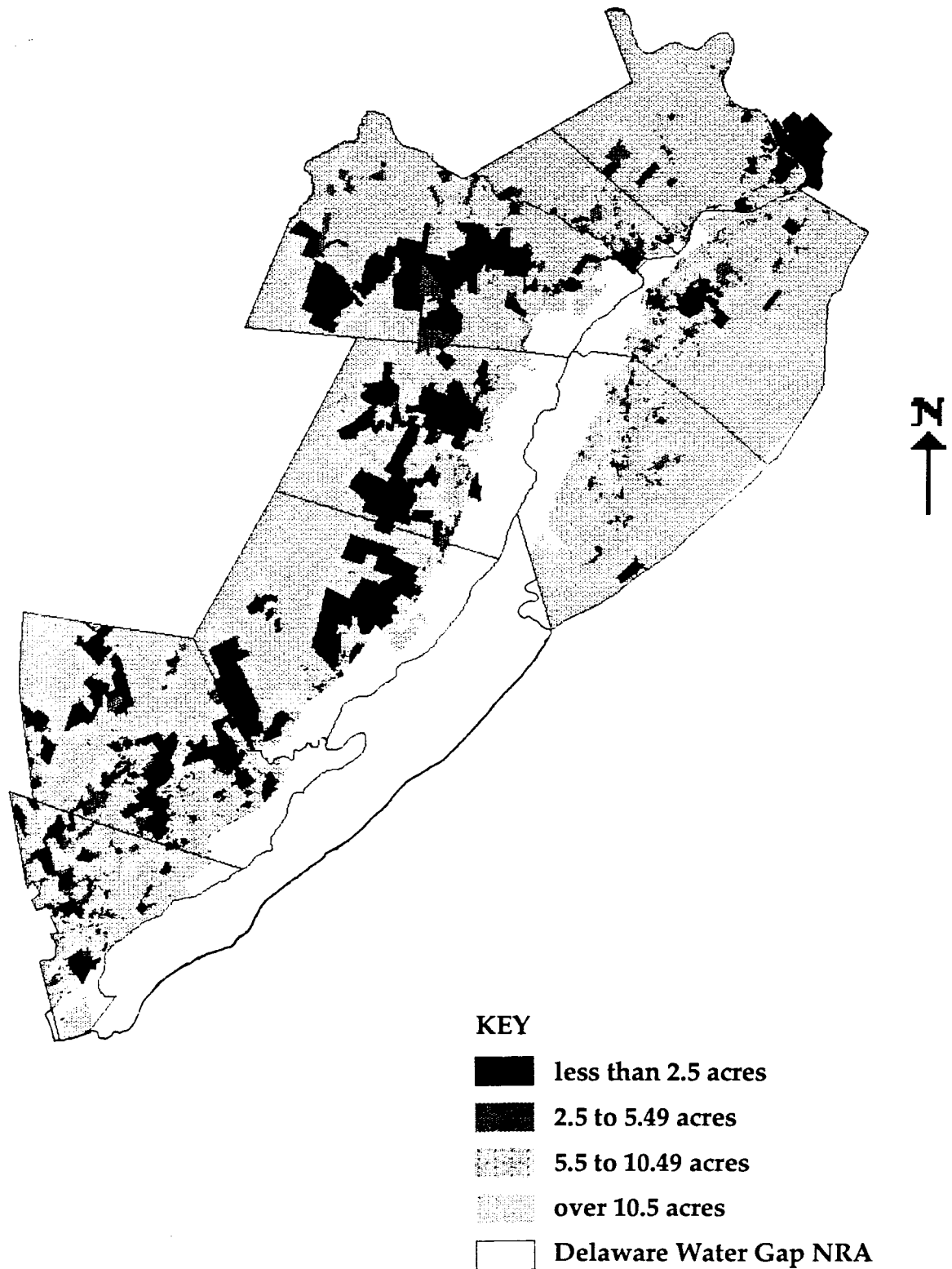


FIGURE 8: Parcels • Westfall Township

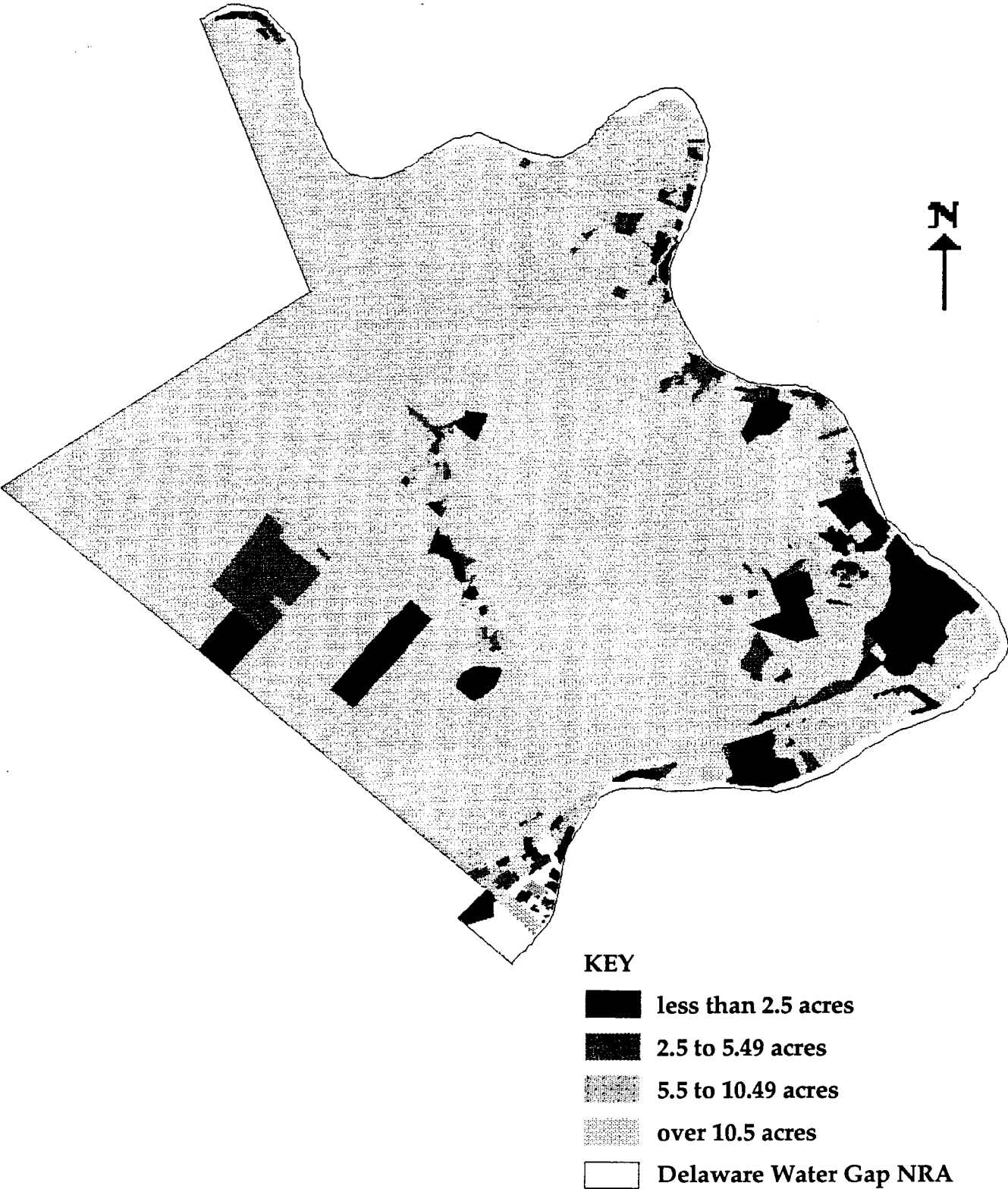


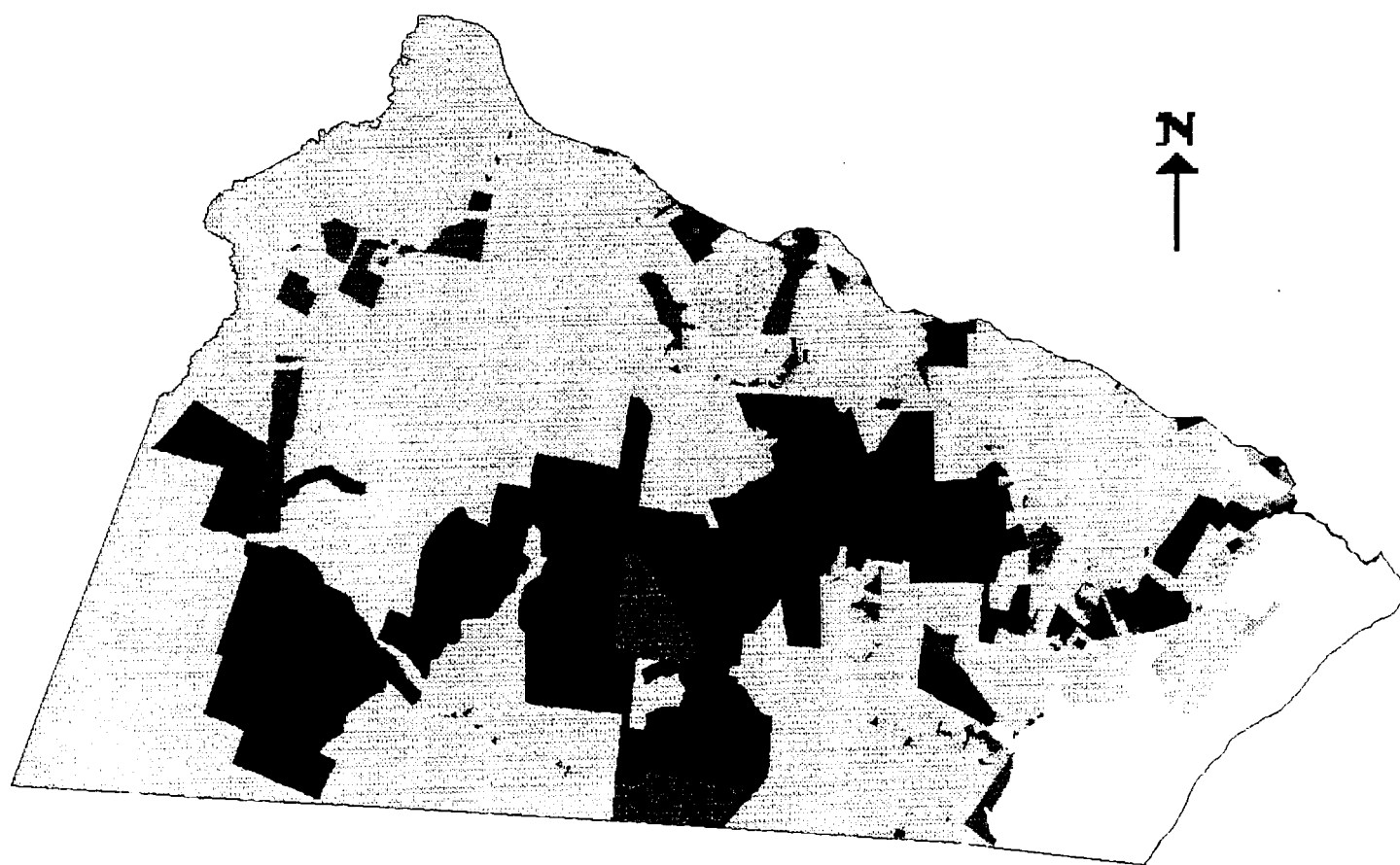
FIGURE 9: Parcels • Milford Township



KEY

-  less than 2.5 acres
-  2.5 to 5.49 acres
-  5.5 to 10.49 acres
-  over 10.5 acres
-  Delaware Water Gap NRA

FIGURE 10: Parcels • Dingmans Township



KEY

-  less than 2.5 acres
-  2.5 to 5.49 acres
-  5.5 to 10.49 acres
-  over 10.5 acres
-  Delaware Water Gap NRA

FIGURE 11: Parcels • Delaware Township

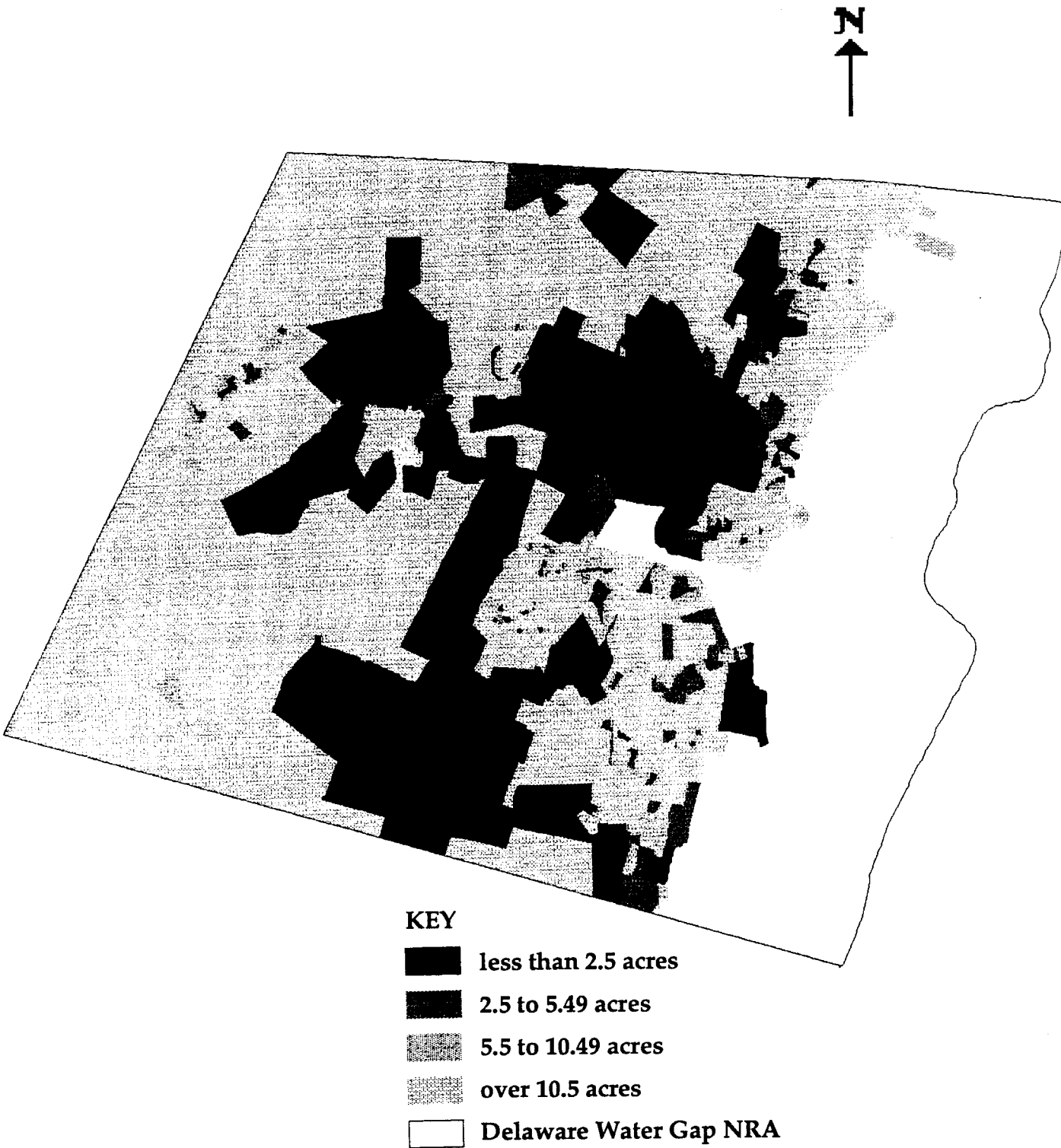


FIGURE 12: Parcels • Lehman Township

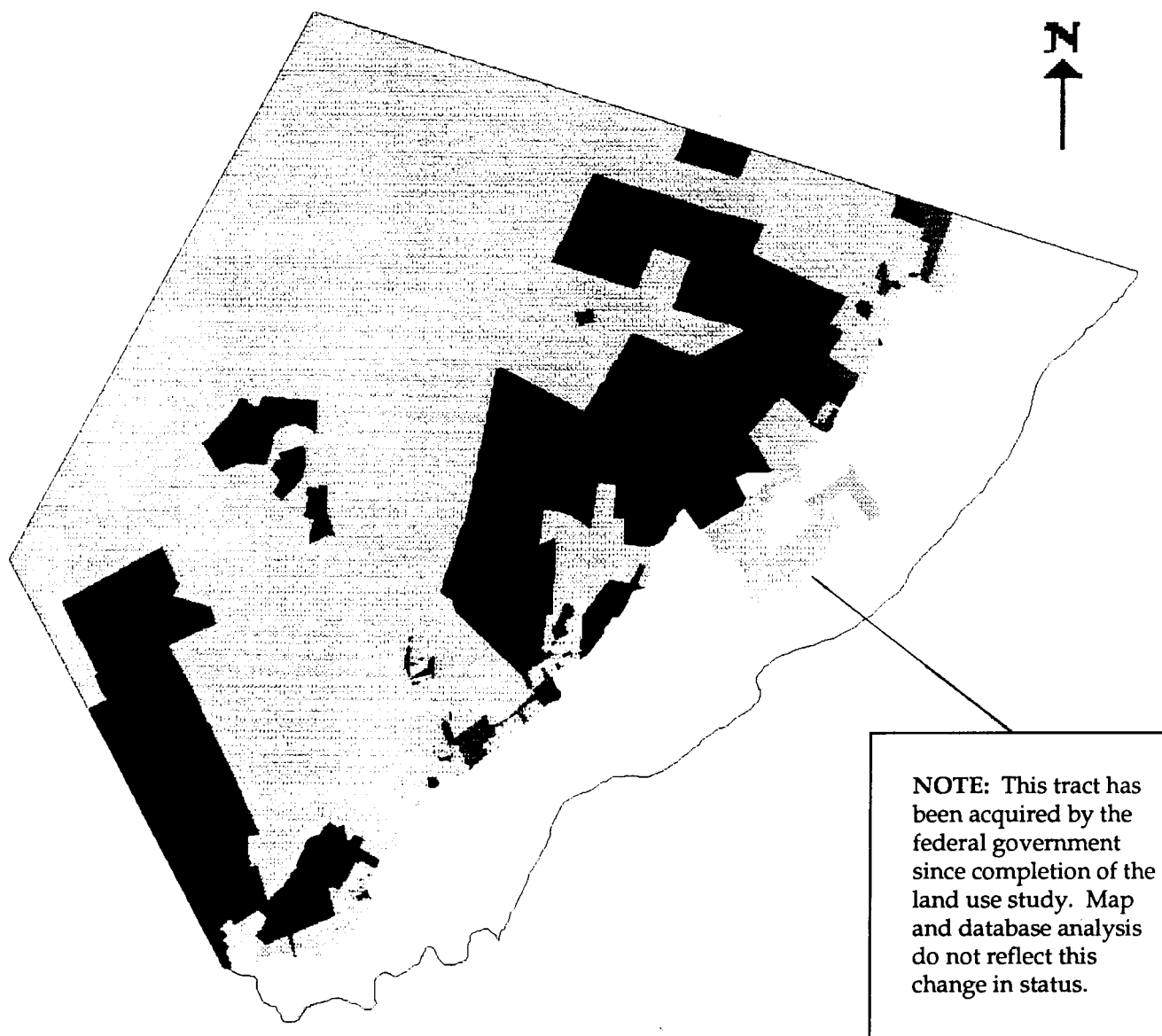


FIGURE 13: Parcels • Middle Smithfield Township

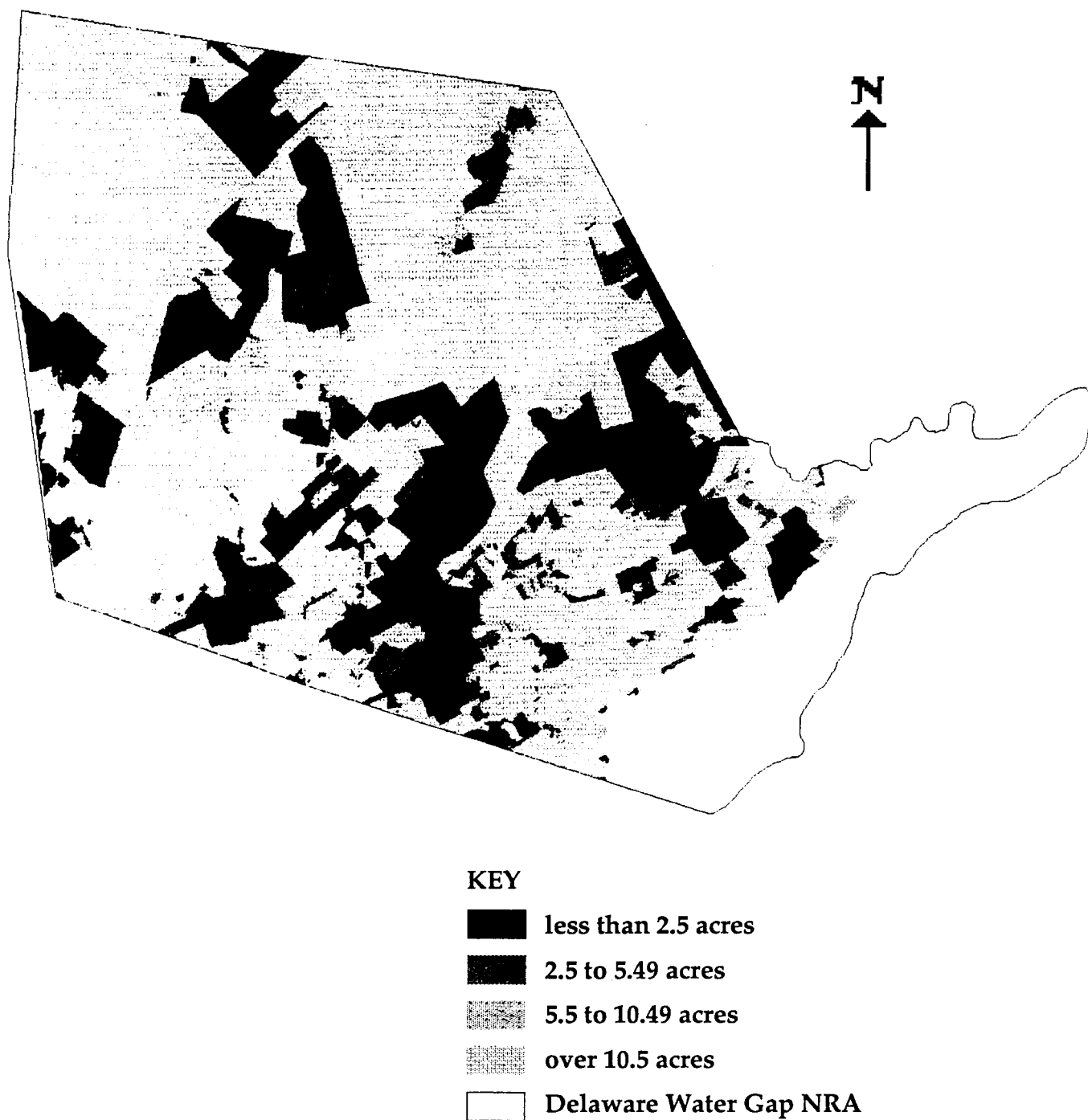


FIGURE 15: Parcels • Montague Township

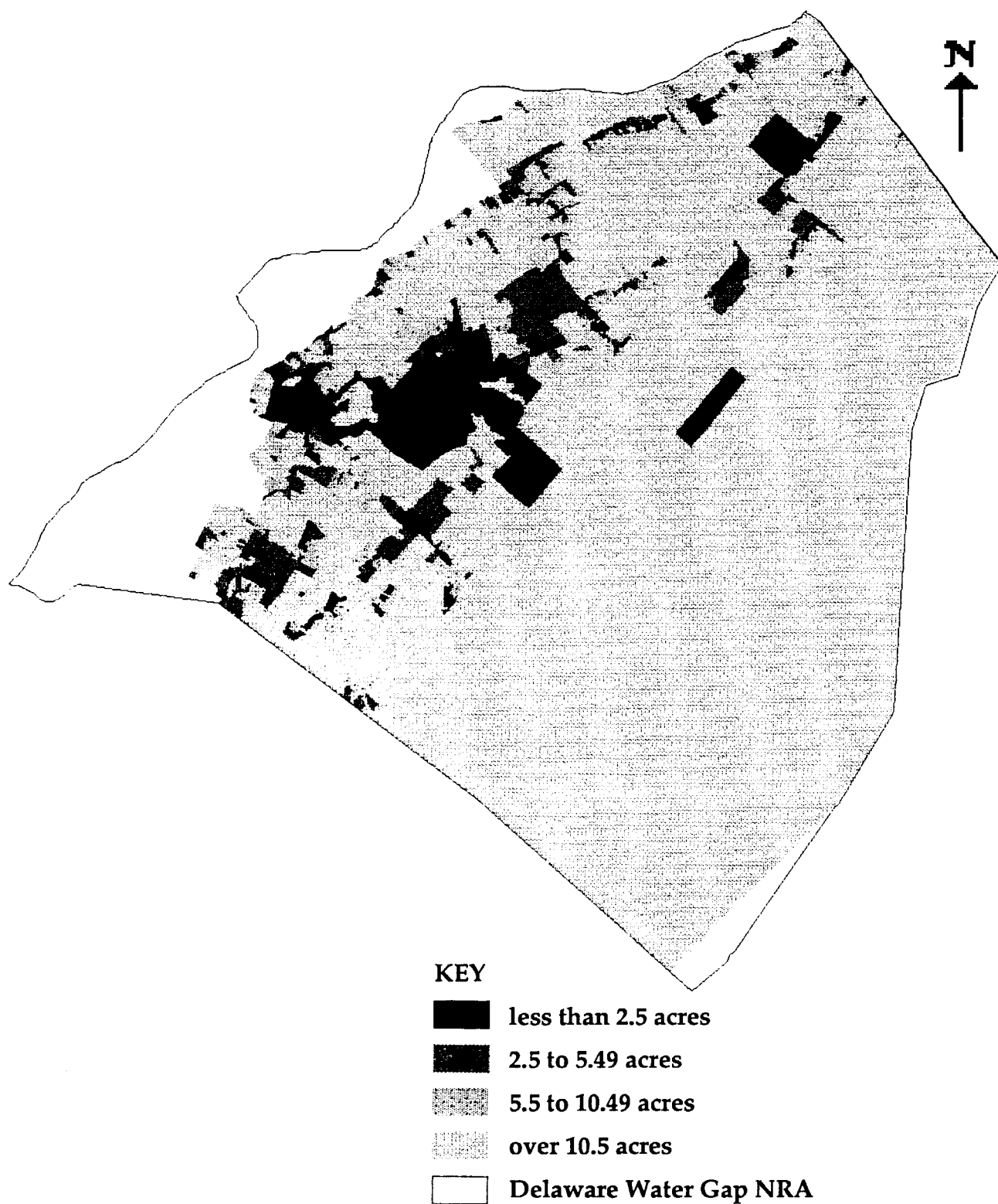
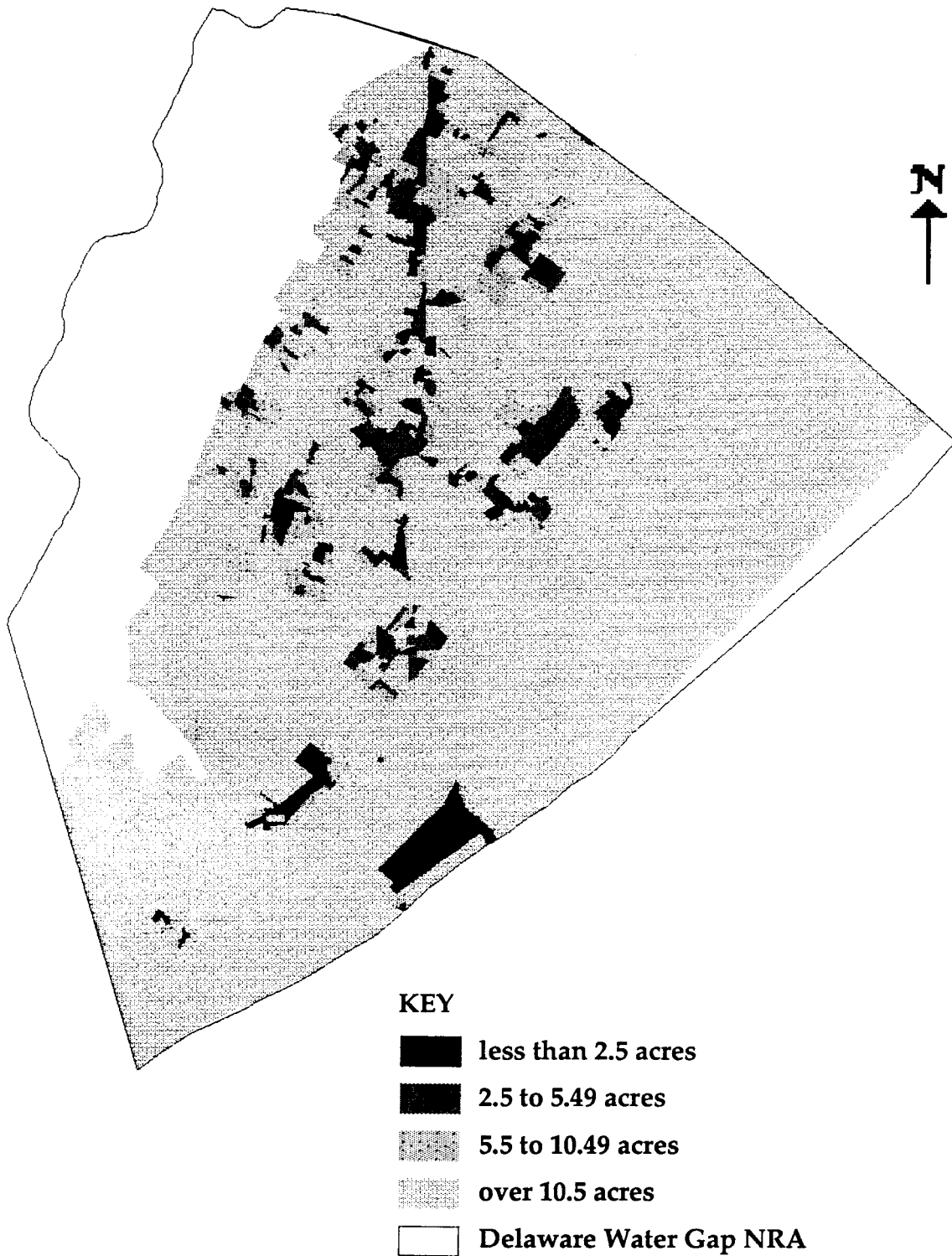


FIGURE 16: Parcels • Sandyston Township



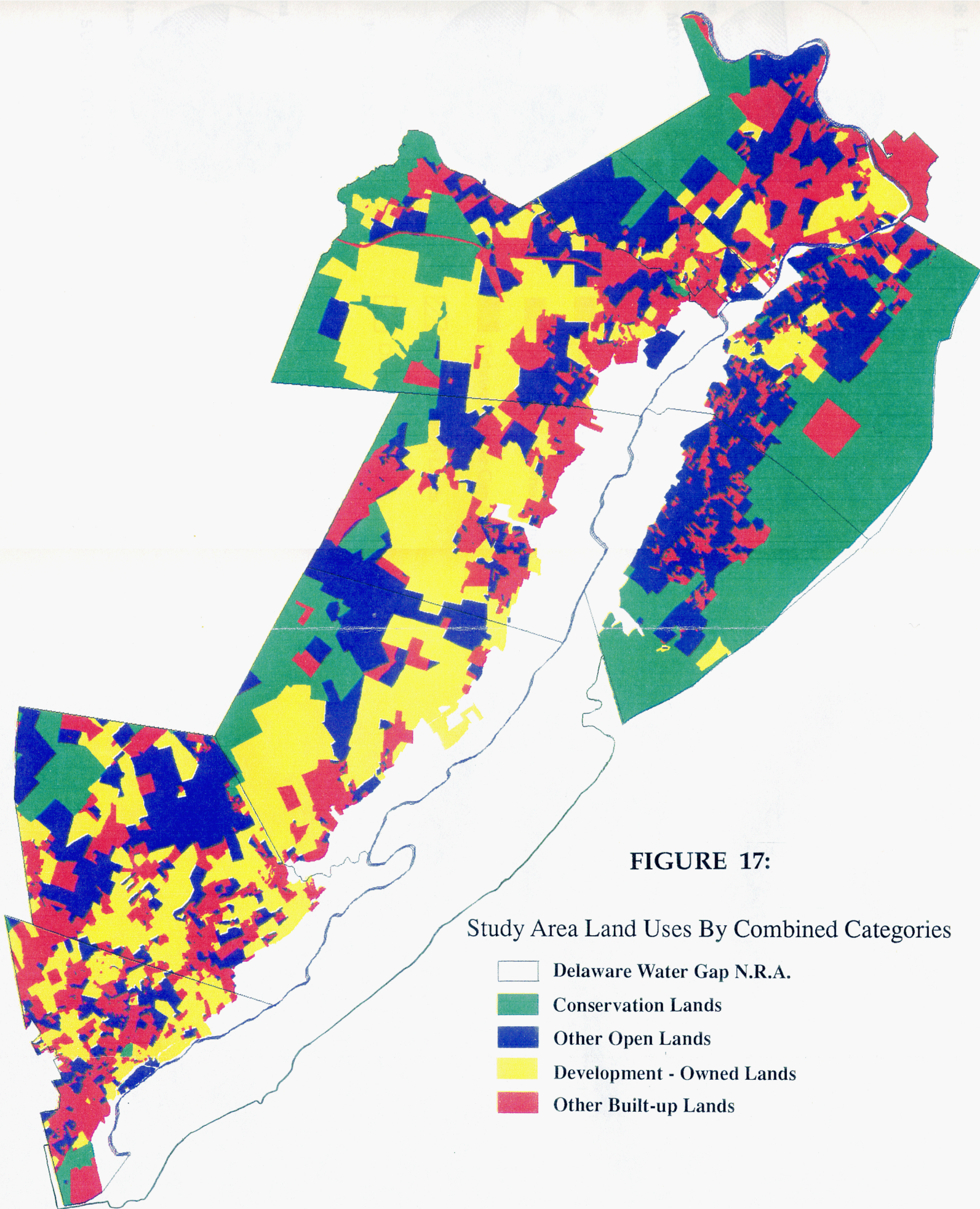


FIGURE 18: Land Use by County for Study Area Townships

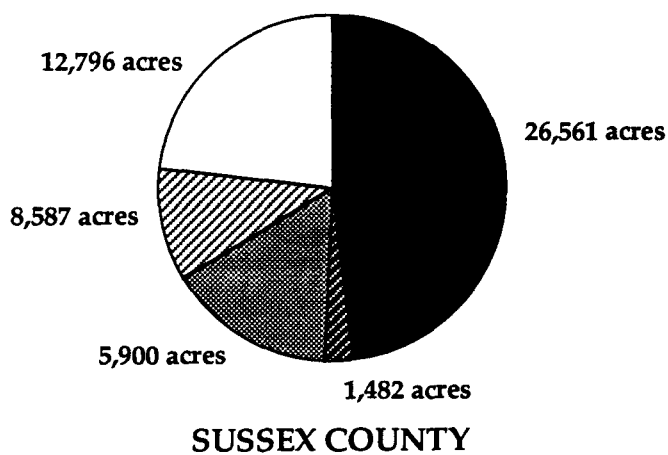
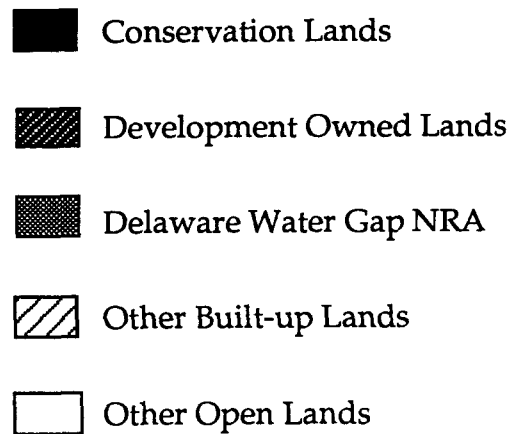
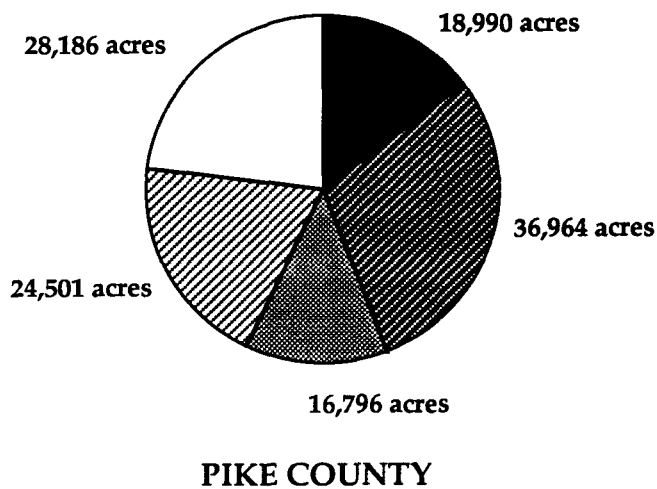
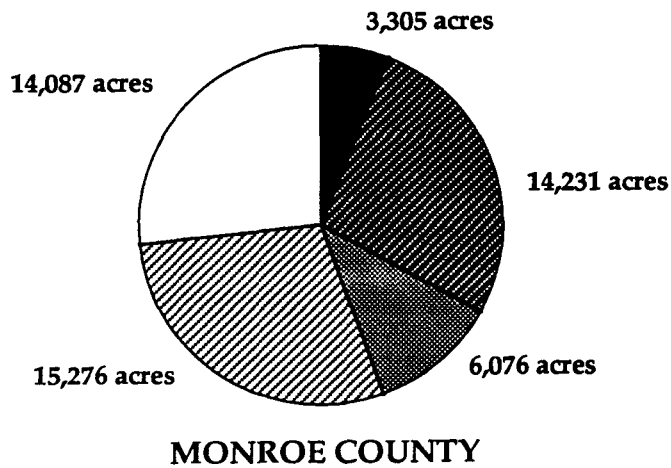


FIGURE 19: Land Use • Westfall Township

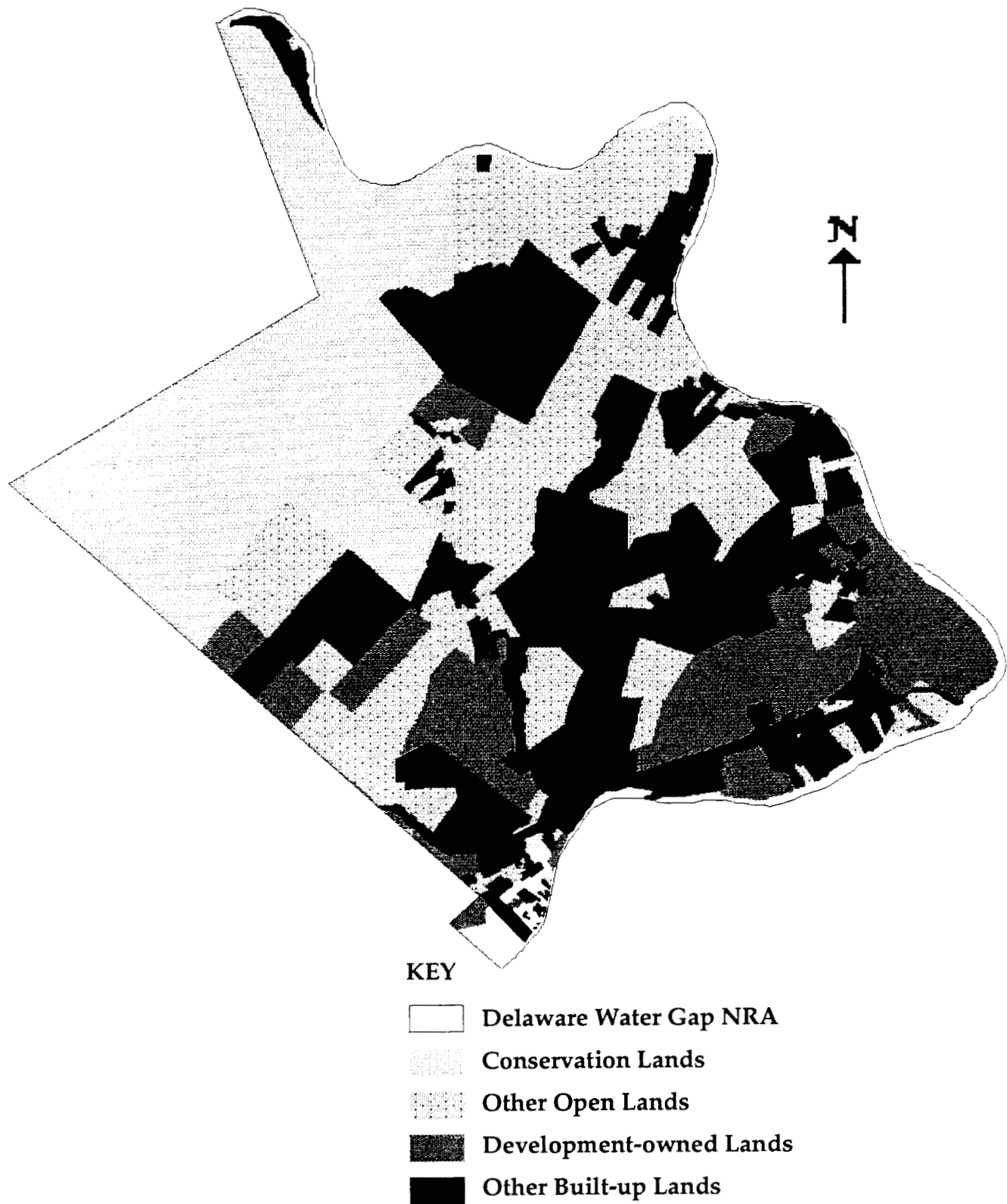


TABLE 2: Land Use • WESTFALL TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	6732	317	349
Vacant	3469	128	0
Farm	170	2	0
Commercial	272	26	49
Industrial	22	2	9
Hunting/Fishing	1195	3	2
Camps	0	0	0
Campgrounds	46	1	11
Golfcourses	0	0	0
Other State & Federal lands	5068	67	4
Quasi-public	183	8	24
Existing development	779	817	272
Proposed development	810	99	1
Resorts	196	2	16
Reserved	0	0	0
Unsubdivided	503	2	0
Data not available	51	3	0
TOTAL	19496	1477	737

FIGURE 20: Acreage By Use Type • WESTFALL TOWNSHIP

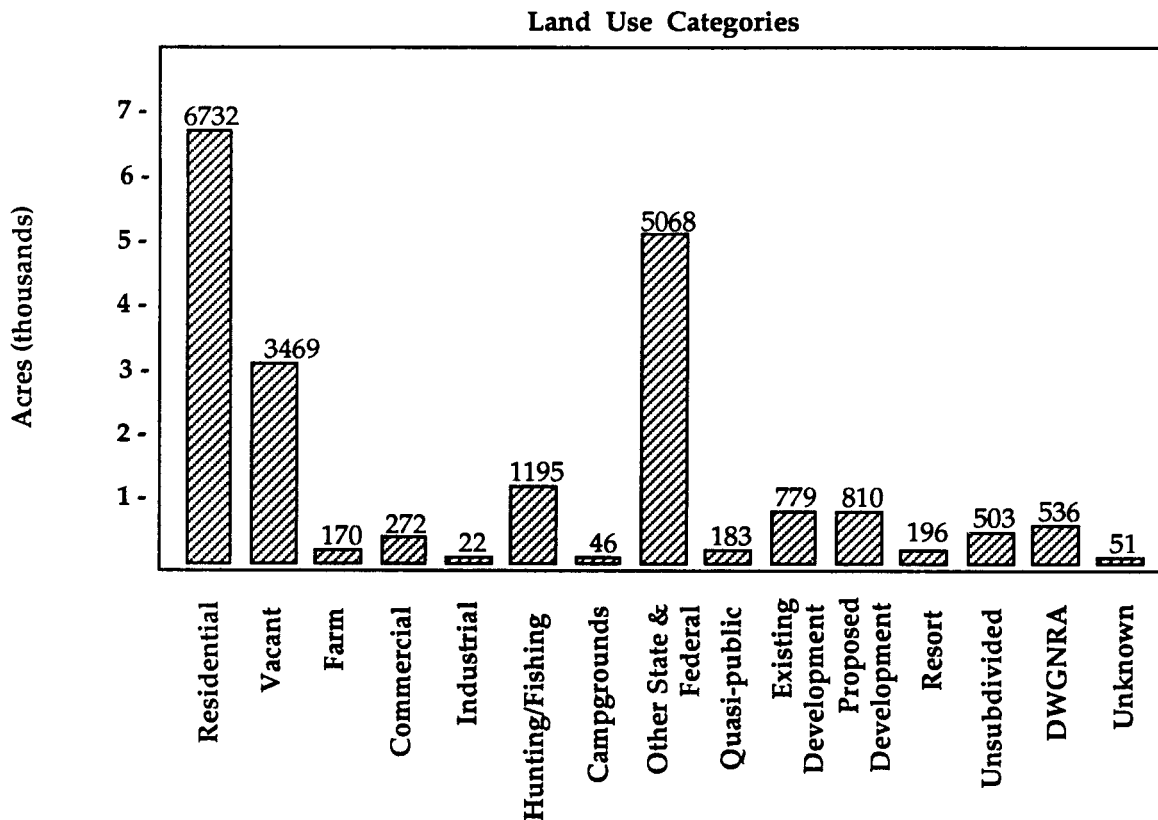
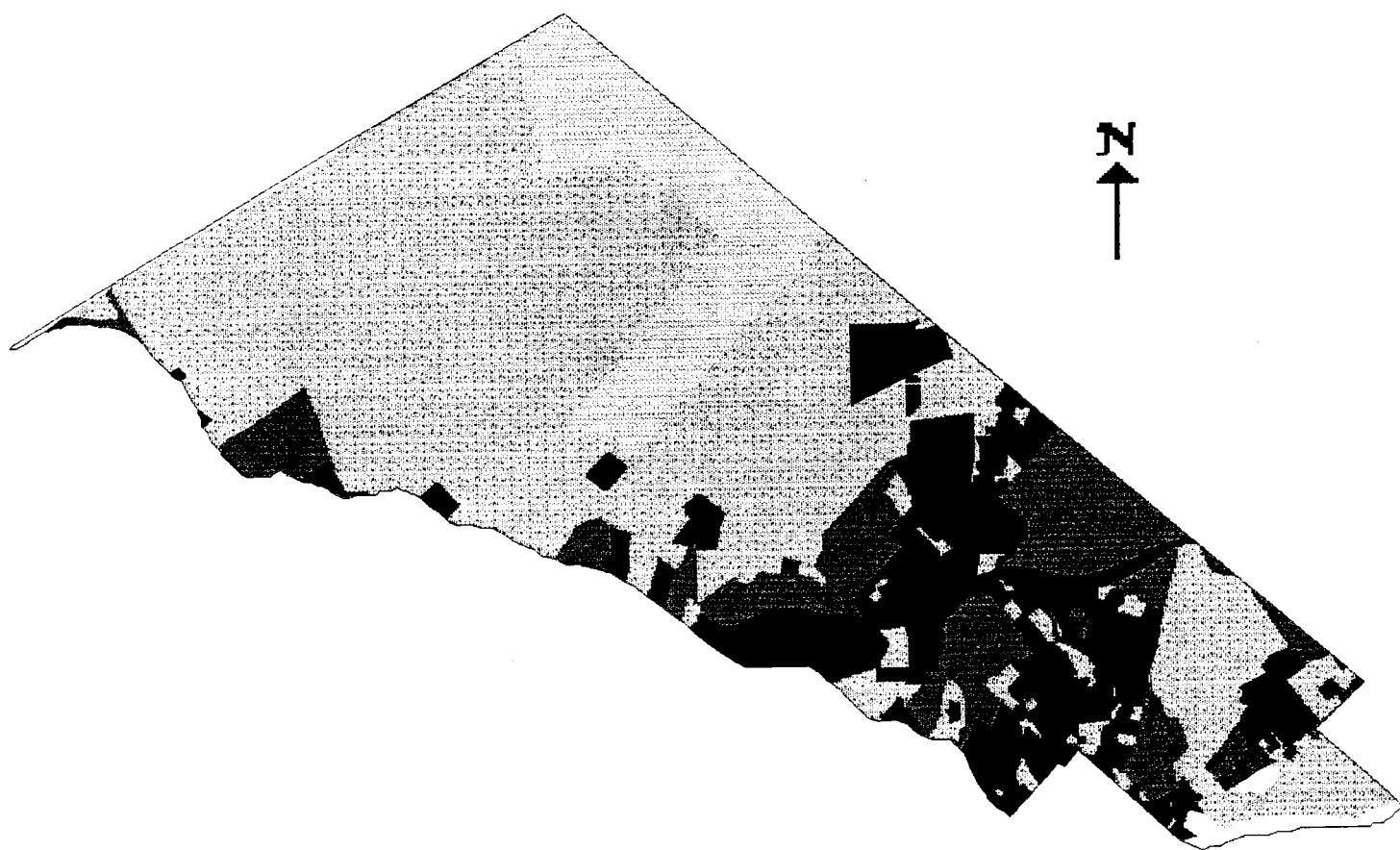


FIGURE 21: Land Use • Milford Township



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

TABLE 3: Land Use • MILFORD TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	1080	301	302
Vacant	2770	90	0
Farm	124	1	5
Commercial	205	46	98
Industrial	0	0	0
Hunting/Fishing	0	0	0
Camps	1663	3	8
Campgrounds	0	0	0
Golfcourses	0	0	0
Other State & Federal lands	125	4	18
Quasi-public	32	5	2
Existing development	542	298	130
Proposed development	350	3	0
Resorts	0	0	0
Reserved	0	0	0
Unsubdivided	118	3	1
Data not available	1	1	0
TOTAL	7010	755	564

FIGURE 22: Acreage By Use Type • MILFORD TOWNSHIP

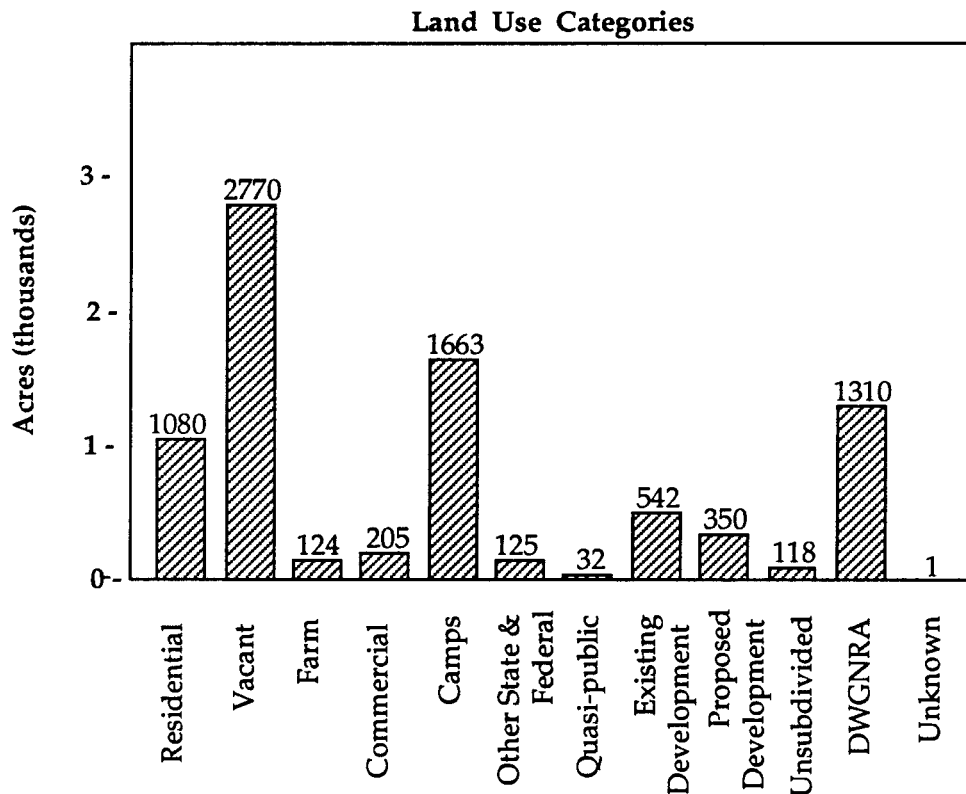
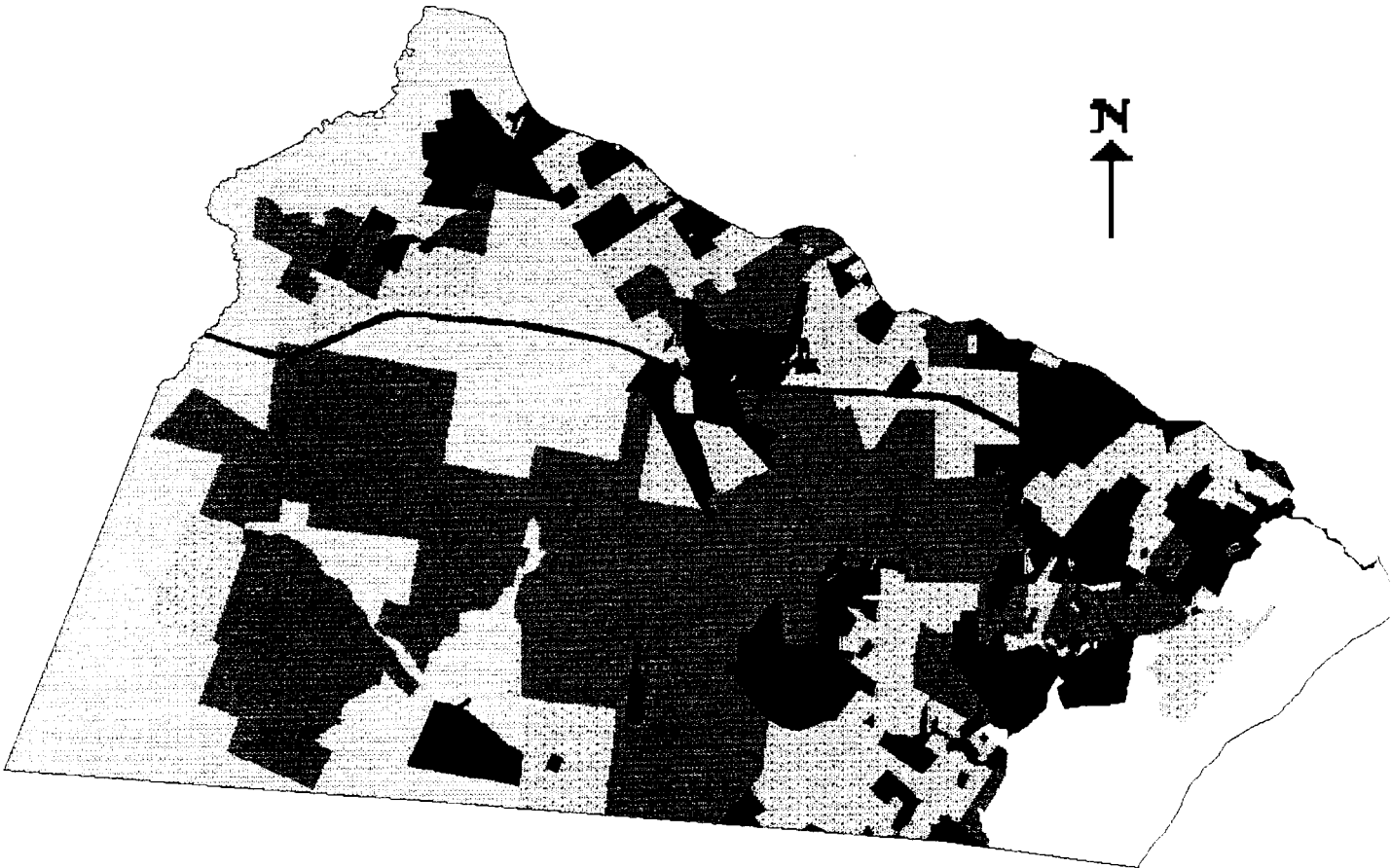


FIGURE 23: Land Use • Dingmans Township



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

TABLE 4: Land Use • DINGMANS TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	5708	356	387
Vacant	3946	132	0
Farm	0	0	0
Commercial	72	11	47
Industrial	275	6	6
Hunting/Fishing	344	2	1
Camps	2579	7	272
Campgrounds	0	0	0
Golfcourses	455	1	20
Other State & Federal lands	7217	8	0
Quasi-public	61	19	15
Existing development	9632	9299	3686
Proposed development	203	1	15
Resorts	0	0	0
Reserved	59	2	0
Unsubdivided	2694	7	5
Data not available	2	1	0
TOTAL	33247	9852	4454

FIGURE 24: Acreage By Use Type • DINGMANS TOWNSHIP

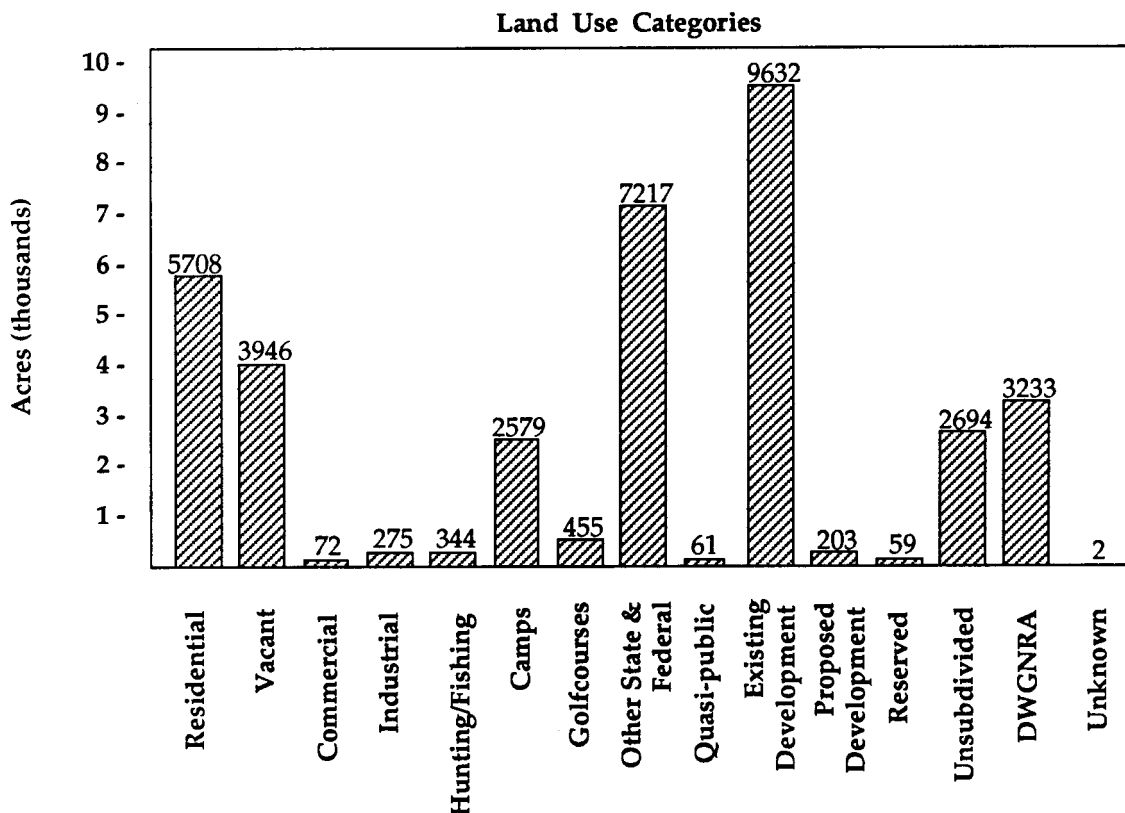


FIGURE 25: Land Use • Delaware Township

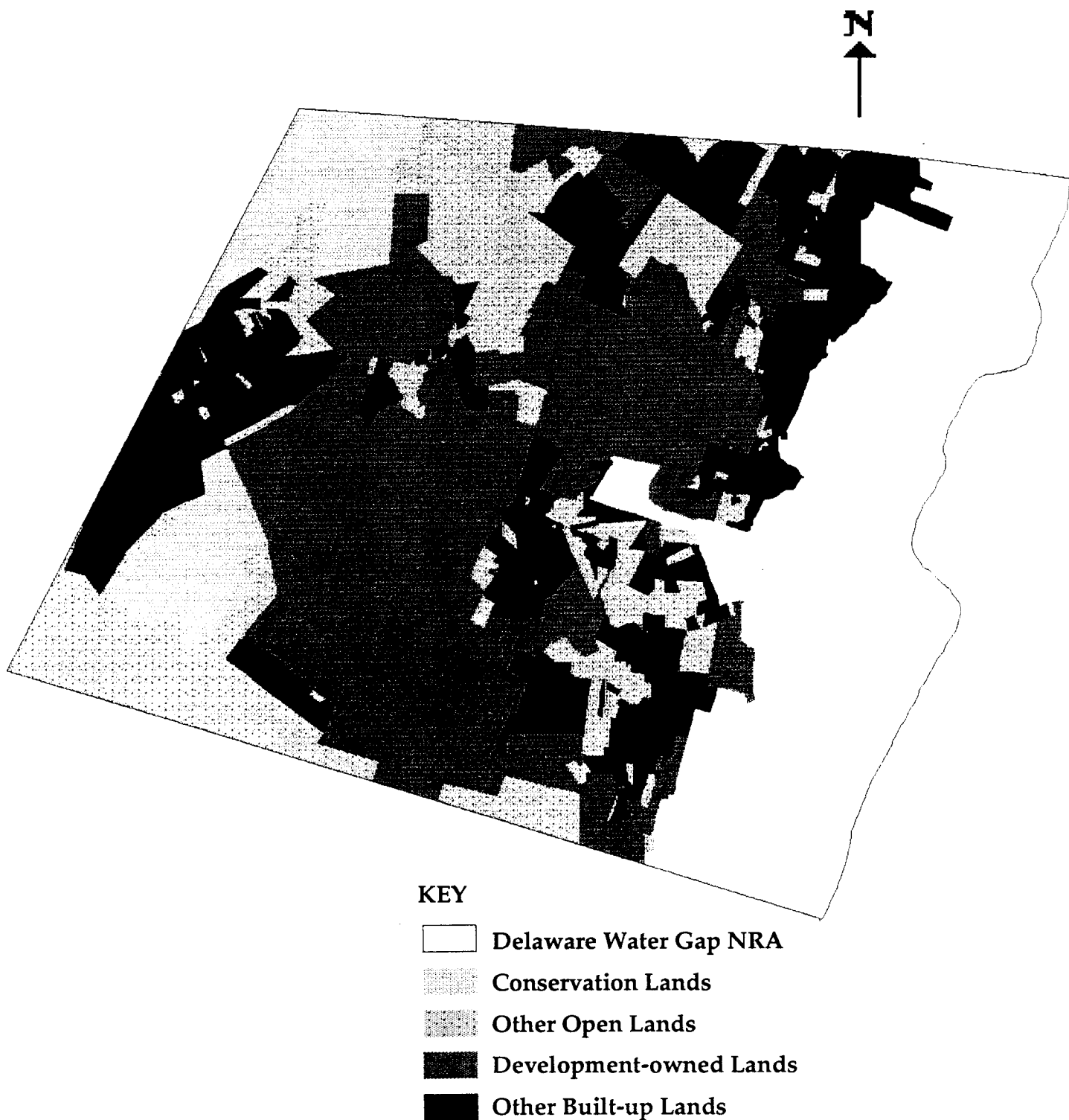


TABLE 5: Land Use • DELAWARE TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	5565	313	297
Vacant	2828	124	0
Farm	0	0	0
Commercial	107	50	27
Industrial	11	1	2
Hunting/Fishing	930	19	43
Camps	1594	5	118
Campgrounds	18	1	60
Golfcourses	0	0	0
Other State & Federal lands	2162	3	1
Quasi-public	222	14	13
Existing development	8240	11498	2568
Proposed development	0	0	0
Resorts	0	0	0
Reserved	0	0	0
Unsubdivided	1723	3	2
Data not available	0	1	74
TOTAL	23400	12032	3205

FIGURE 26: Acreage By Use Type • DELAWARE TOWNSHIP

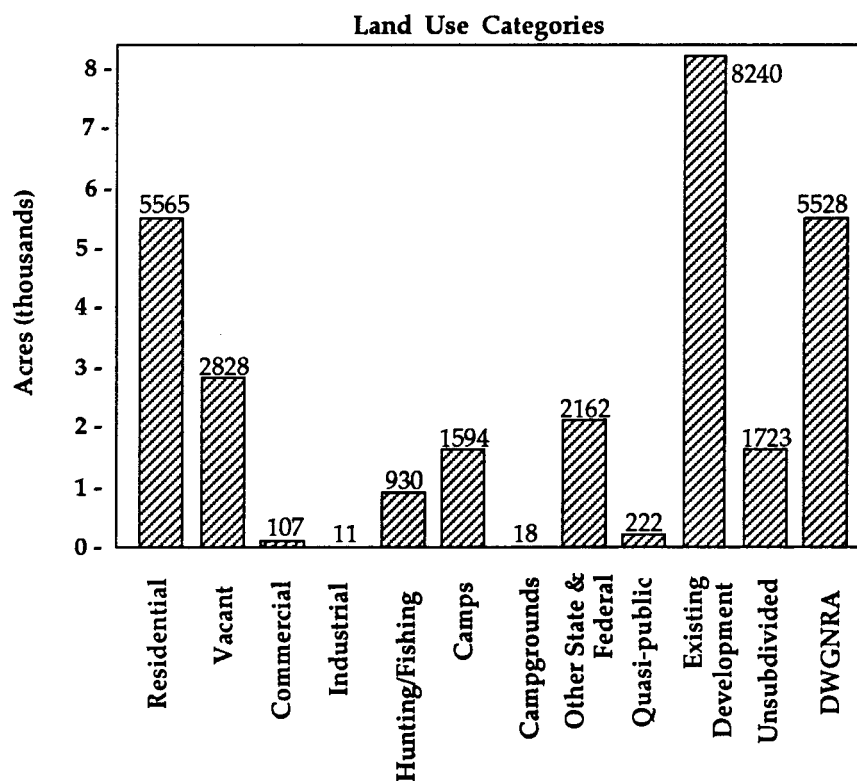


FIGURE 27: Land Use • Lehman Township

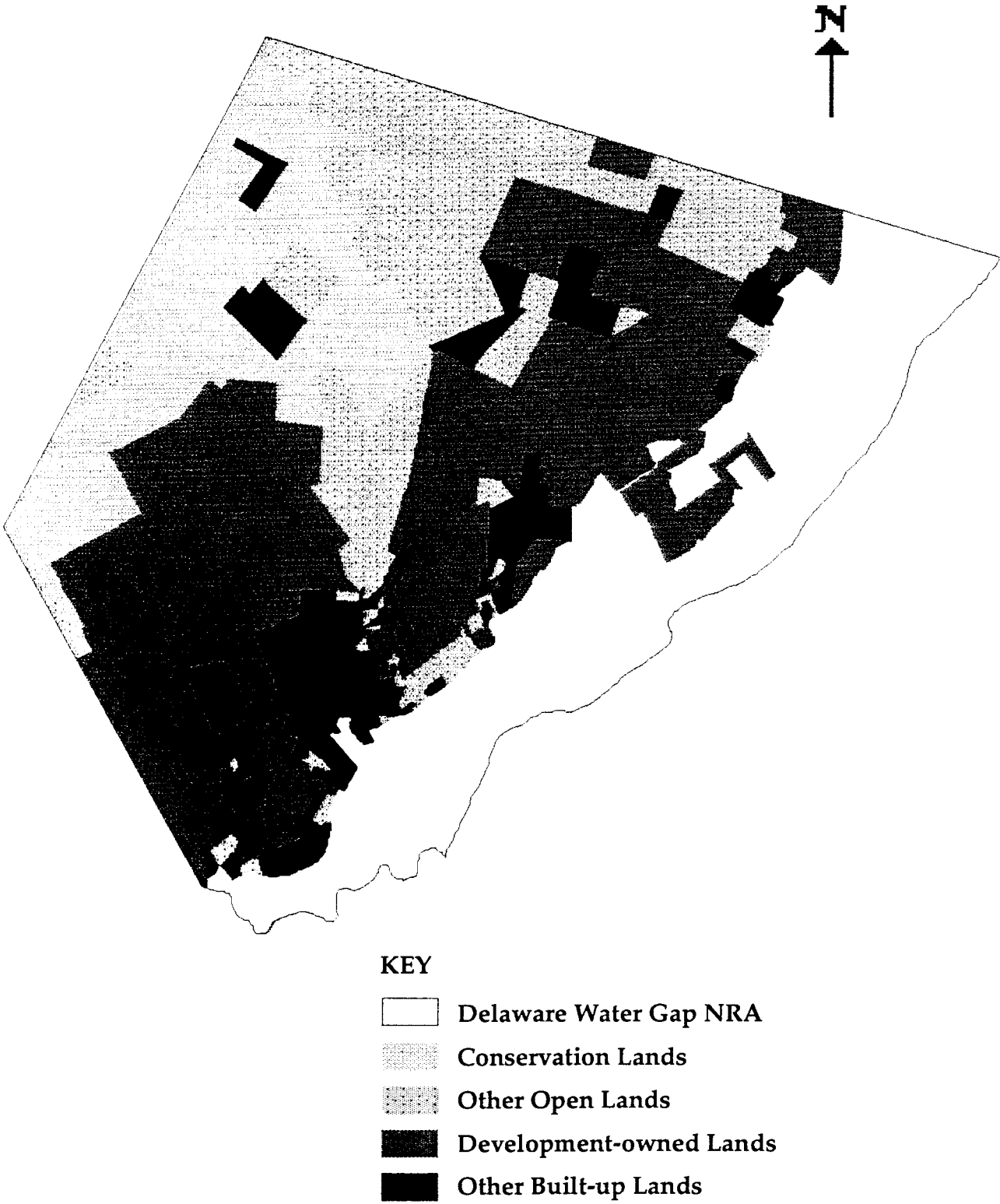


TABLE 6: Land Use • LEHMAN TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	2627	116	141
Vacant	1049	49	0
Farm	0	0	0
Commercial	30	11	34
Industrial	0	0	0
Hunting/Fishing	3648	6	5
Camps	1176	2	27
Campgrounds	0	0	0
Golfcourses	110	1	0
Other State & Federal lands	4442	4	0
Quasi-public	392	3	4
Existing development	8092	9133	2694
Proposed development	1056	3	34
Resorts	2024	2	107
Reserved	0	0	0
Unsubdivided	0	0	0
Data not available	13	3	0
TOTAL	24659	9333	3046

FIGURE 28: Acreage By Use Type • LEHMAN TOWNSHIP

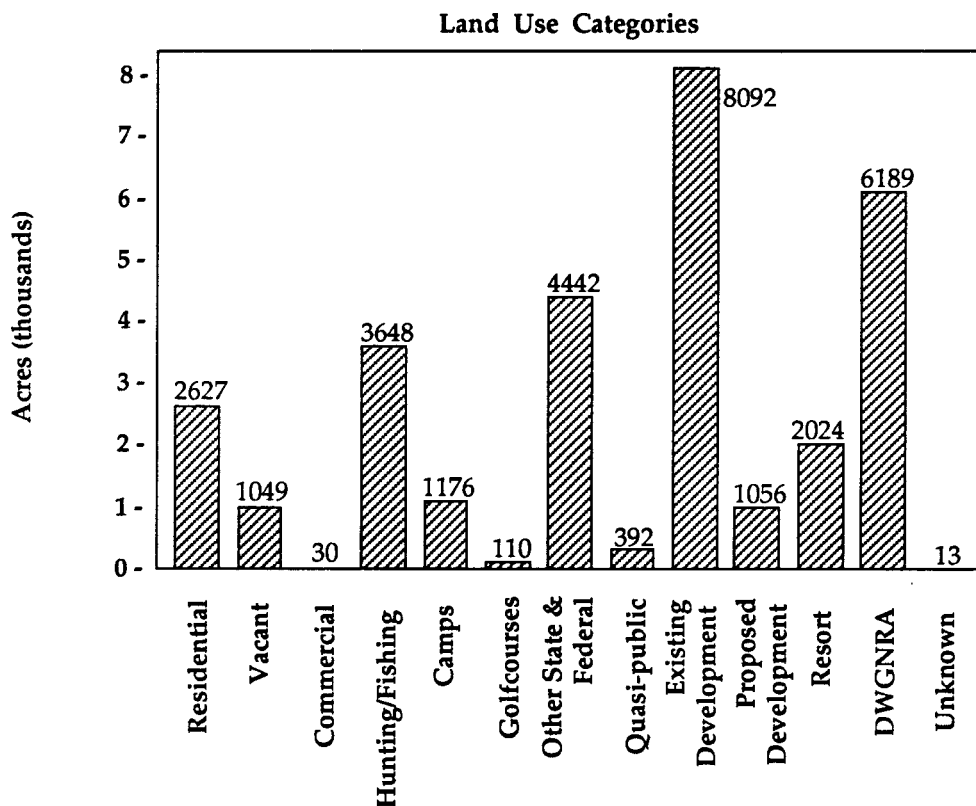


FIGURE 29: Land Use • Middle Smithfield Township



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

TABLE 7: Land Use • MIDDLE SMITHFIELD TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	5733	668	641
Vacant	4649	272	0
Farm	328	2	1
Commercial	86	10	9
Industrial	9	2	2
Hunting/Fishing	1472	5	1
Camps	4537	11	120
Campgrounds	43	1	0
Golfcourses	27	1	1
Other State & Federal lands	2520	13	1
Quasi-public	888	13	7
Existing development	6411	7994	3128
Proposed development	1350	3301	60
Resorts	356	4	407
Reserved	0	0	0
Unsubdivided	1236	41	31
Data not available	17	11	69
TOTAL	29662	12349	4478

FIGURE 30: Acreage By Use Type • MIDDLE SMITHFIELD TOWNSHIP

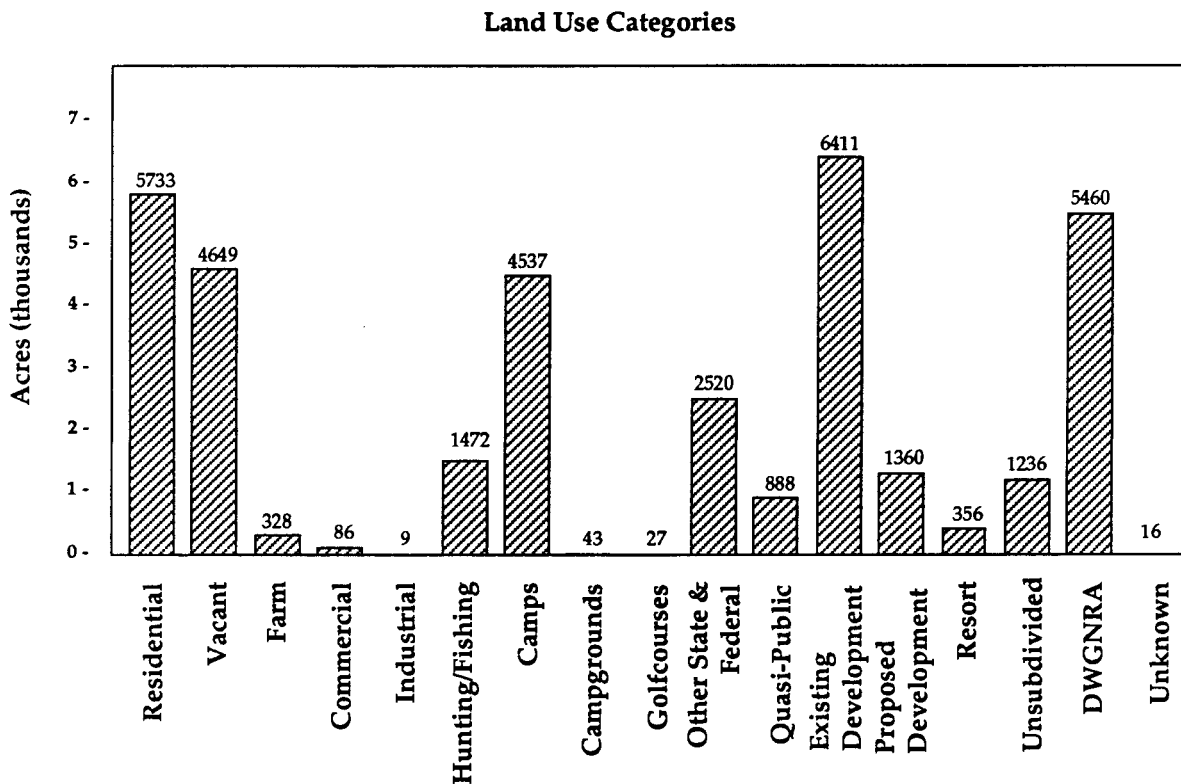


FIGURE 31: Land Use • Smithfield Township

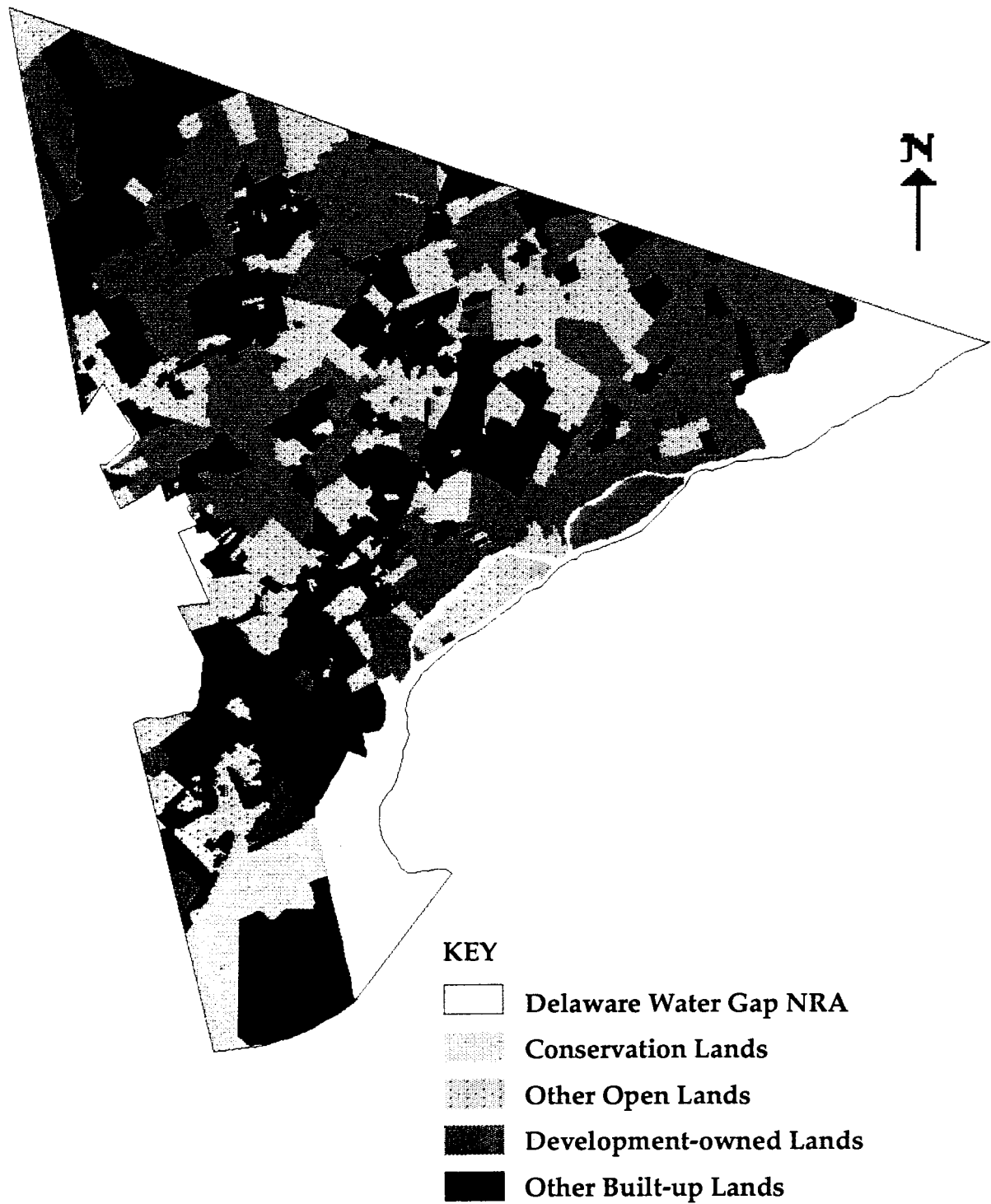


TABLE 8: Land Use • SMITHFIELD TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	2961	567	561
Vacant	1991	201	0
Farm	416	12	9
Commercial	628	65	56
Industrial	417	5	1
Hunting/Fishing	99	9	9
Camps	0	0	0
Campgrounds	525	5	31
Golfcourses	0	0	0
Other State & Federal lands	785	10	5
Quasi-public	1216	33	15
Existing development	1993	1819	1052
Proposed development	102	1	1
Resorts	1268	44	181
Reserved	0	0	0
Unsubdivided	1515	28	10
Data not available	83	7	0
TOTAL	13999	2806	1931

FIGURE 32: Acreage By Use Type • SMITHFIELD TOWNSHIP

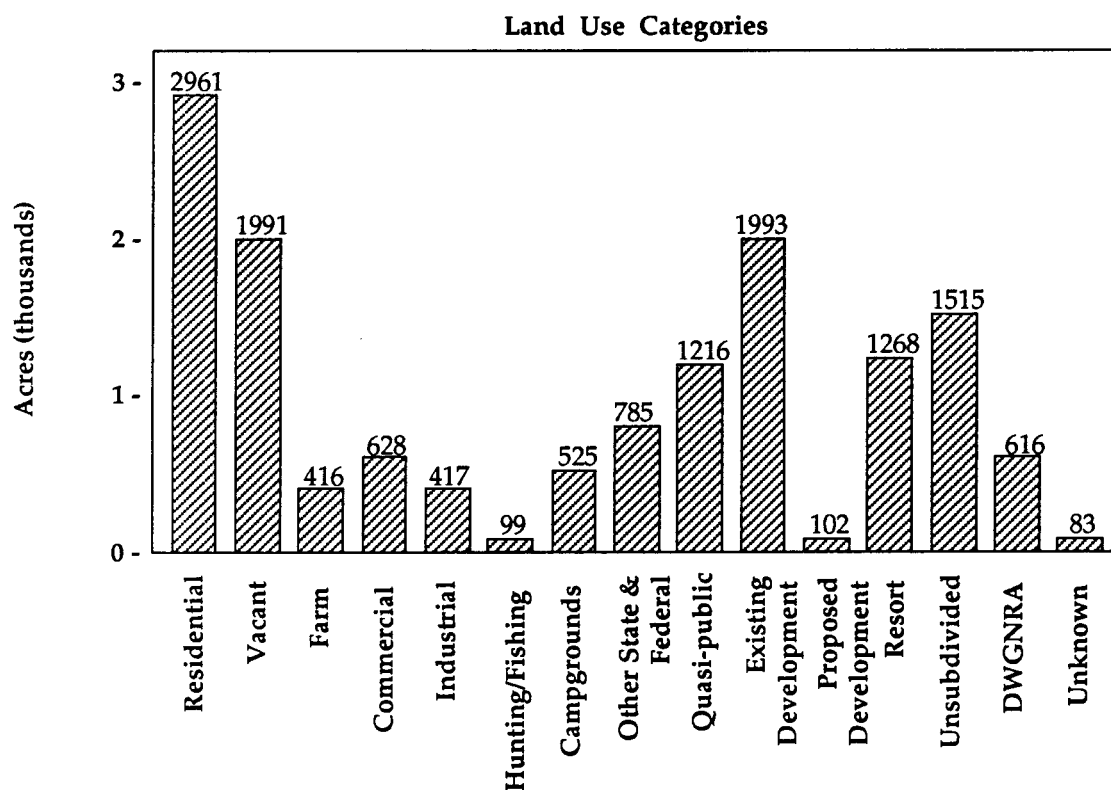


FIGURE 33: Land Use • Montague Township

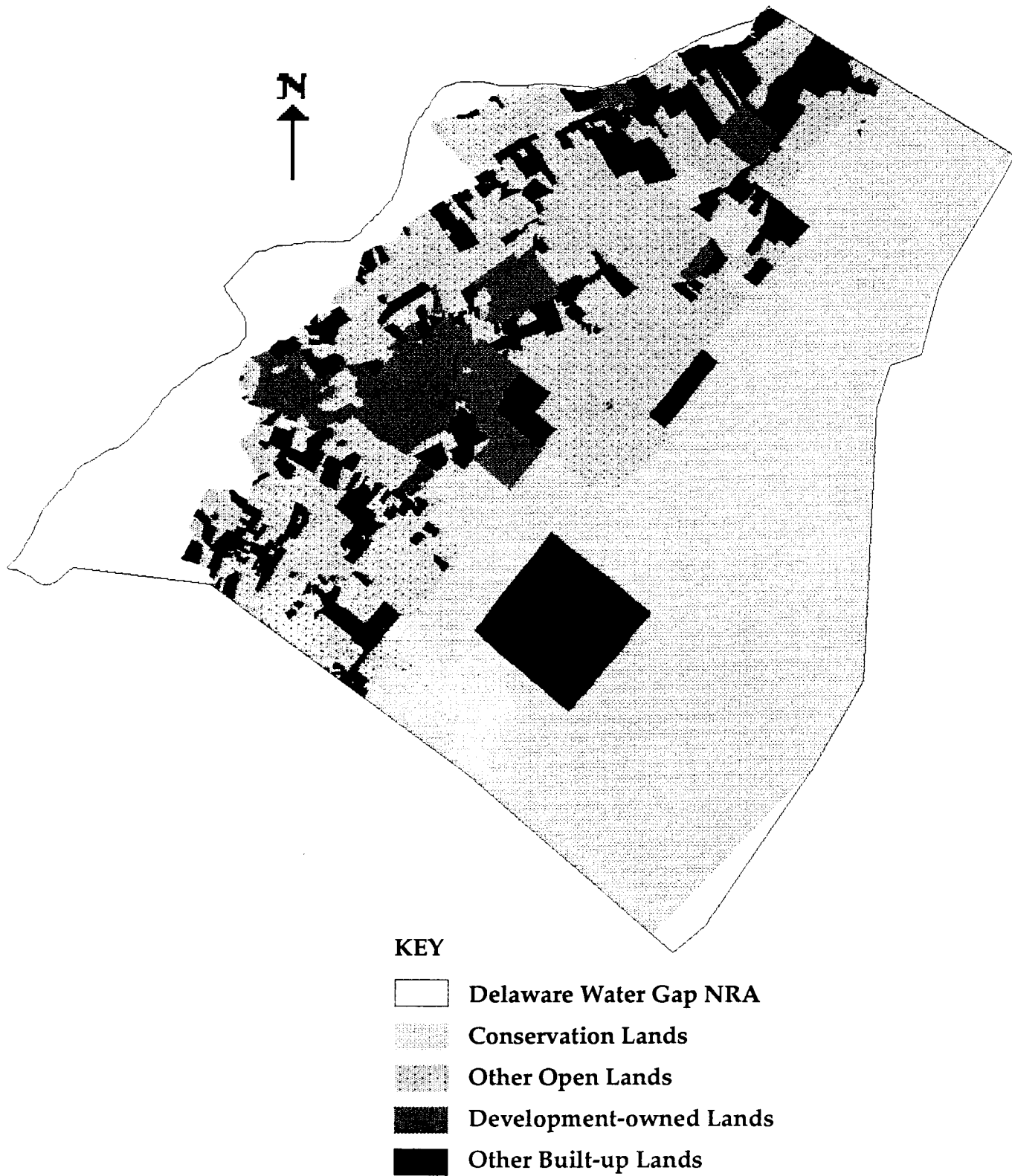


TABLE 9: Land Use • MONTAGUE TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	2392	601	441
Vacant	2784	329	0
Farm	3712	80	38
Commercial	1232	26	25
Industrial	6	2	1
Hunting/Fishing	0	0	0
Camps	0	0	0
Campgrounds	0	0	0
Golfcourses	59	1	1
Other State & Federal lands	14490	23	1
Quasi-public	69	8	6
Existing development	758	1093	592
Proposed development	221	36	0
Resorts	0	0	0
Reserved	271	12	0
Unsubdivided	395	19	0
Data not available	85	15	2
TOTAL	26474	2245	1107

FIGURE 34: Acreage By Use Type • MONTAGUE TOWNSHIP

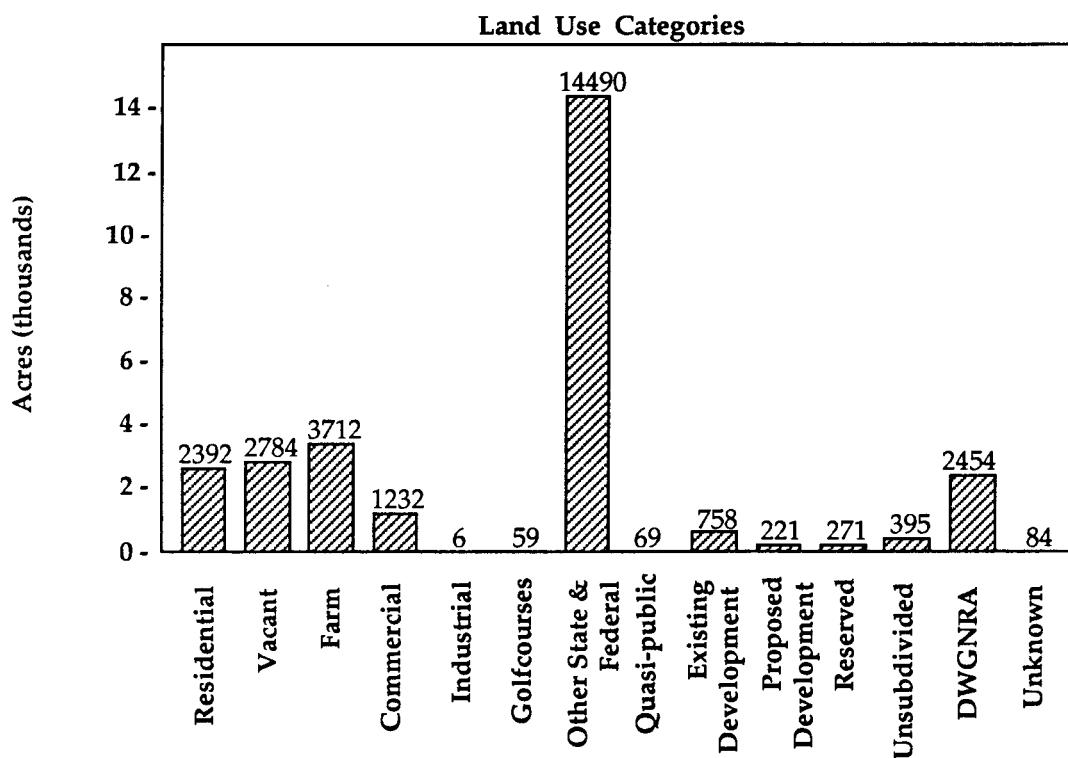


FIGURE 35: Land Use • Sandyston Township

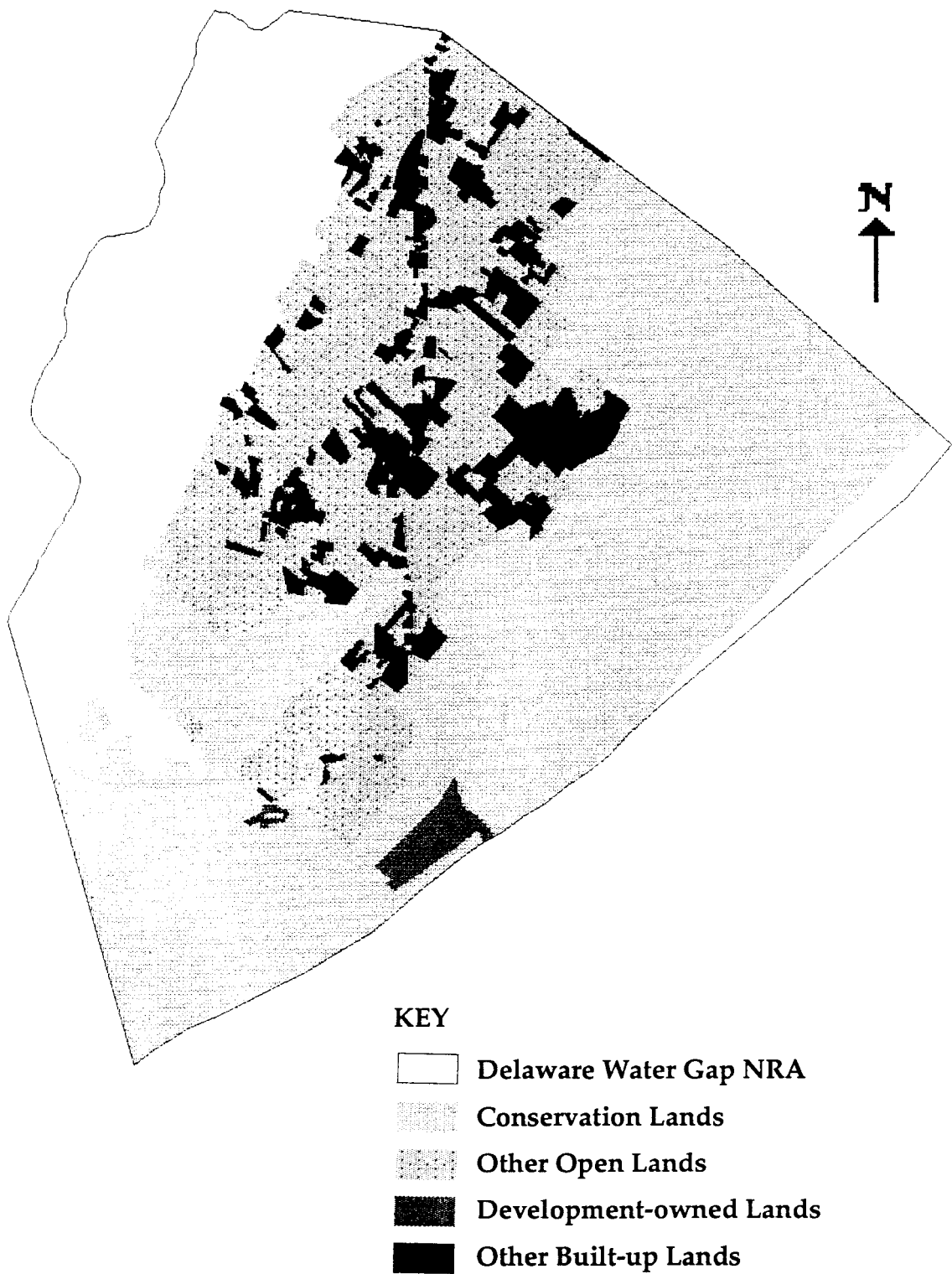


TABLE 10: Land Use • SANDYSTON TOWNSHIP

Land Use Category	acres	lots	dwellings
Residential	2062	679	542
Vacant	1079	147	0
Farm	4035	154	66
Commercial	105	26	28
Industrial	8	2	2
Hunting/Fishing	150	2	1
Camps	595	5	2
Campgrounds	0	0	0
Golfcourses	0	0	0
Other State & Federal lands	12047	36	4
Quasi-public	32	8	8
Existing development	108	326	242
Proposed development	0	0	0
Resorts	0	0	0
Reserved	96	2	0
Unsubdivided	0	0	0
Data not available	46	14	0
TOTAL	20363	1401	895

FIGURE 36: Acreage By Use Type • SANDYSTON TOWNSHIP

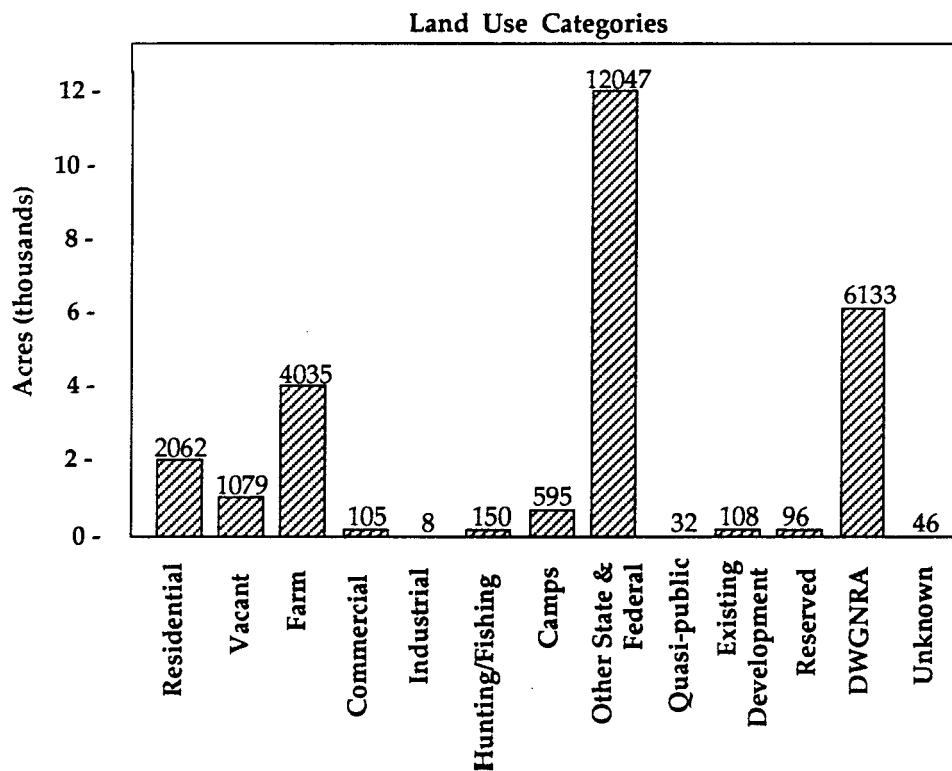


TABLE 11: Land Use Acreage by Watershed

Watershed	TOTAL	CONS¹	OPEN²	DEVEL³	BUILT⁴
Bushkill Creek (Milford)	3236	1593	483	127	1022
Cummins Creek	3776	0	1100	205	2471
Crawford Branch	788	52	189	267	280
Vandermark Creek	3786	796	1088	759	1142
Sawkill Creek	12012	898	6181	2256	2637
Raymondskill Creek	18696	3557	3281	8044	3814
Conashaugh Creek	683	11	444	64	164
Adams Creek	4695	0	1292	1461	1942
Dingmans Creek	8626	107	2309	4474	1736
Hornbecks Creek	5260	0	685	3291	1284
Alicia's Creek	216	0	0	216	0
Brodhead-Hellers	2616	0	1311	1018	287
Toms Creek	5436	0	473	4192	771
Denmark Creek	925	0	244	526	155
Little Bushkill	12957	2219	5198	3405	2132
Saw Creek	8698	3314	556	4062	766
Big Bushkill	13083	2410	5703	3036	1917
Shawnee Creek	2571	0	640	1057	874
Marshalls Creek	16926	1612	4439	6424	4446
Brodhead Creek	10073	968	2984	2303	3744
Cherry Creek	2039	389	258	150	1228
Caledonia Creek	519	161	0	0	358
Direct Drainage	12971	1900	4800	2416	3850
Shimers Brook	4619	1422	1745	840	604
White Brook	1084	0	523	109	446
Mill Brook	7802	4567	2153	377	692
Little Flatbrook	6771	32	4987	0	1653
Big Flatbrook	23928	20473	1628	108	1719

Note: acreage figures include only those portions of watersheds contained within the study area; Delaware Water Gap National Recreation Area lands and upper watershed lands lying outside of study area townships are excluded (see watershed maps for indication of percent coverage). Parcels with land use unknown were not tabulated.

Footnotes:

1. Conservation lands (all other state and federal lands)
2. Other open lands
3. Development-owned lands
4. Other built-up lands

FIGURE 37: Land Use • Bushkill Creek (Milford Township)

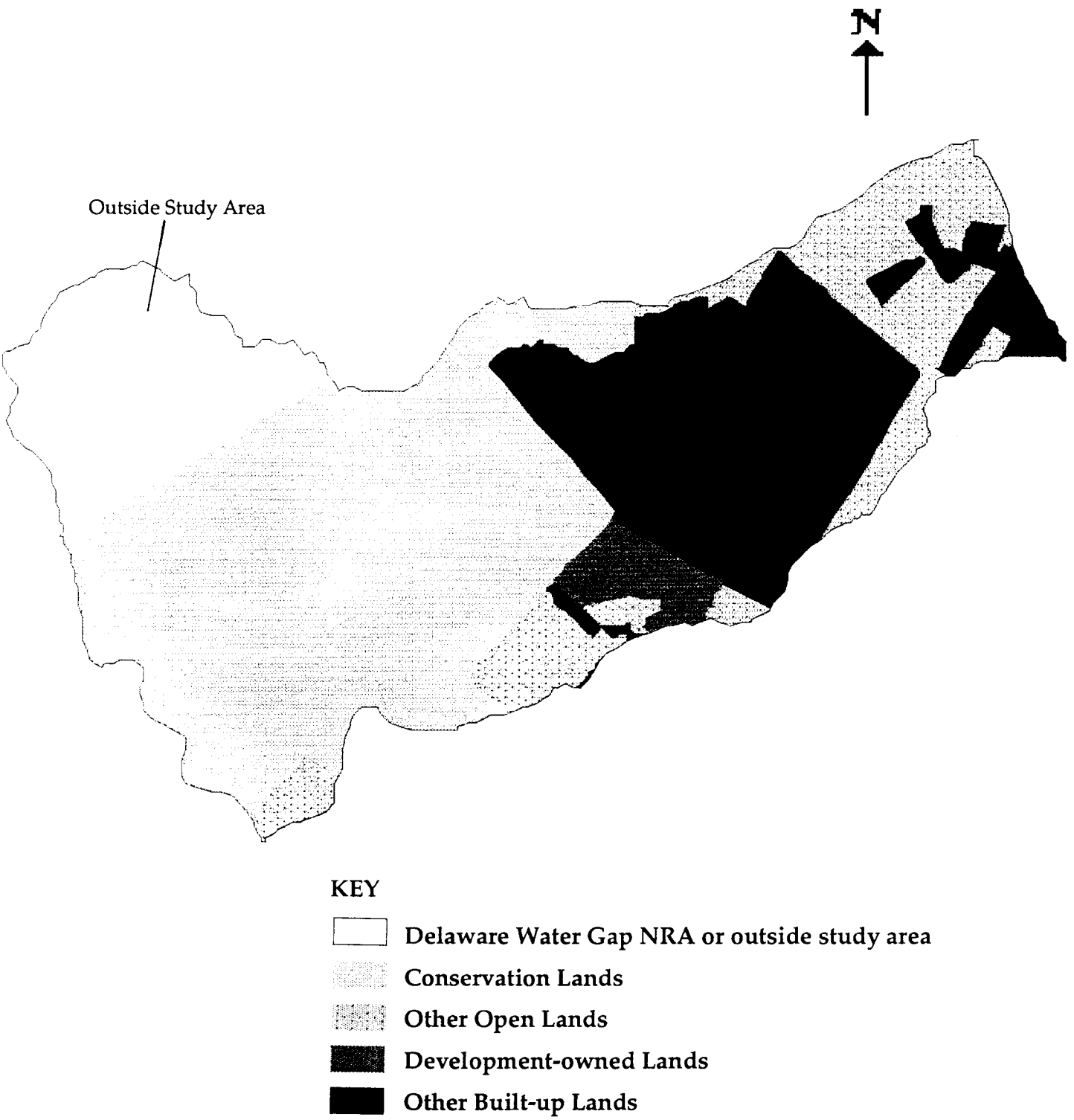


FIGURE 38: Acreage By Use Type • BUSHKILL CREEK (Milford)

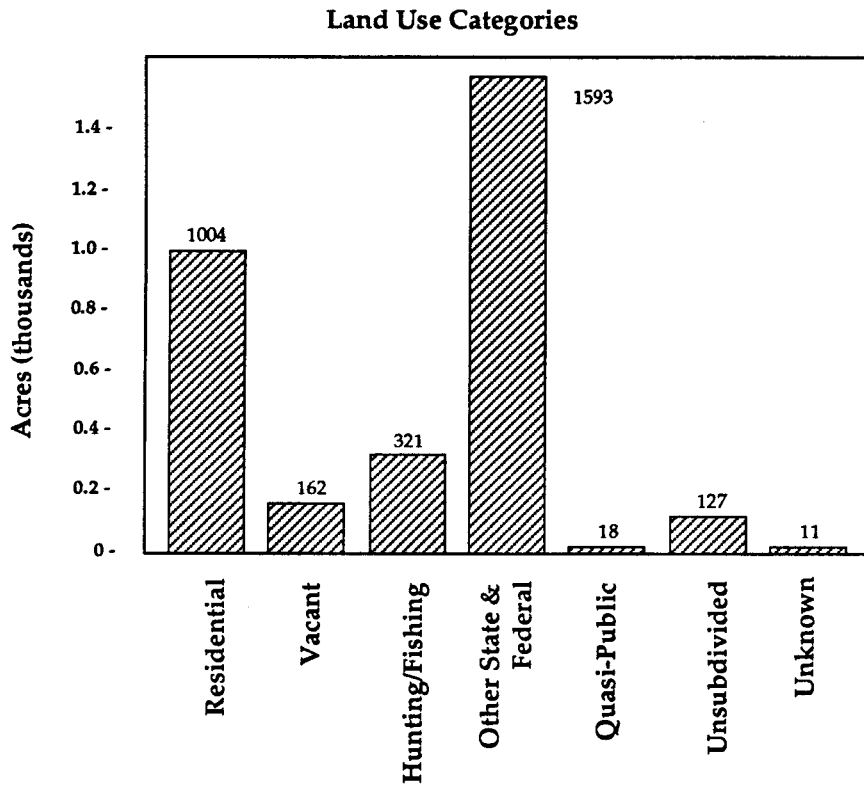


FIGURE 39: Acreage By Use Type • CUMMINS CREEK

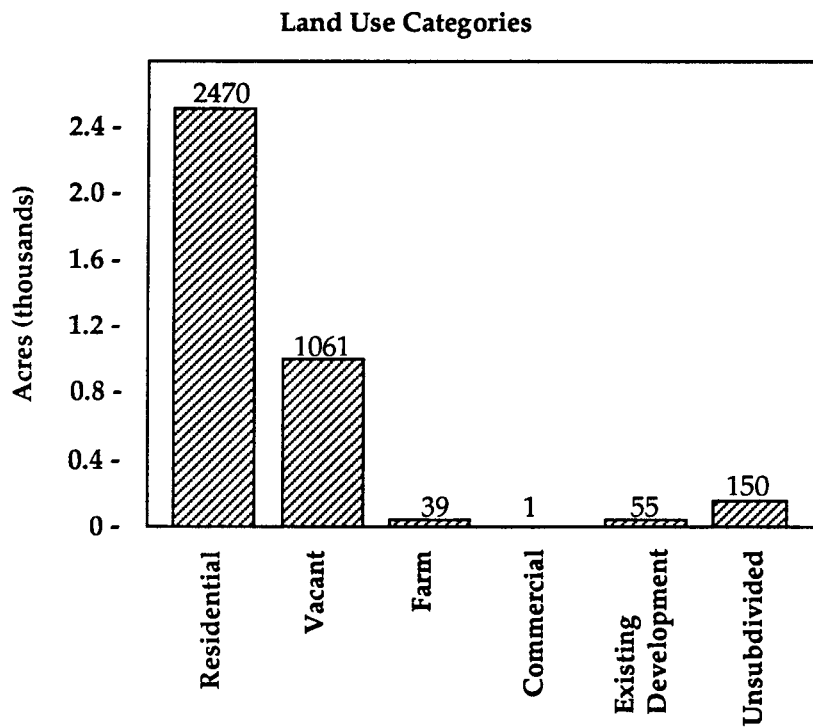


FIGURE 40: Land Use • Cummins Creek

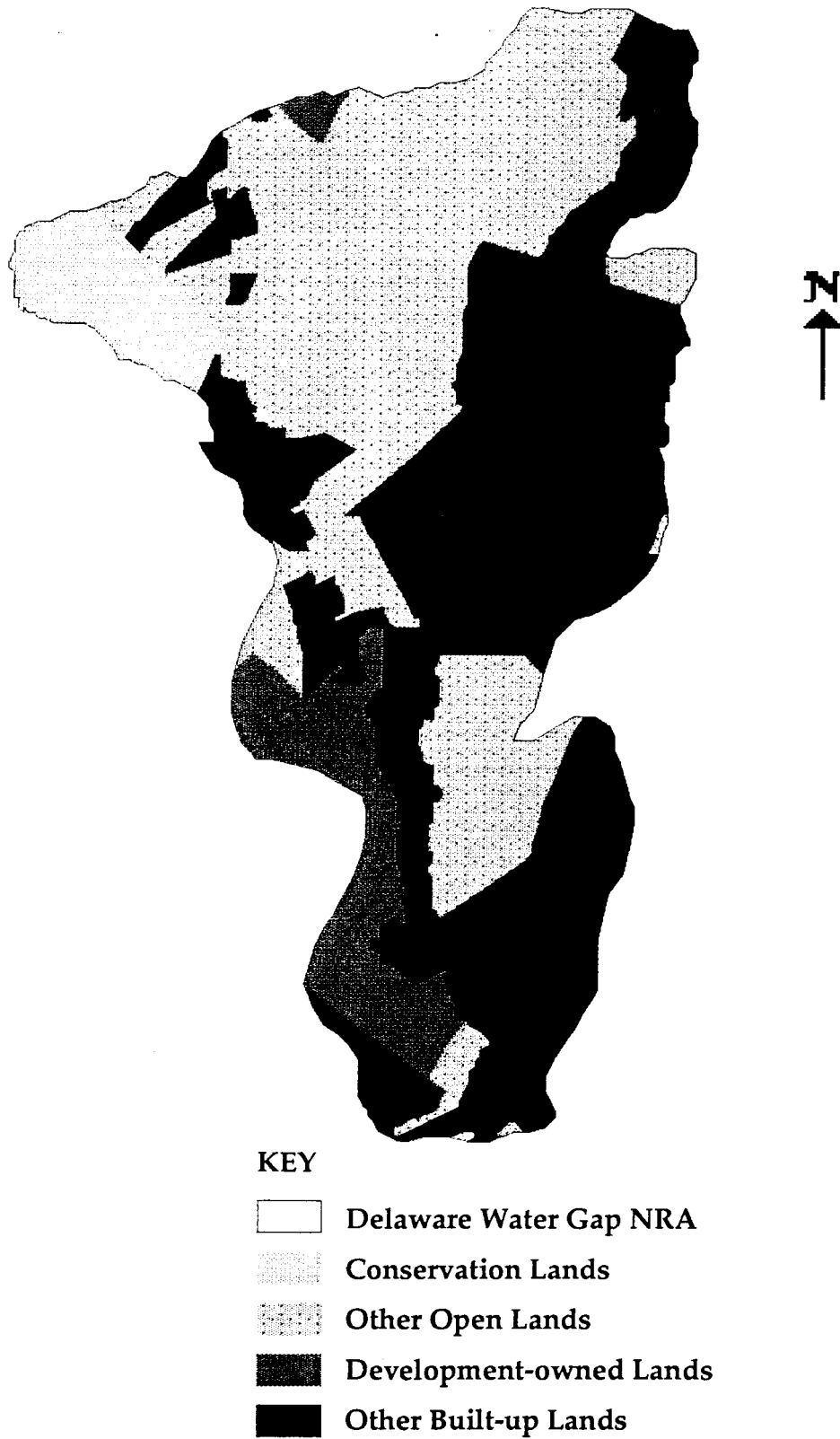
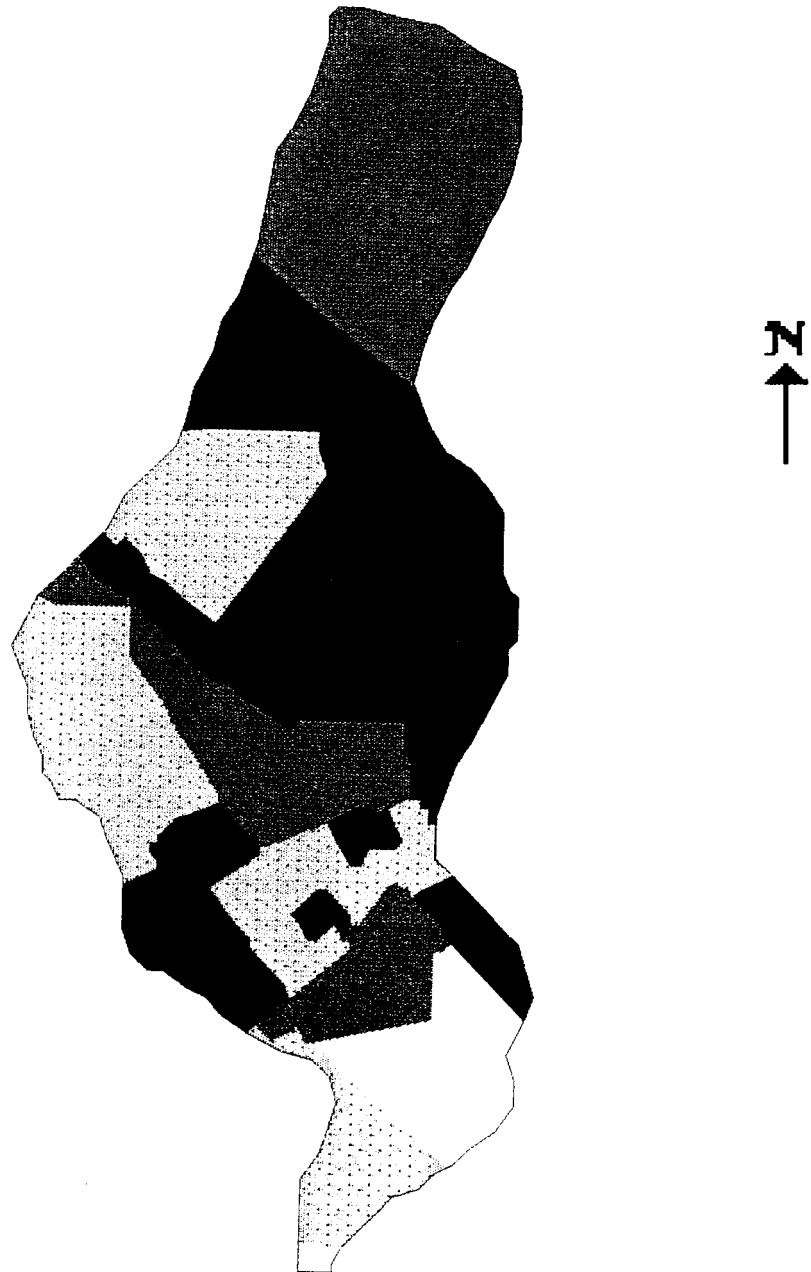


FIGURE 41: Land Use • Crawford Branch



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

FIGURE 42: Acreage By Use Type • CRAWFORD BRANCH

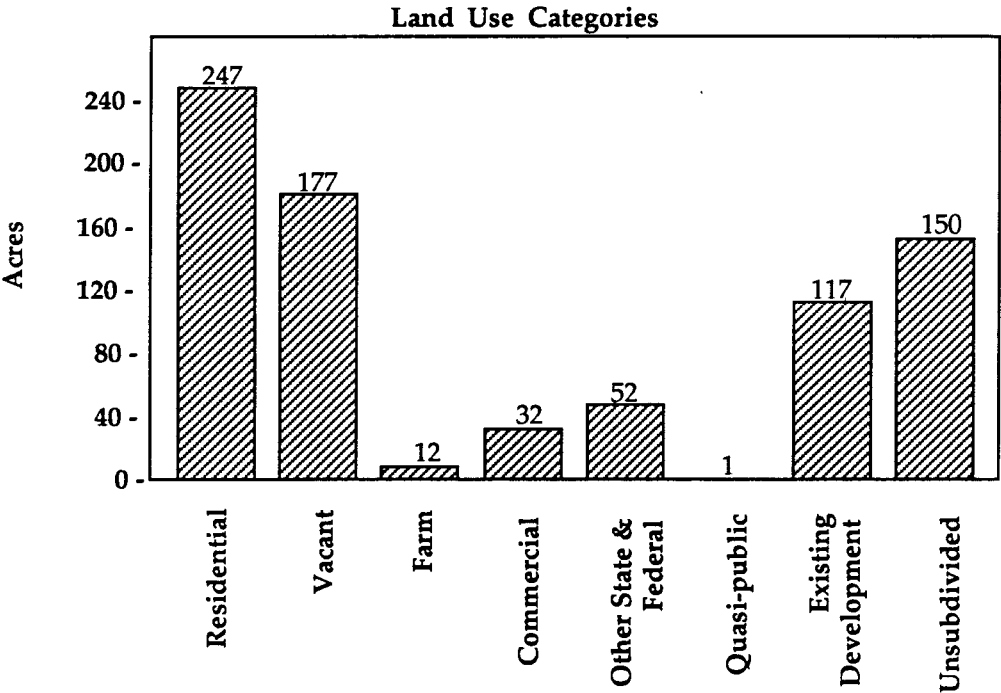


FIGURE 43: Acreage By Use Type • VANDERMARK CREEK

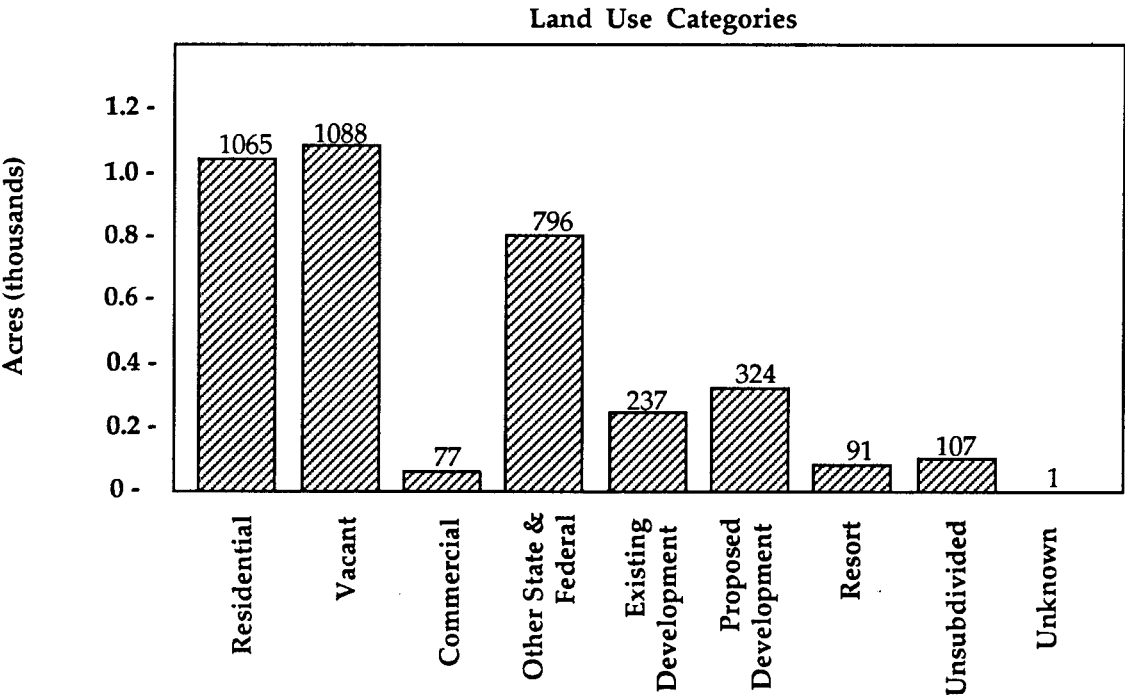
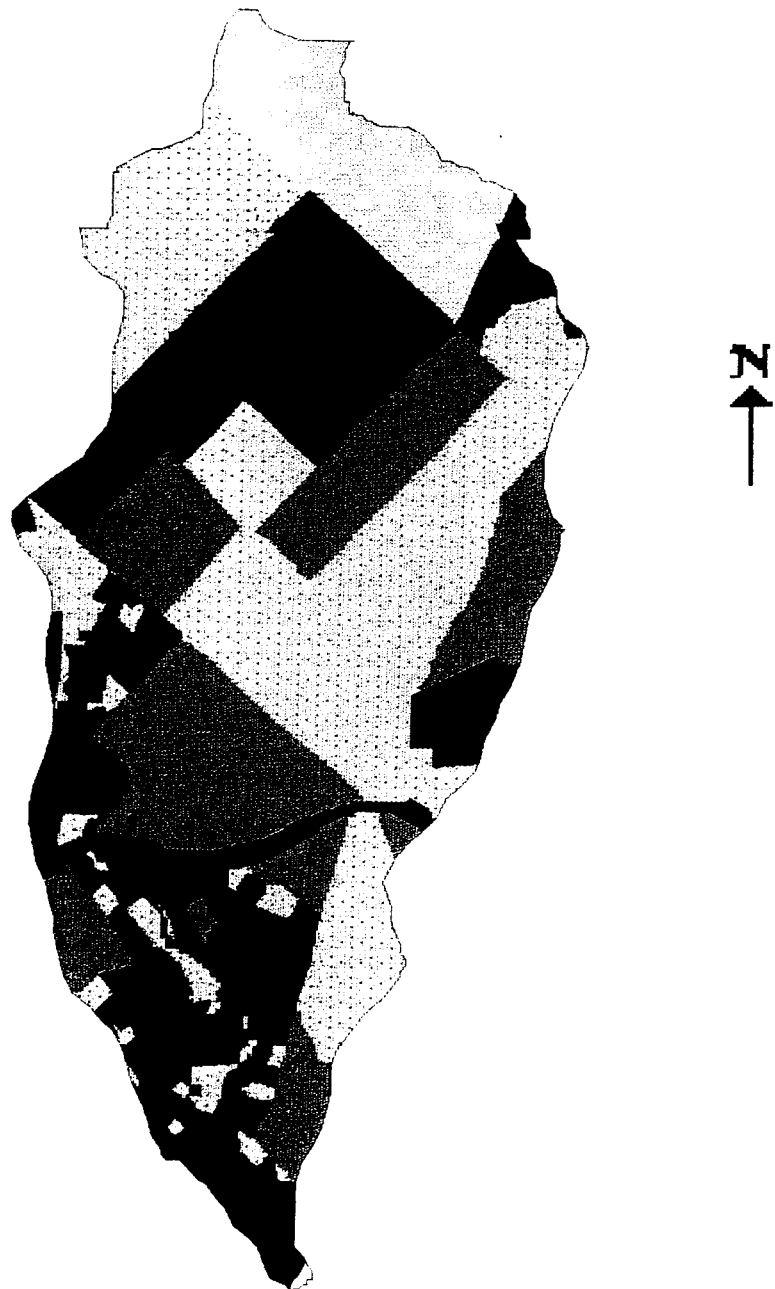


FIGURE 44: Land Use • Vandermark Creek



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

FIGURE 45: Land Use • Sawkill Creek

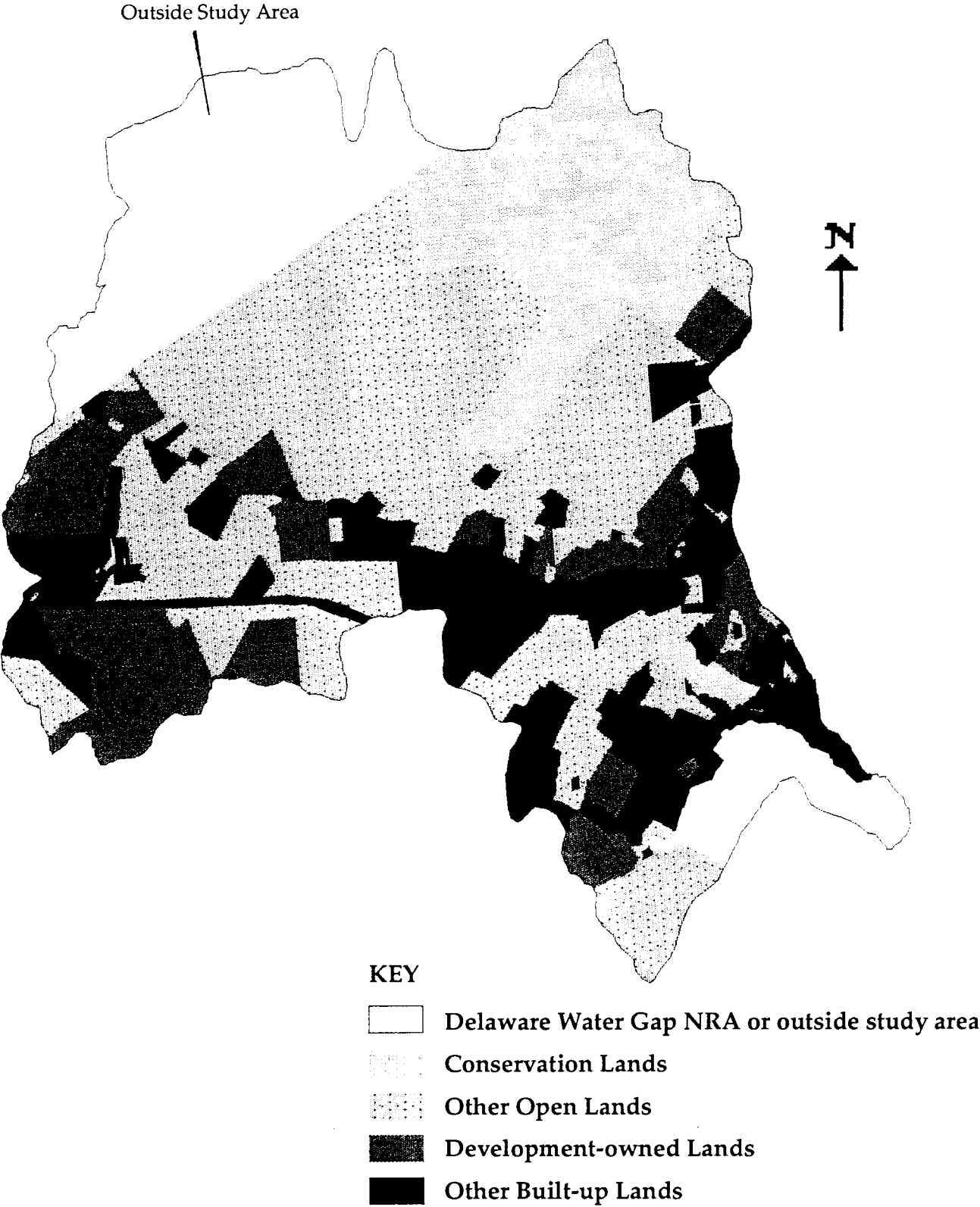


FIGURE 46: Acreage By Use Type ● SAWKILL CREEK

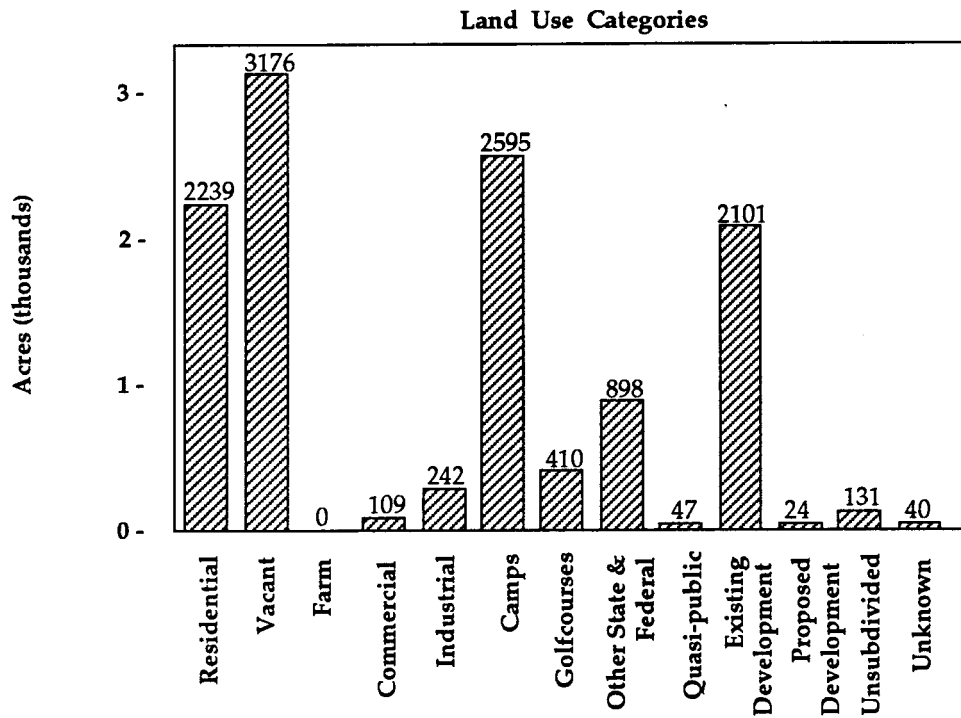


FIGURE 47: Acreage By Use Type ● RAYMONDSKILL CREEK

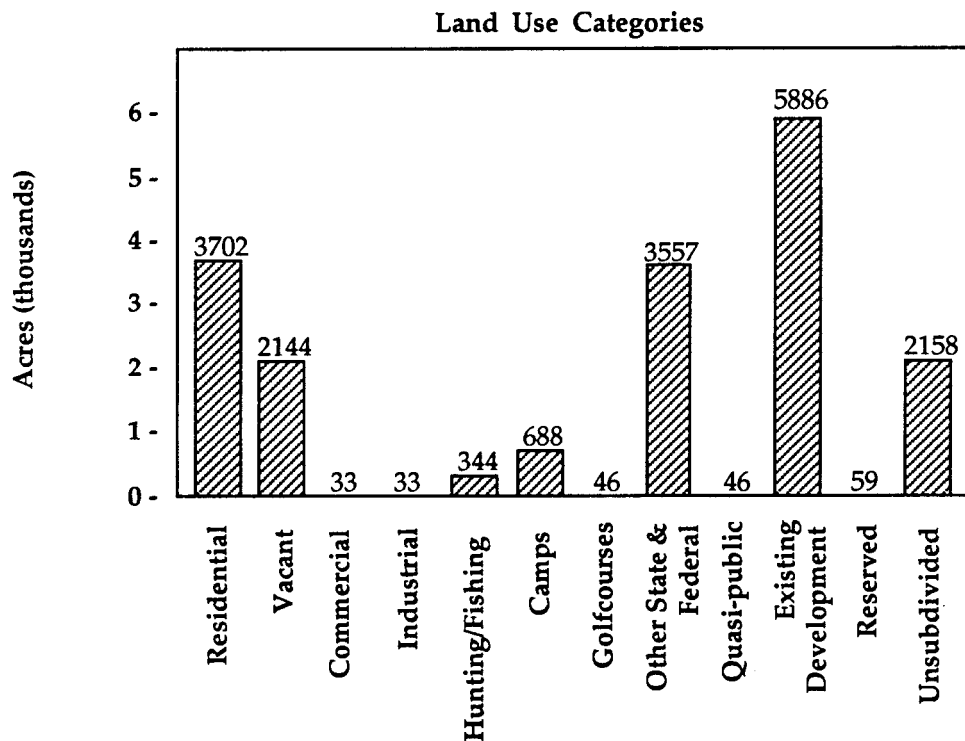


FIGURE 48: Land Use • Raymondskill Creek

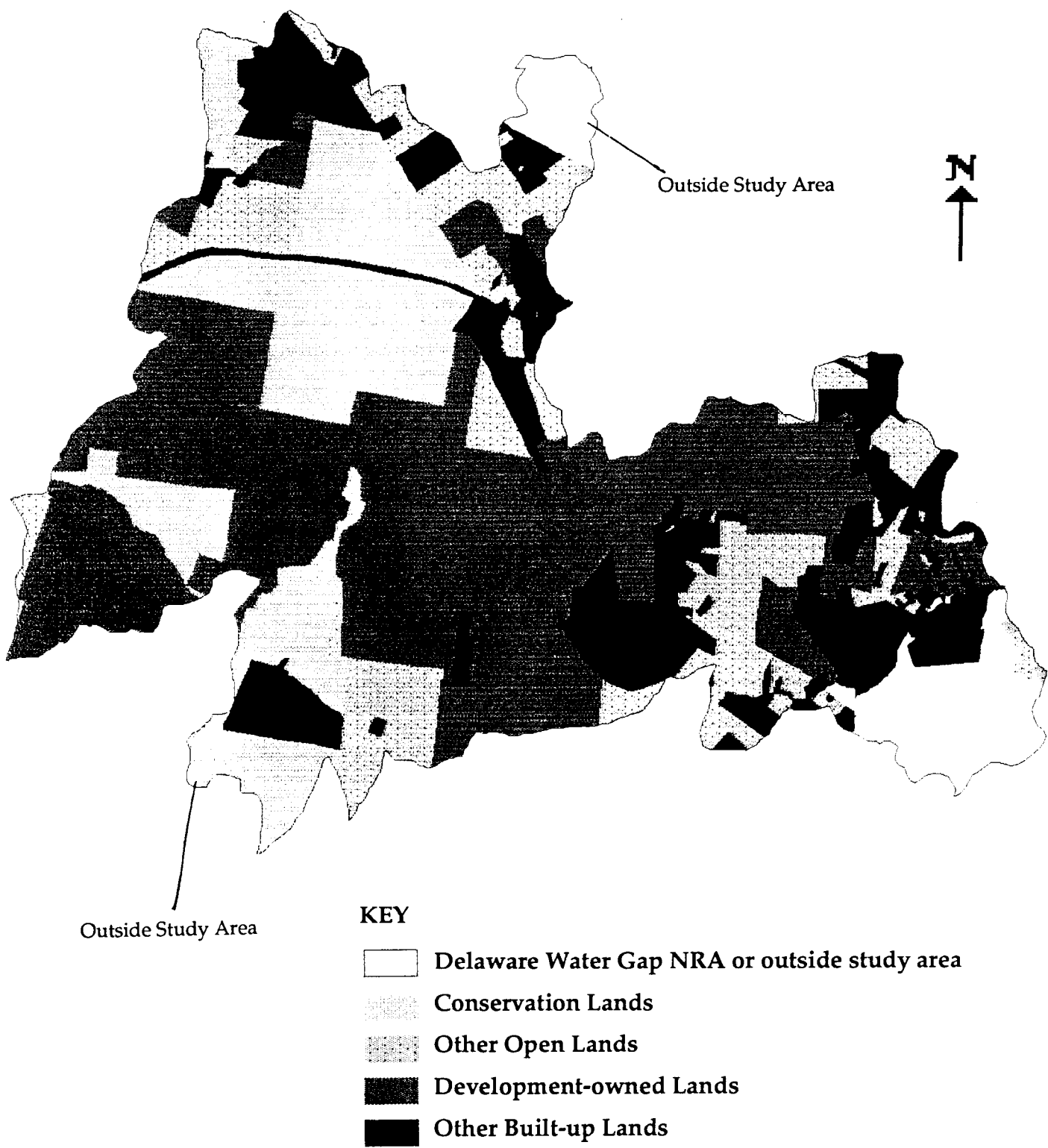


FIGURE 49: Land Use • Conashaugh Creek

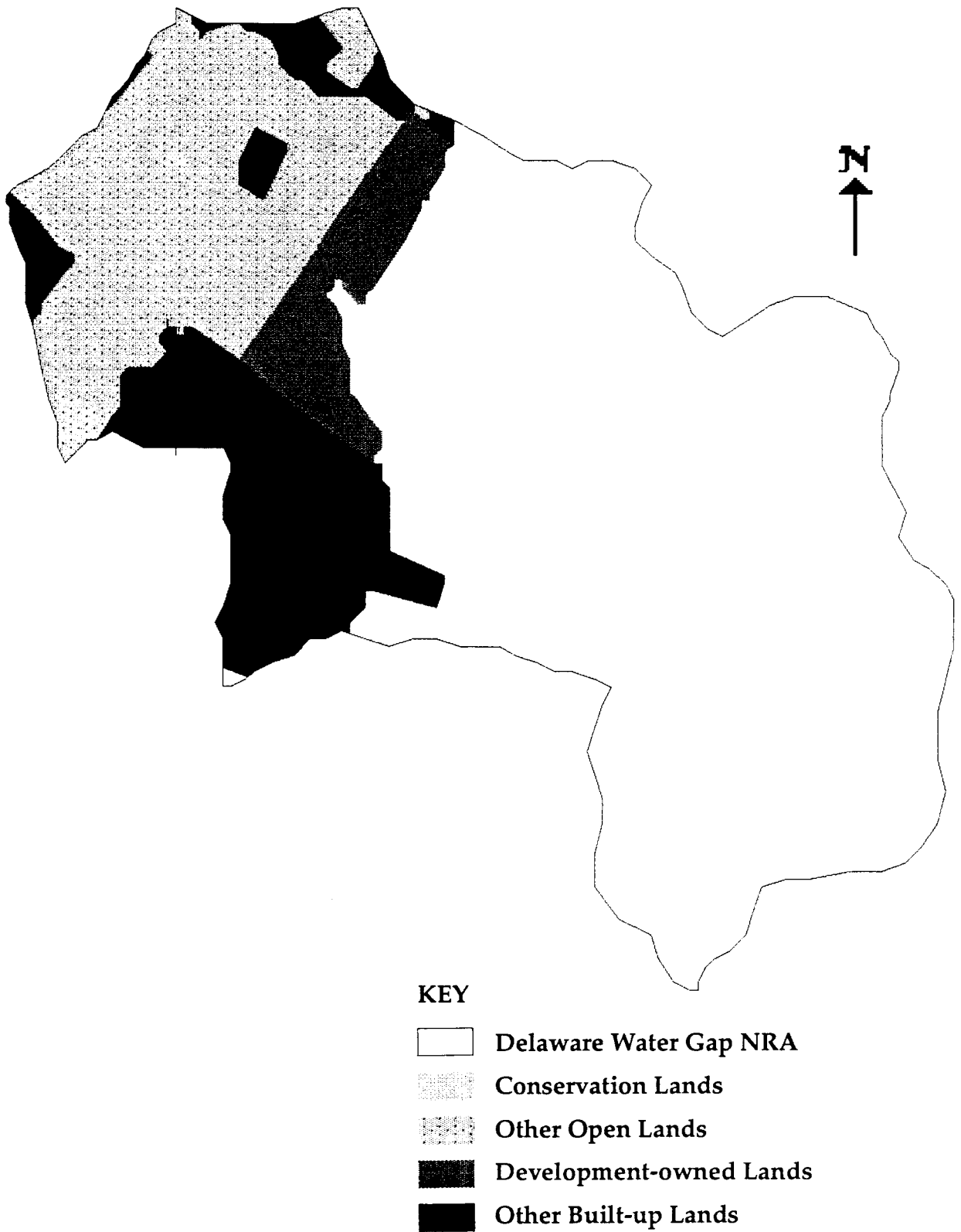


FIGURE 50: Acreage By Use Type ● CONASHAUGH CREEK

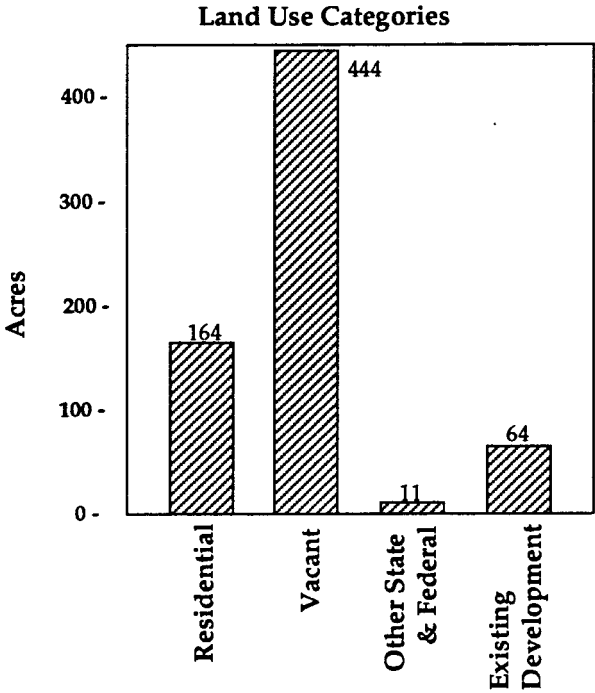


FIGURE 51: Acreage By Use Type ● ADAMS CREEK

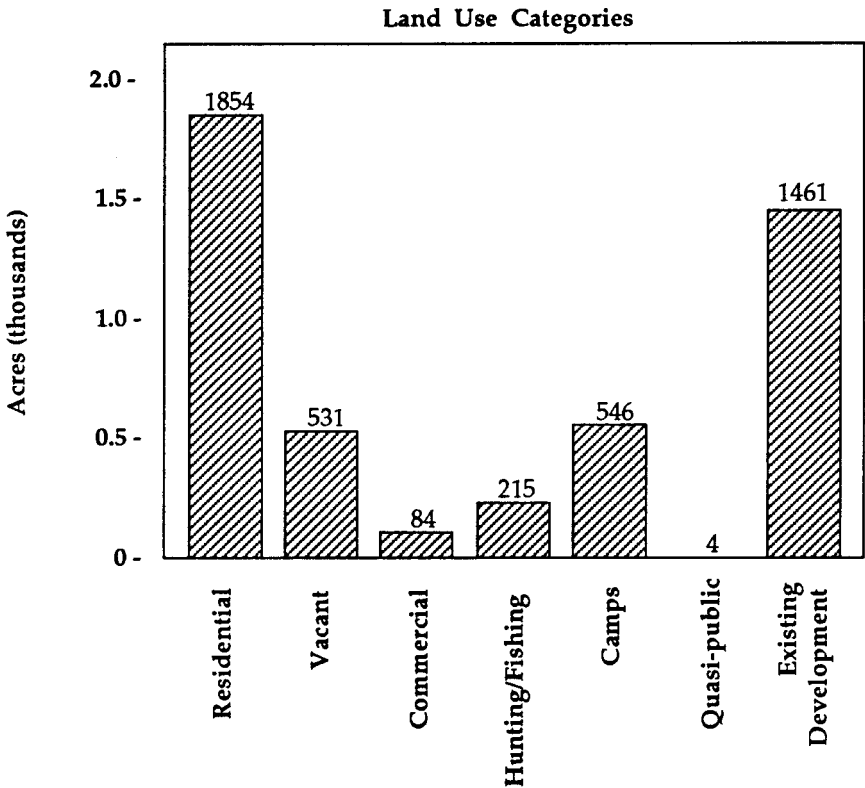
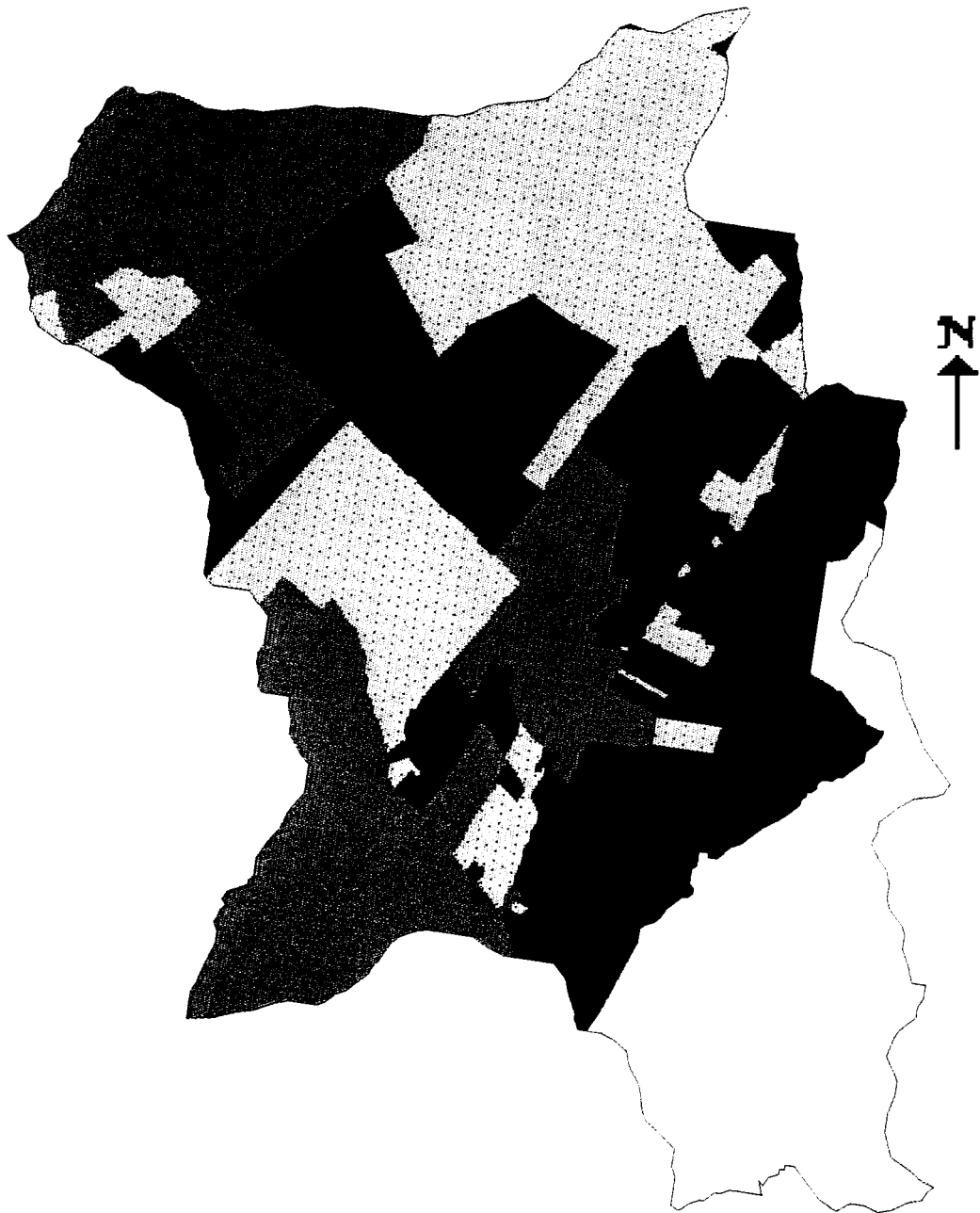


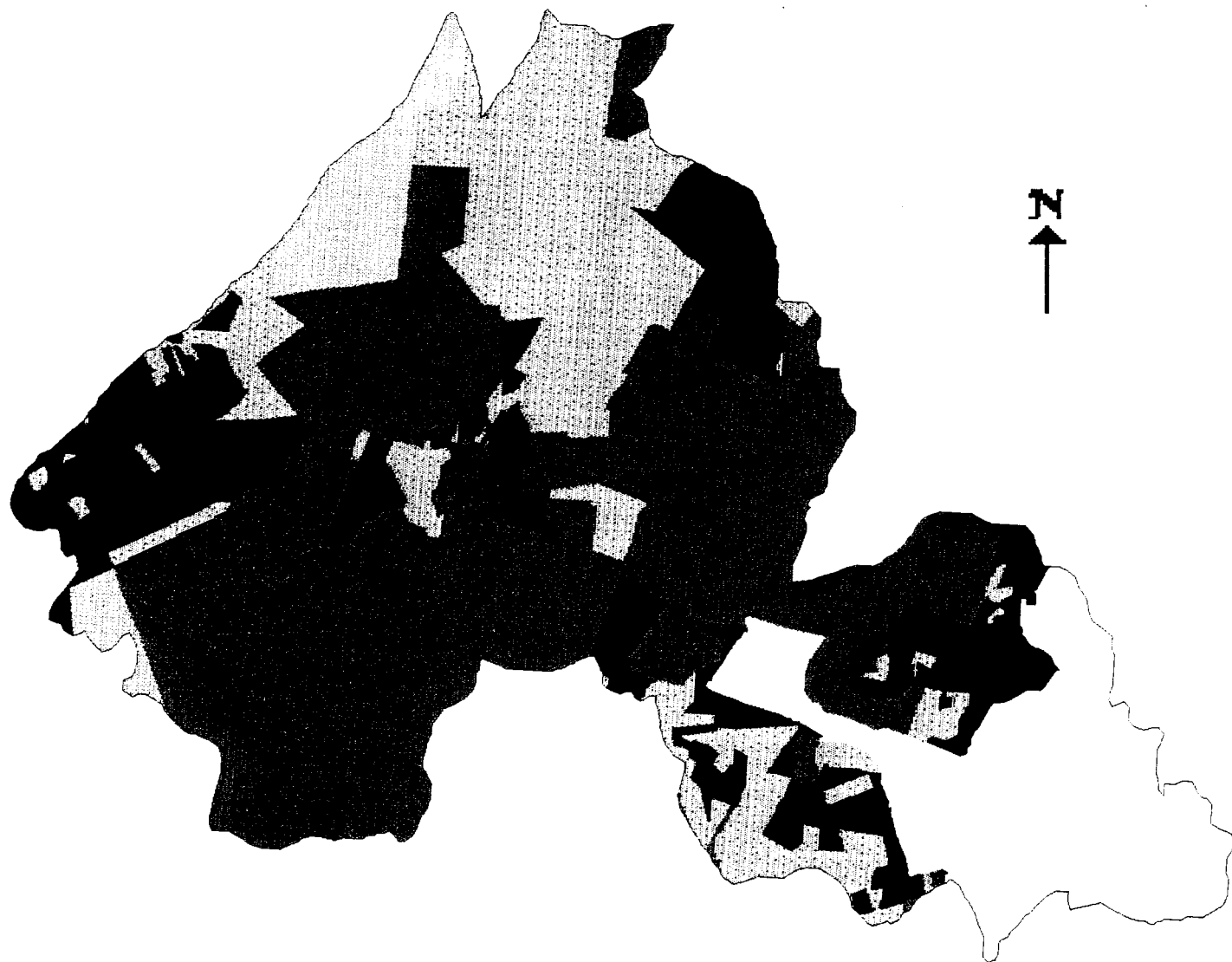
FIGURE 52: Land Use • Adams Creek



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

FIGURE 53: Land Use • Dingmans Creek



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

FIGURE 54: Acreage By Use Type • DINGMANS CREEK

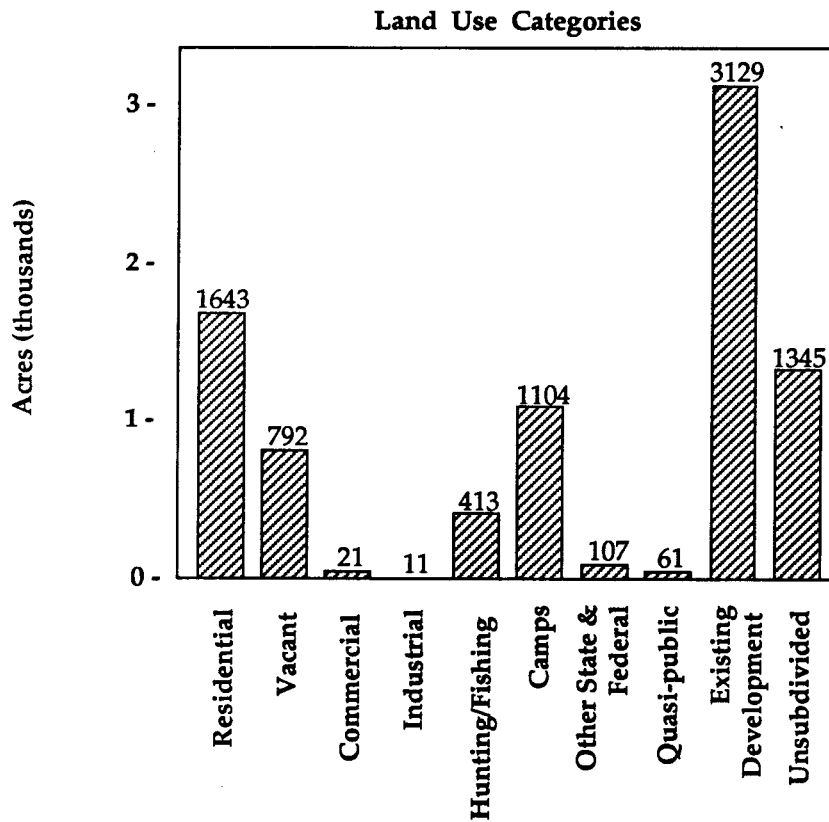


FIGURE 55: Acreage By Use Type • HORNBECKS CREEK

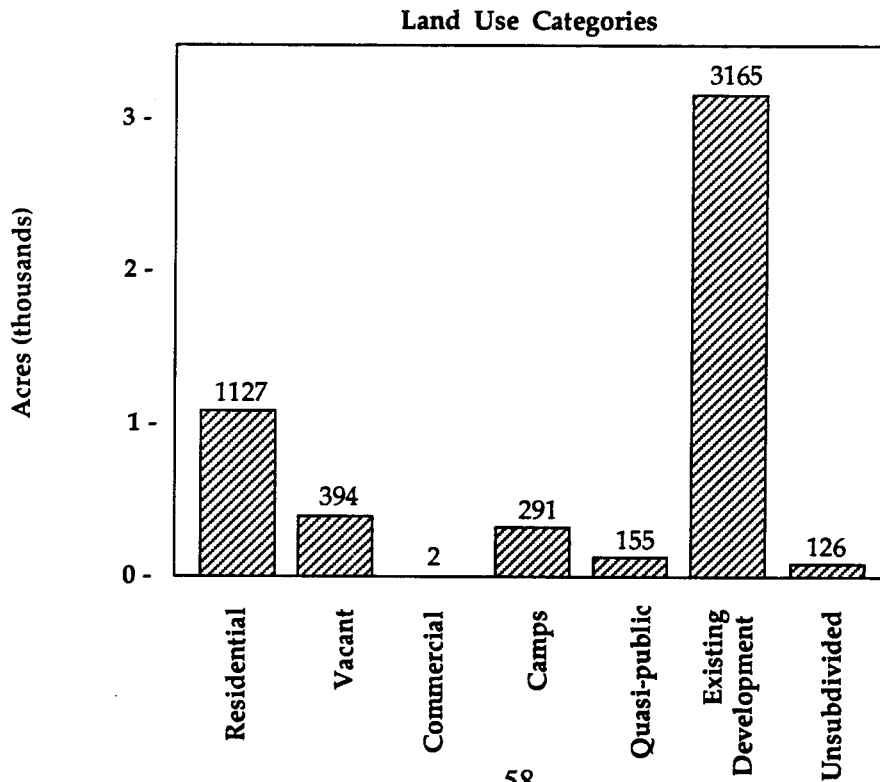
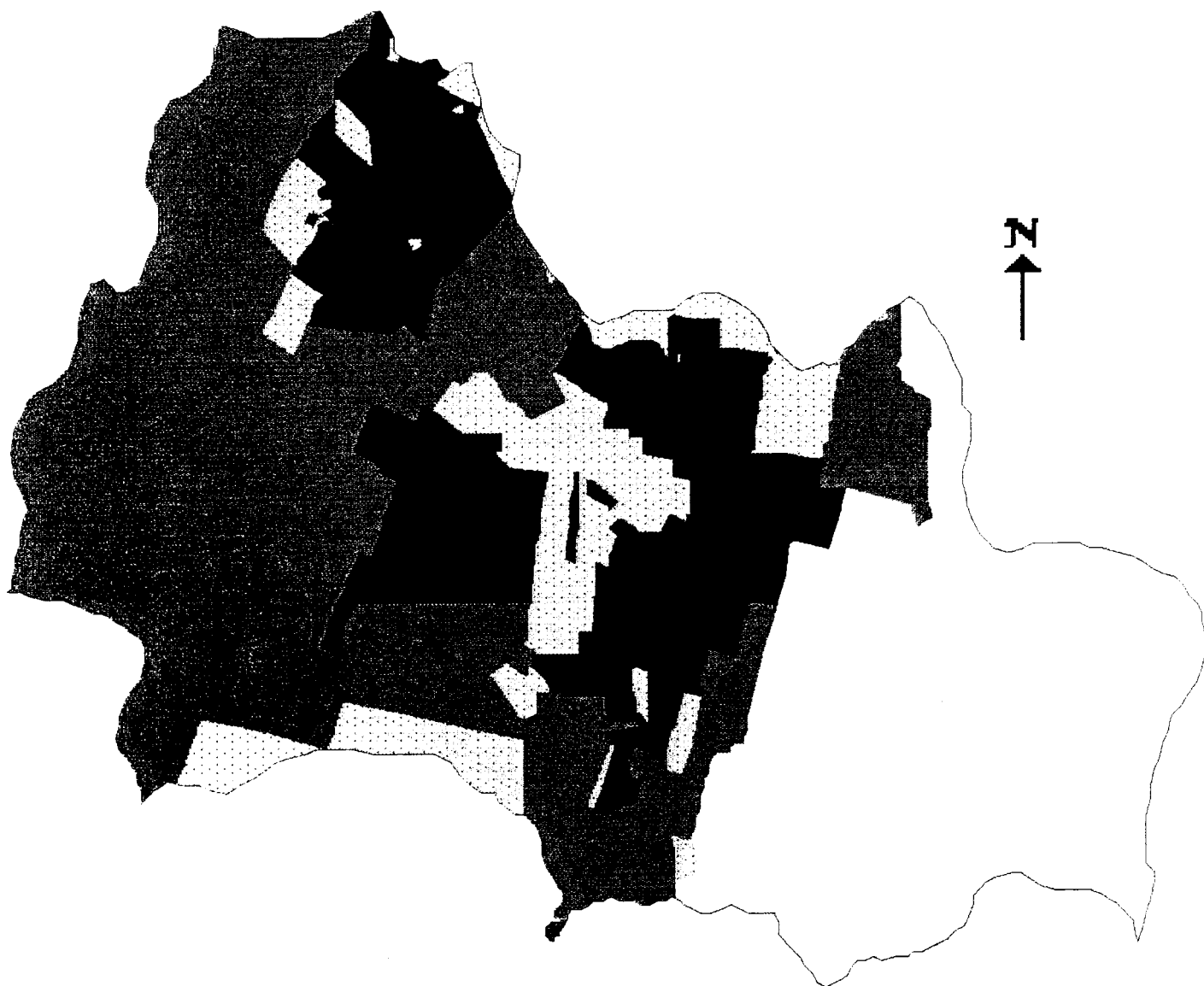


FIGURE 56: Land Use • Hornbecks Creek



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

FIGURE 57: Land Use • Alicia's Creek

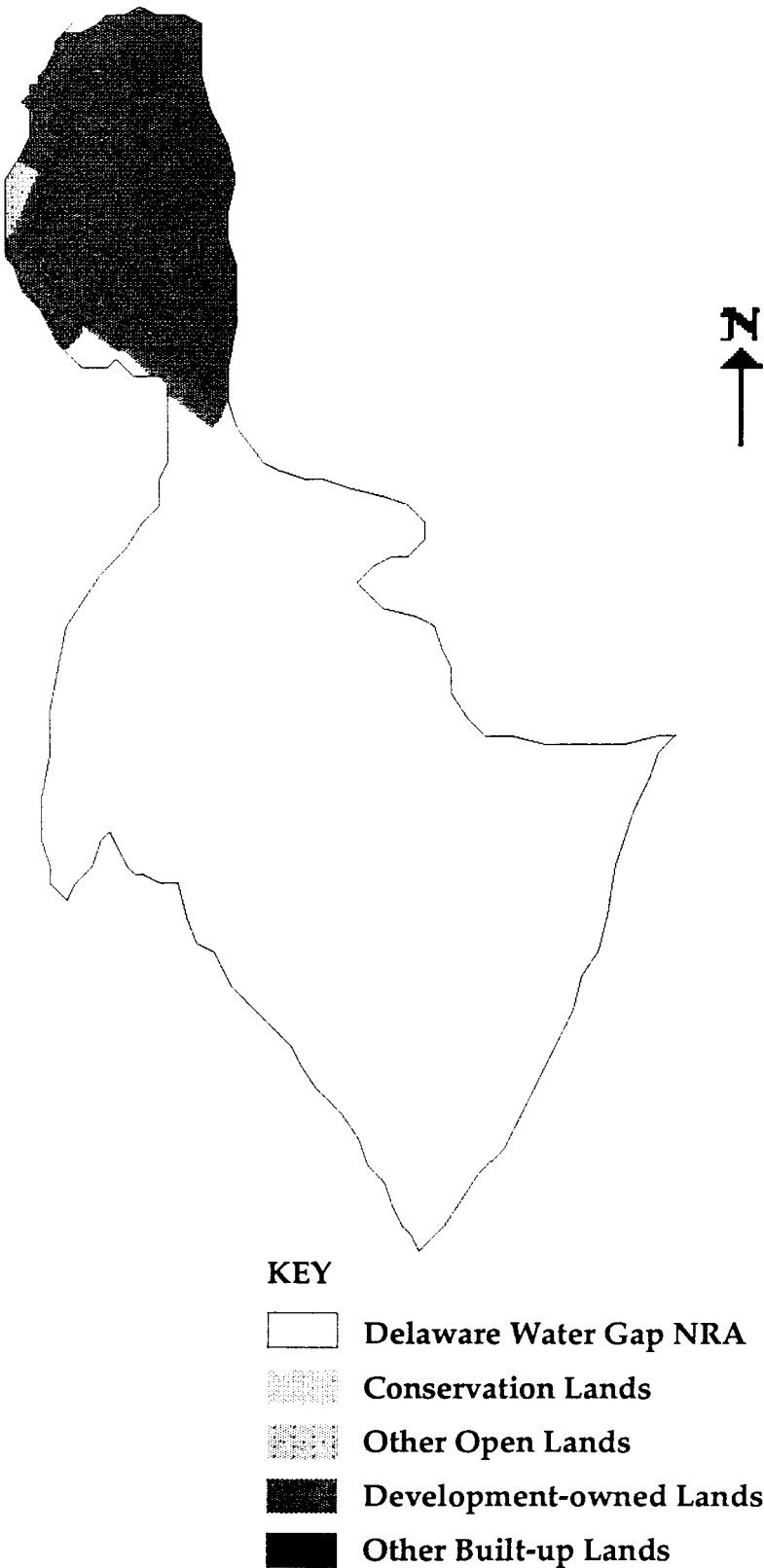


FIGURE 58: Acreage By Use Type • ALICIAS CREEK

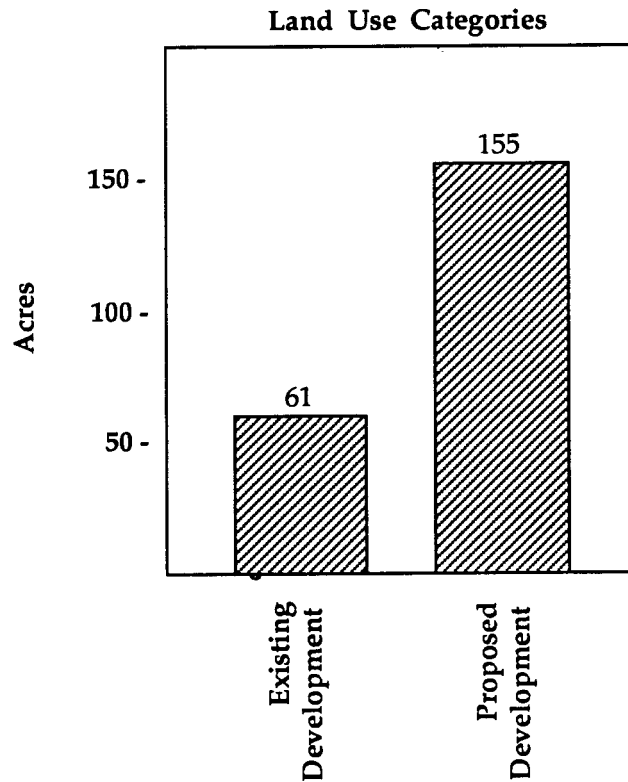


FIGURE 59: Acreage By Use Type • BRODHEAD-HELLERS CREEK

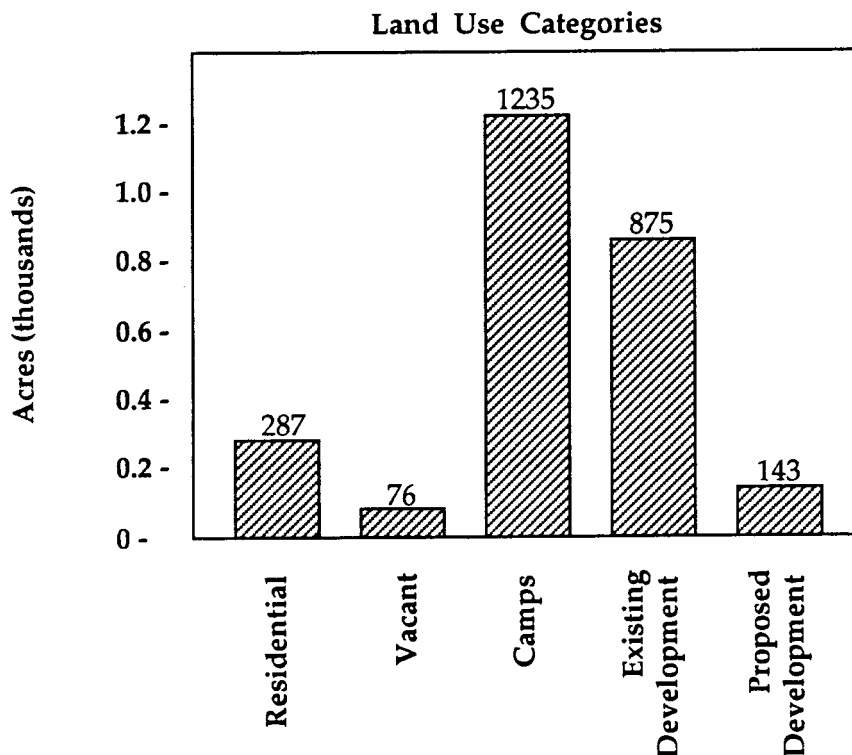
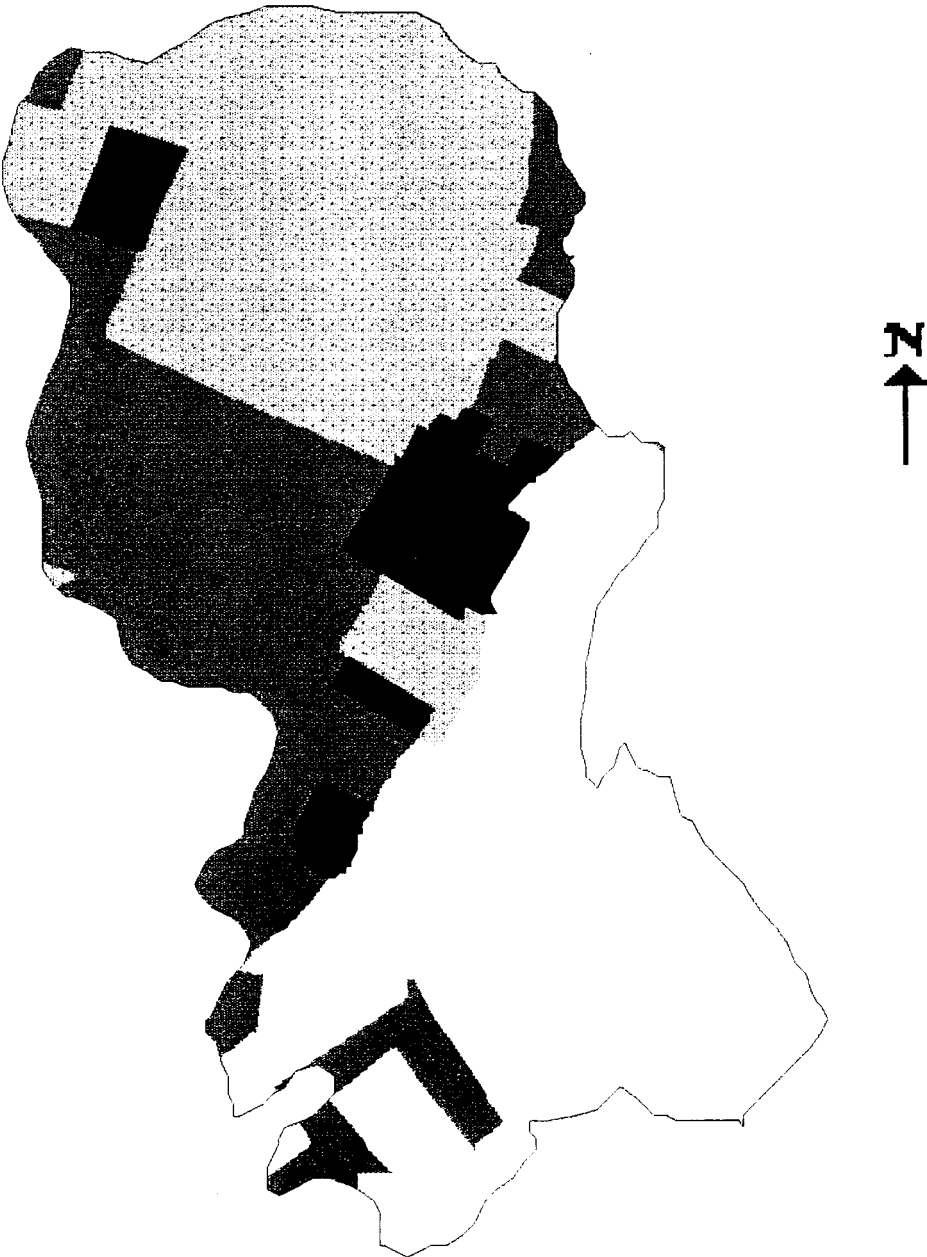
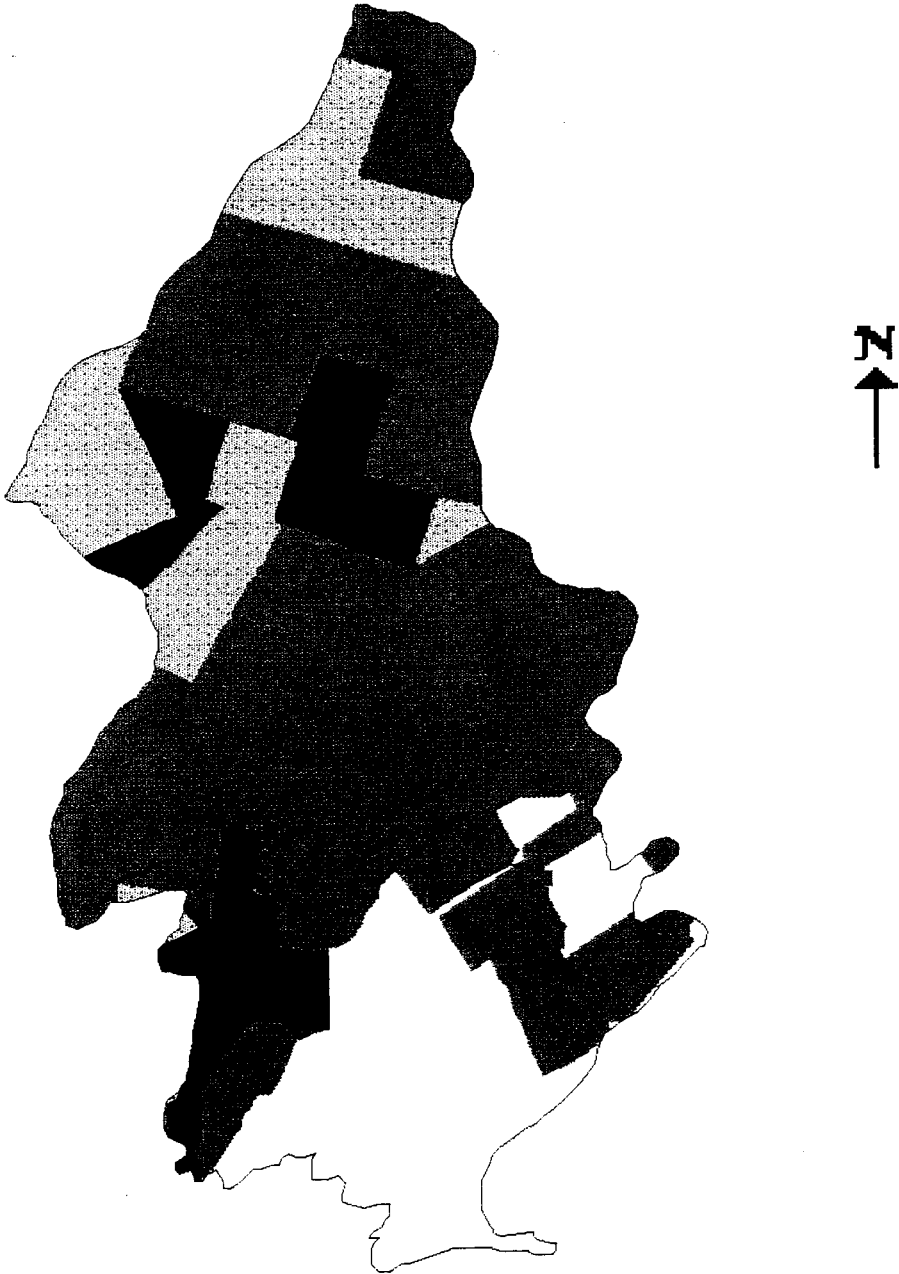


FIGURE 60: Land Use • Brodhead-Hellers Creek



- KEY**
-  Delaware Water Gap NRA
 -  Conservation Lands
 -  Other Open Lands
 -  Development-owned Lands
 -  Other Built-up Lands

FIGURE 61: Land Use • Toms Creek



- KEY**
- Delaware Water Gap NRA
 - Conservation Lands
 - Other Open Lands
 - Development-owned Lands
 - Other Built-up Lands

FIGURE 62: Acreage By Use Type • TOMS CREEK

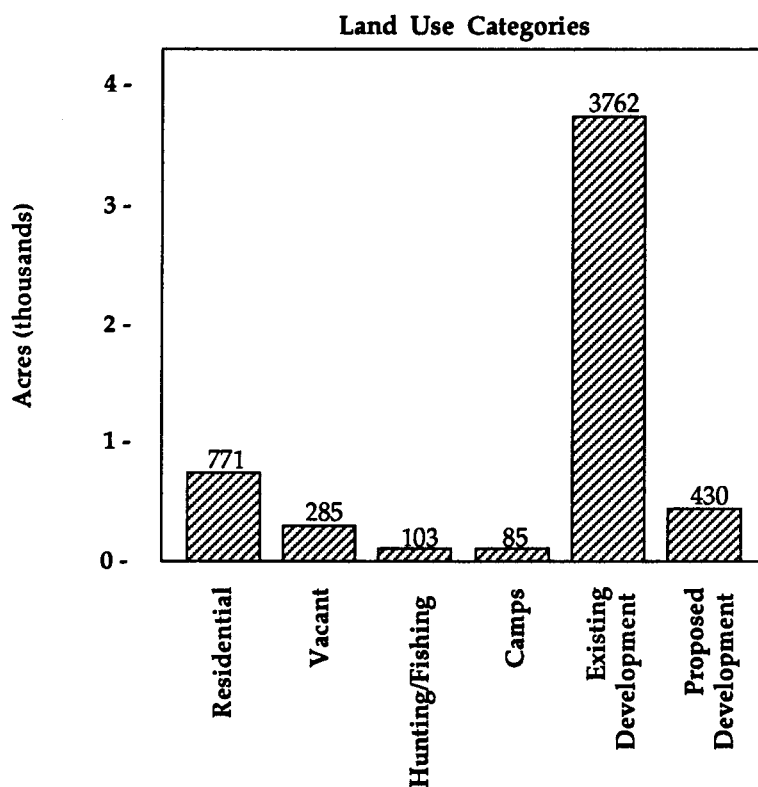


FIGURE 63: Acreage By Use Type • DENMARK CREEK

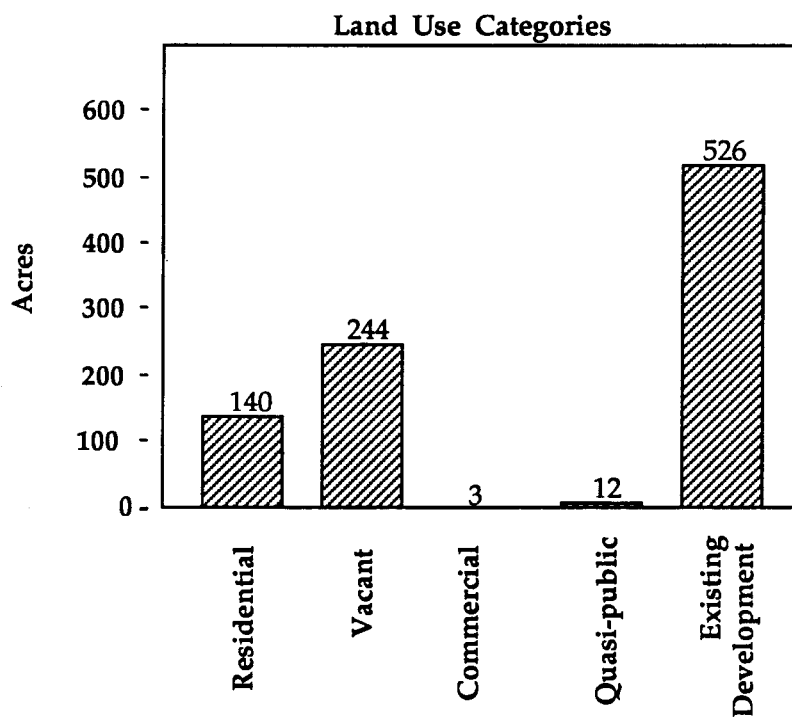


FIGURE 64: Land Use • Denmark Creek

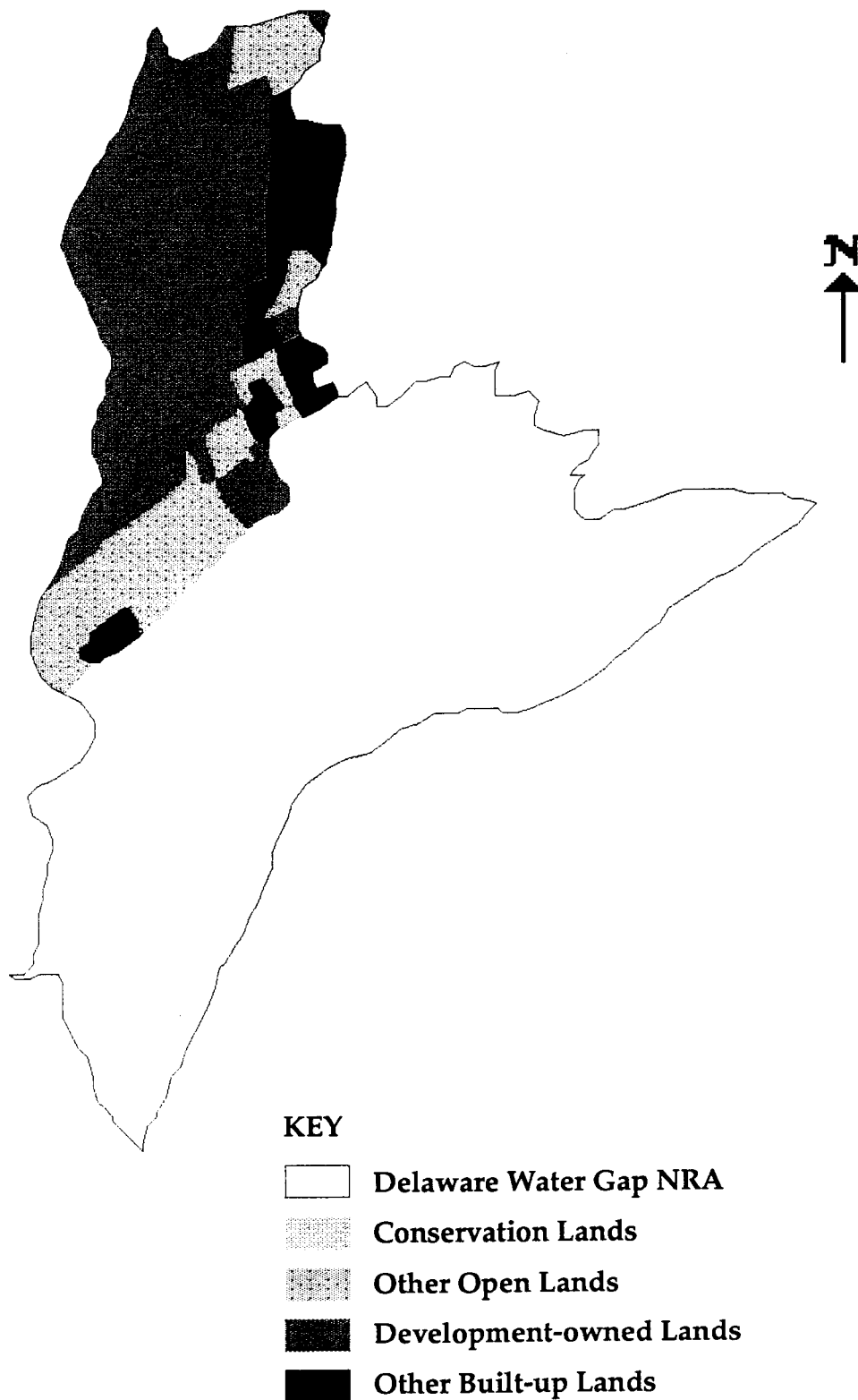


FIGURE 65: Land Use • Little Bushkill Creek

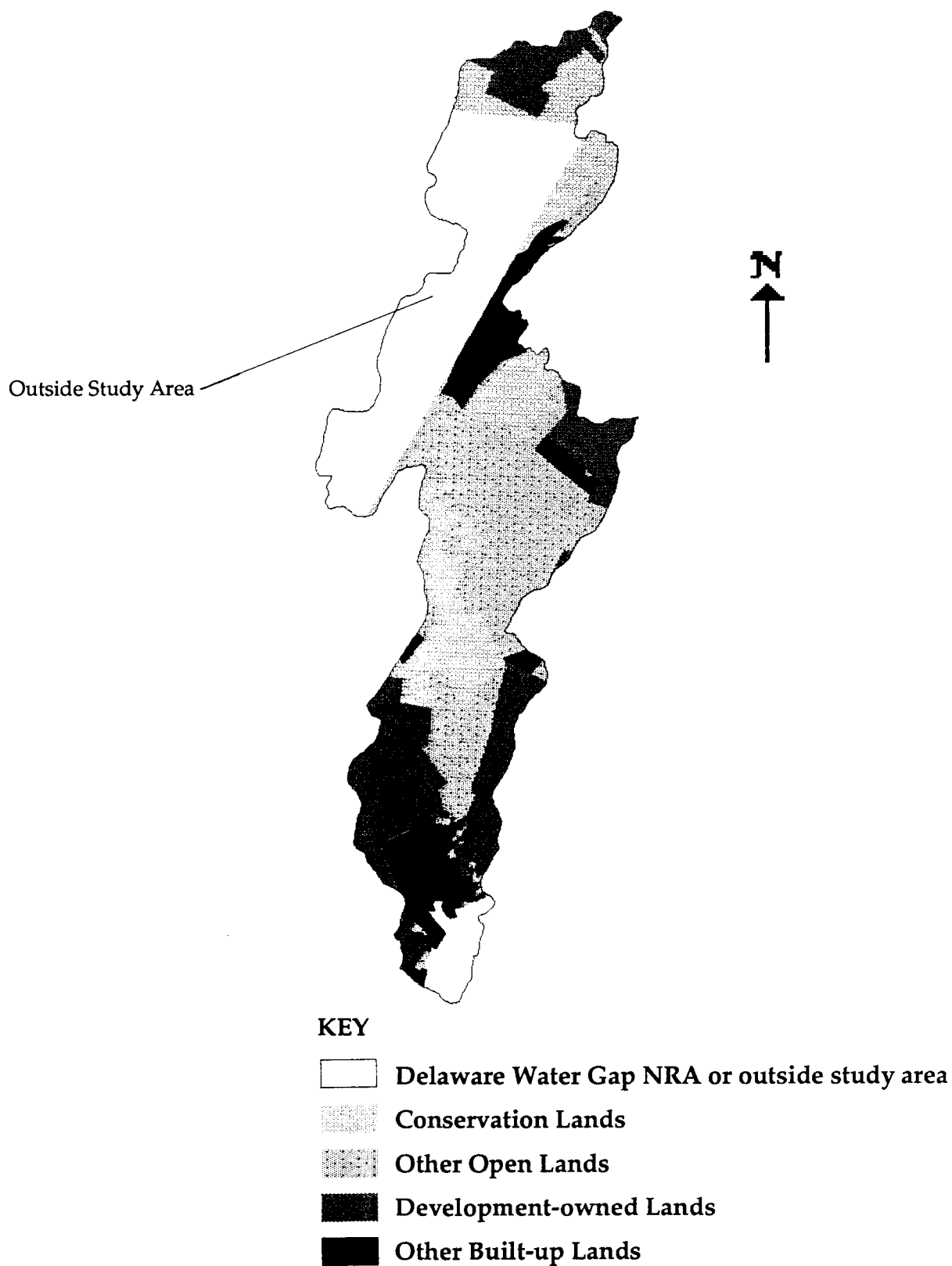


FIGURE 66: Acreage By Use Type • LITTLE BUSHKILL CREEK

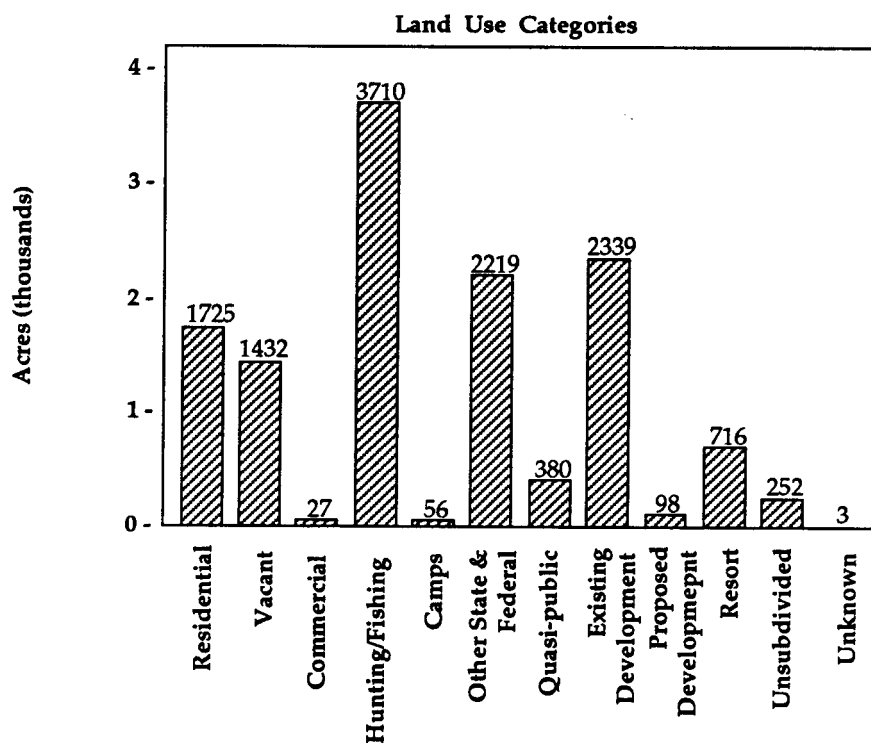


FIGURE 67: Acreage By Use Type • SAW CREEK

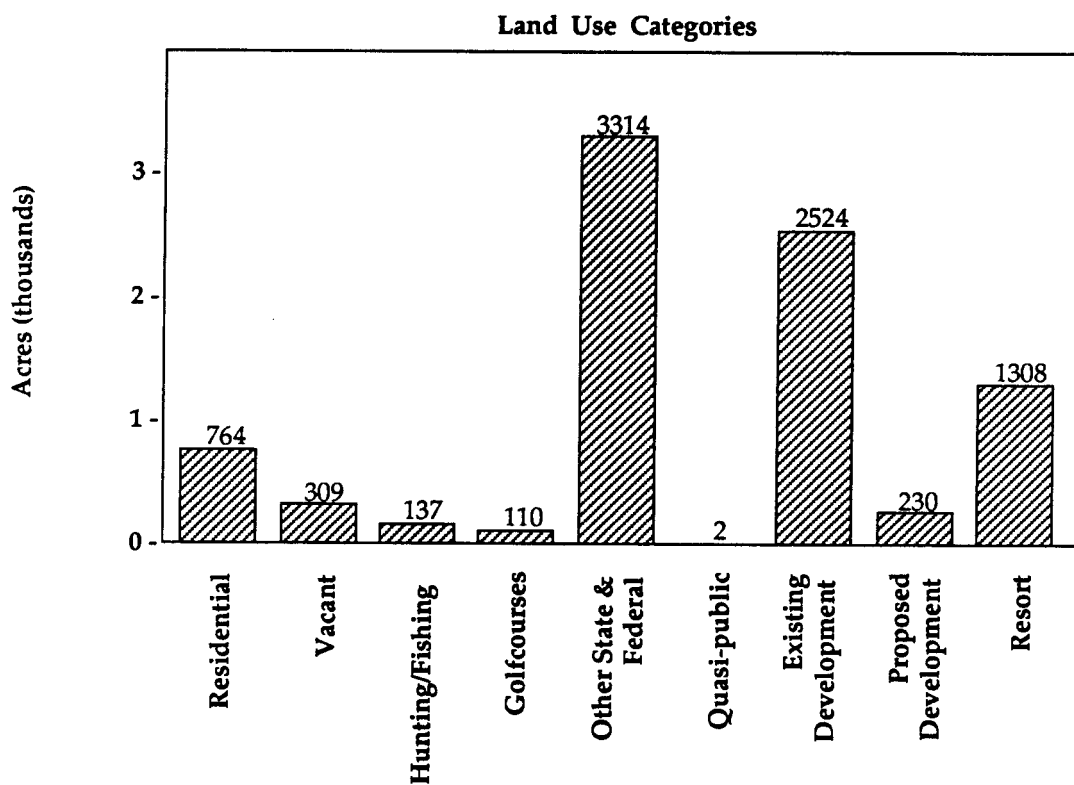


FIGURE 68: Land Use • Saw Creek

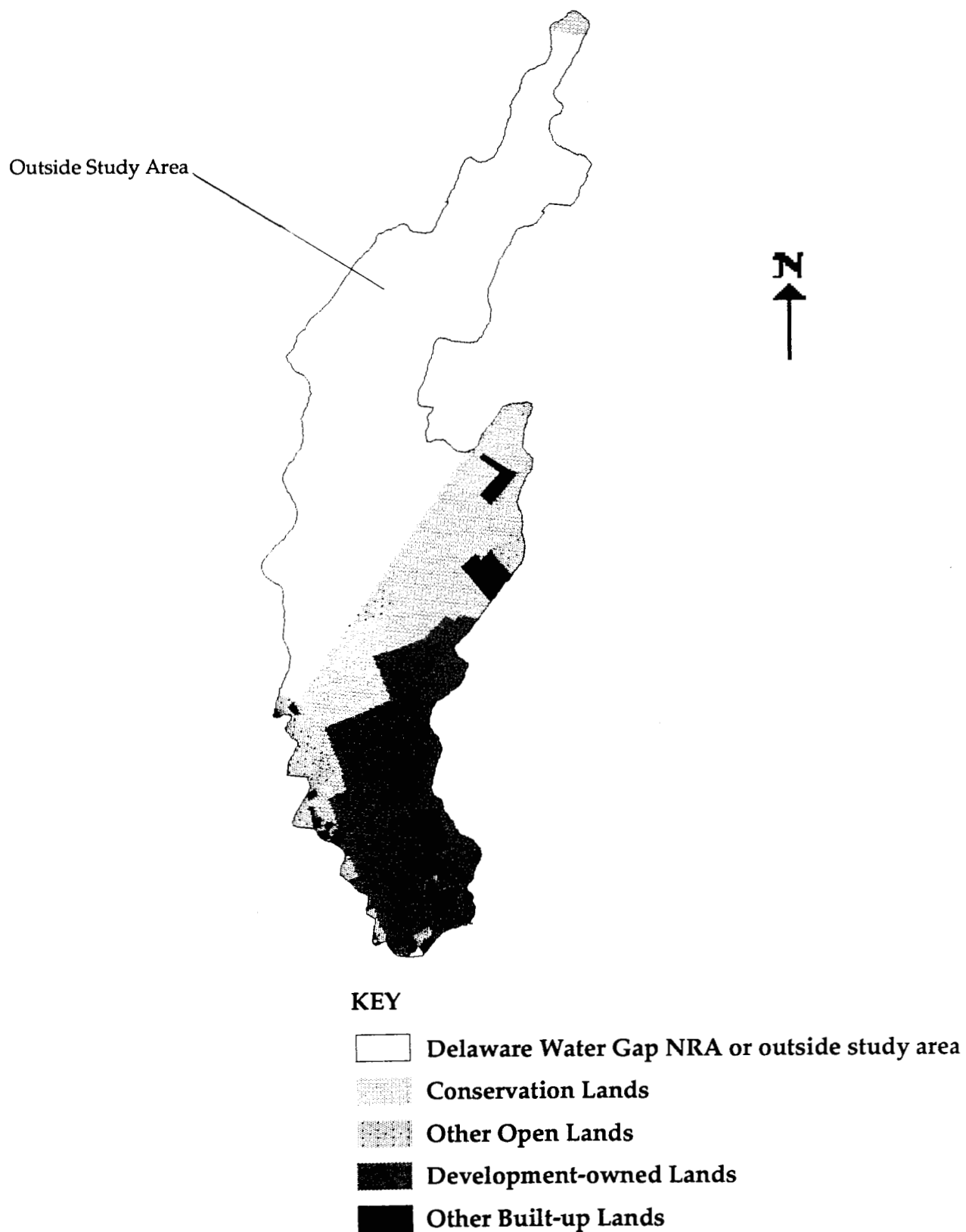


FIGURE 69: Land Use • Bushkill Creek

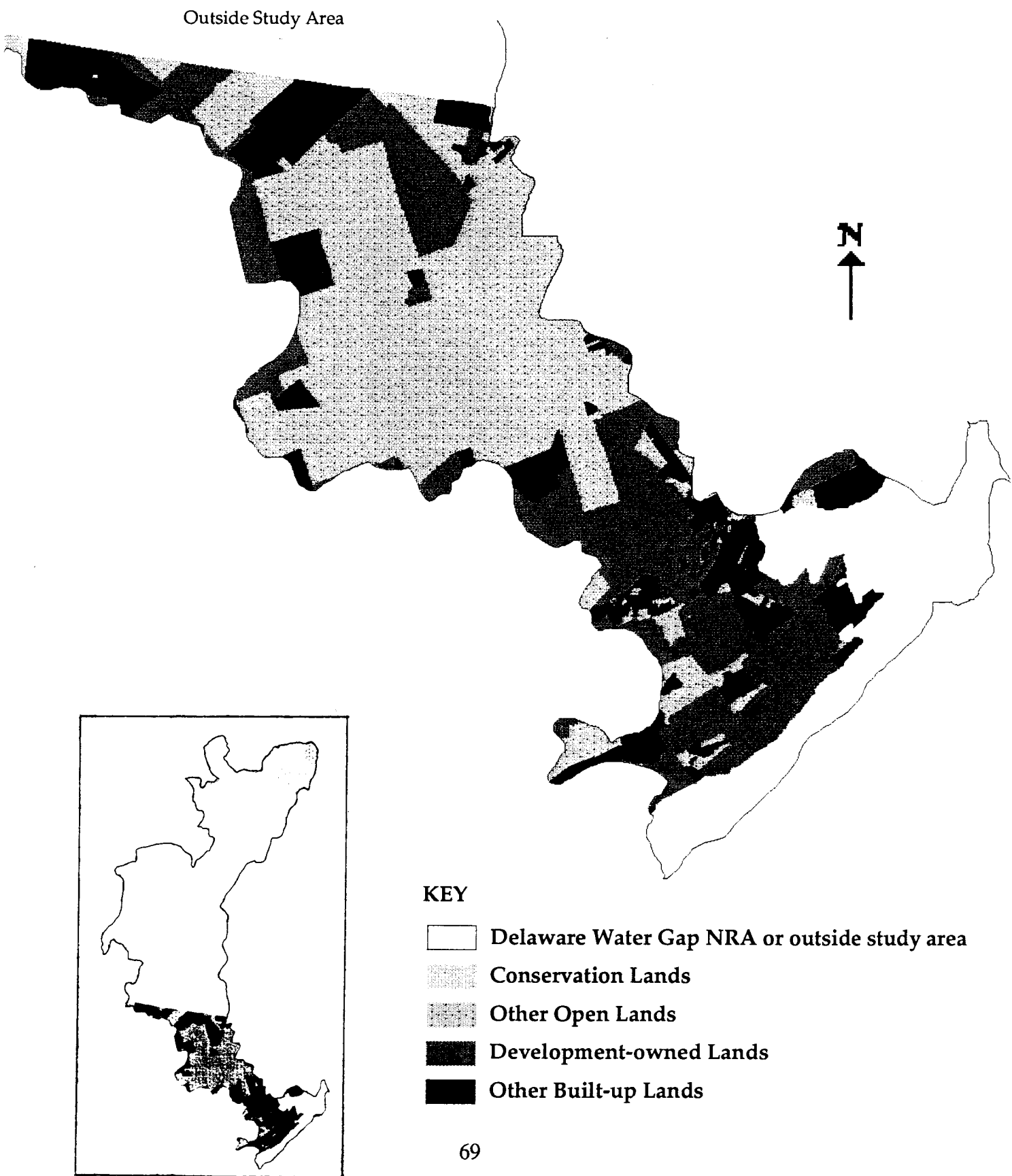


FIGURE 70: Acreage By Use Type • BUSHKILL CREEK

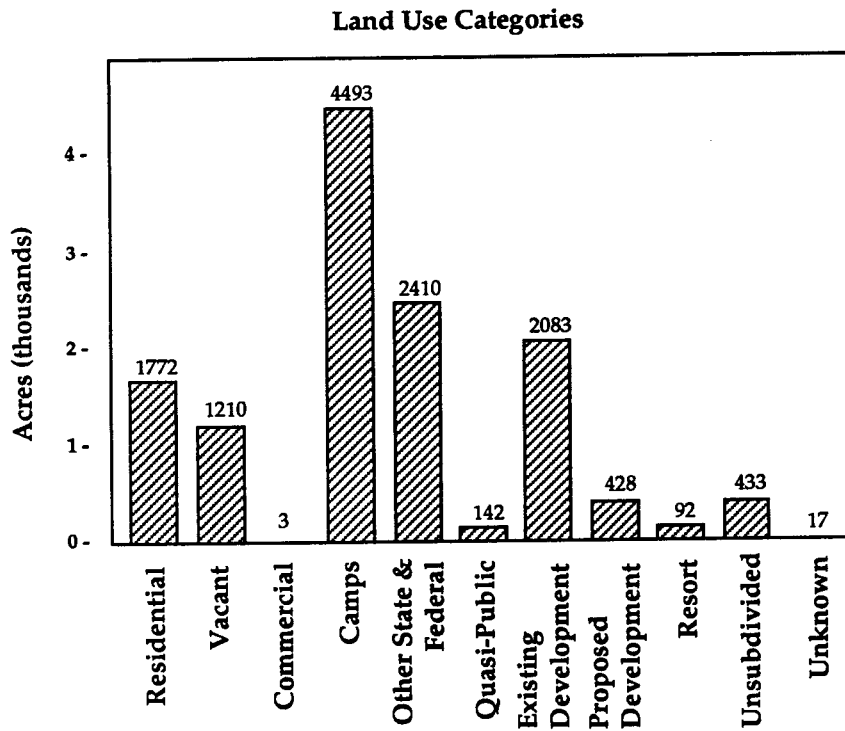


FIGURE 71: Acreage By Use Type • SHAWNEE CREEK

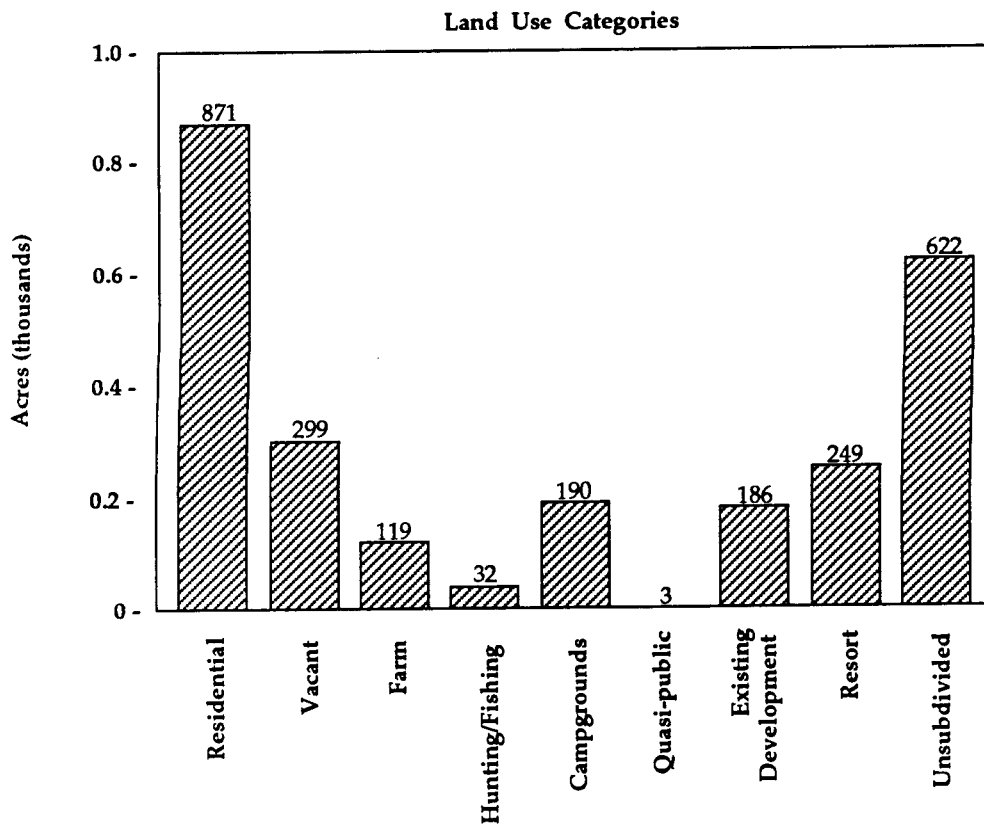
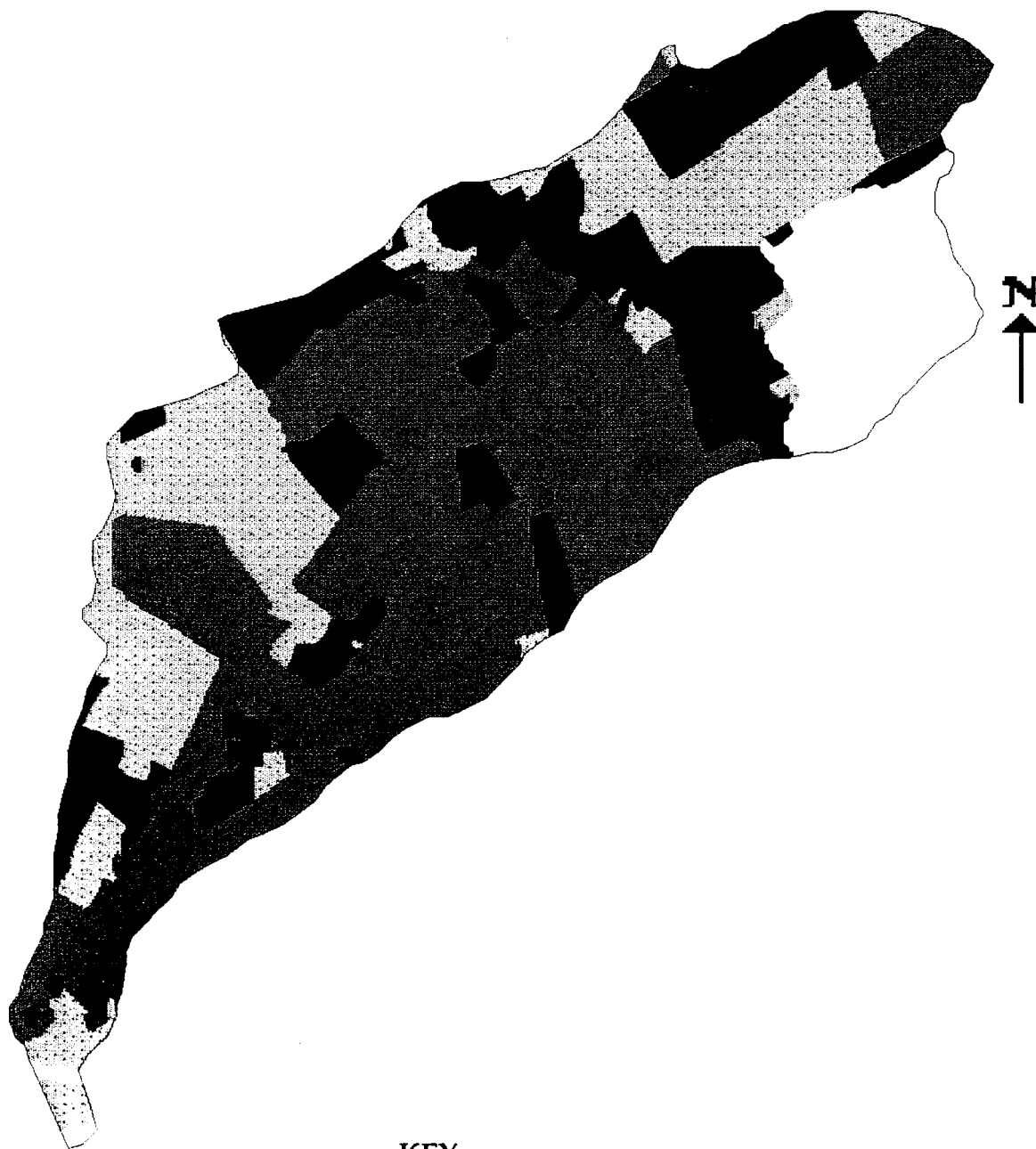


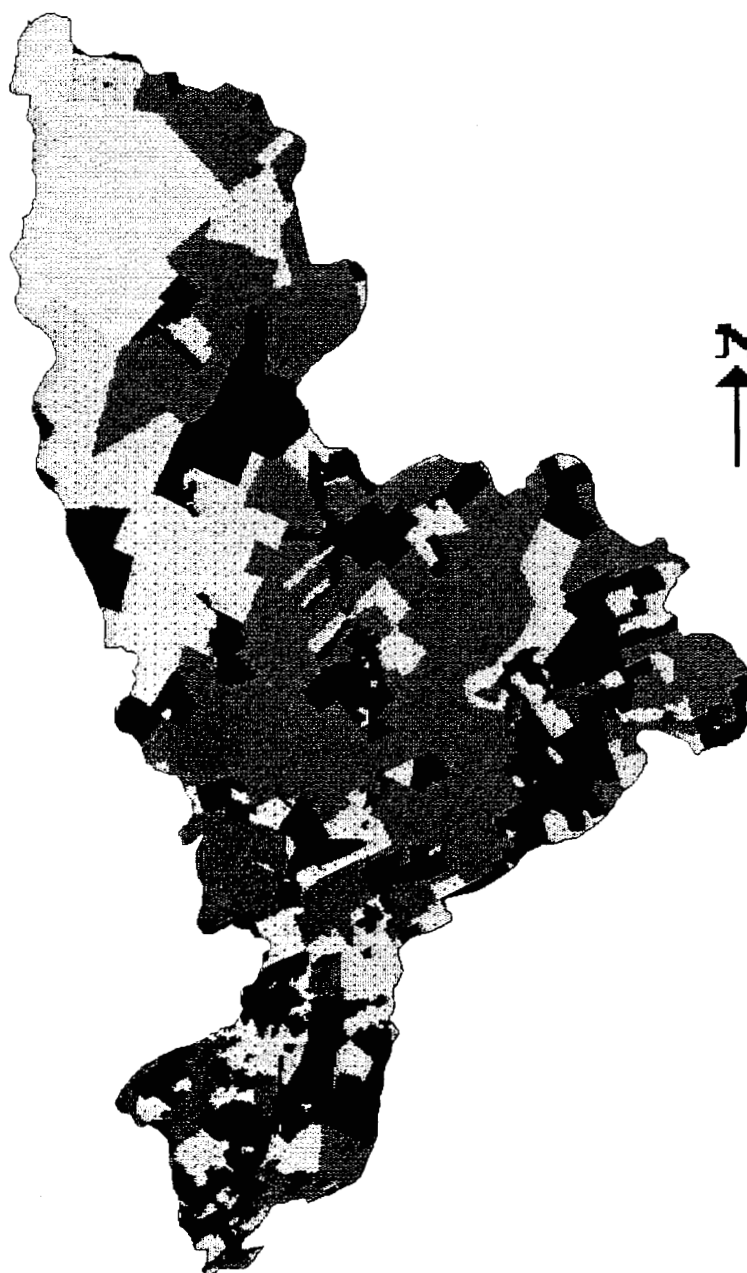
FIGURE 72: Land Use • Shawnee Creek



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

FIGURE 73: Land Use • Marshalls Creek



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

FIGURE 74: Acreage By Use Type • MARSHALLS CREEK

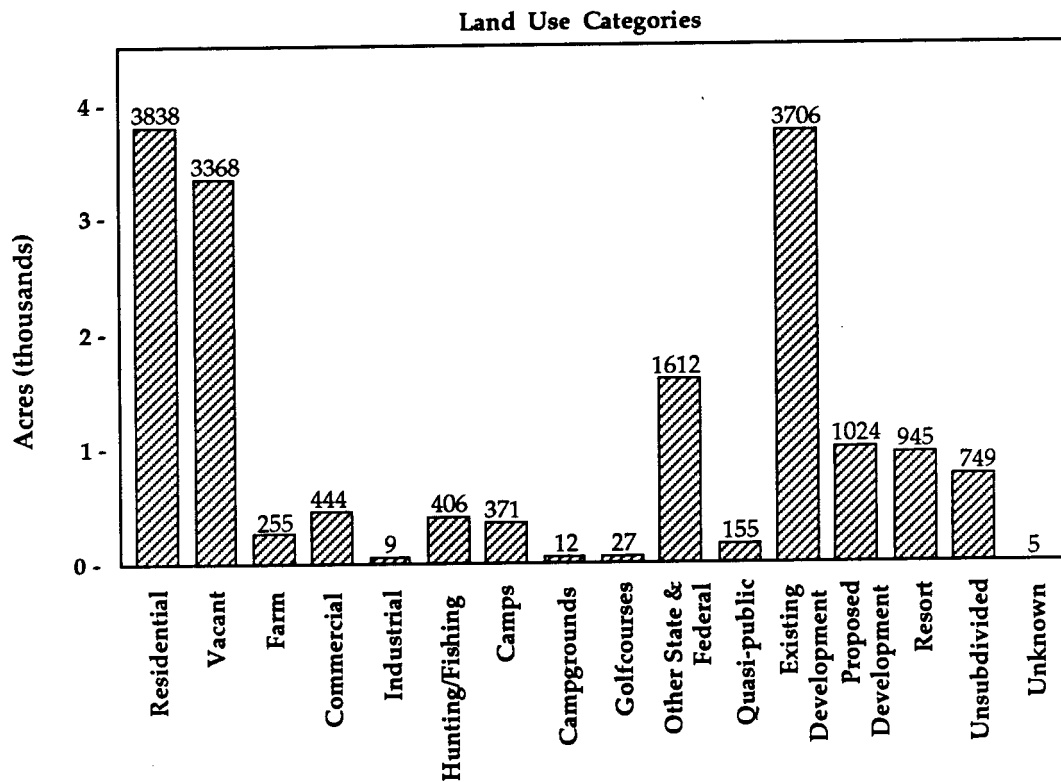


FIGURE 75: Acreage By Use Type • BROADHEAD CREEK

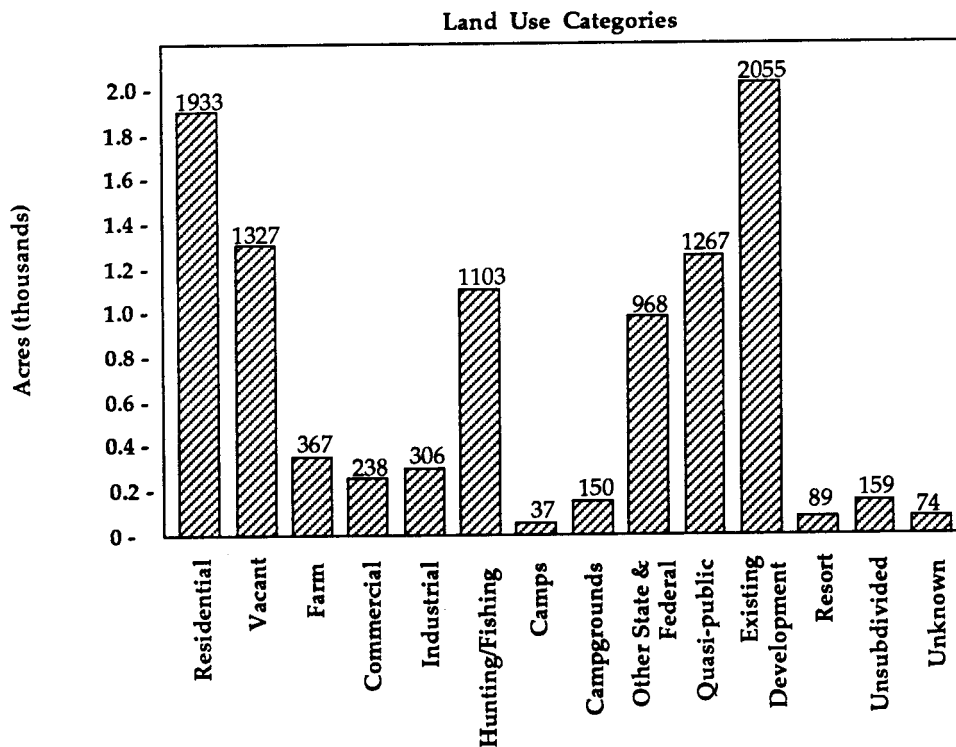


FIGURE 76: Land Use • Brodhead Creek

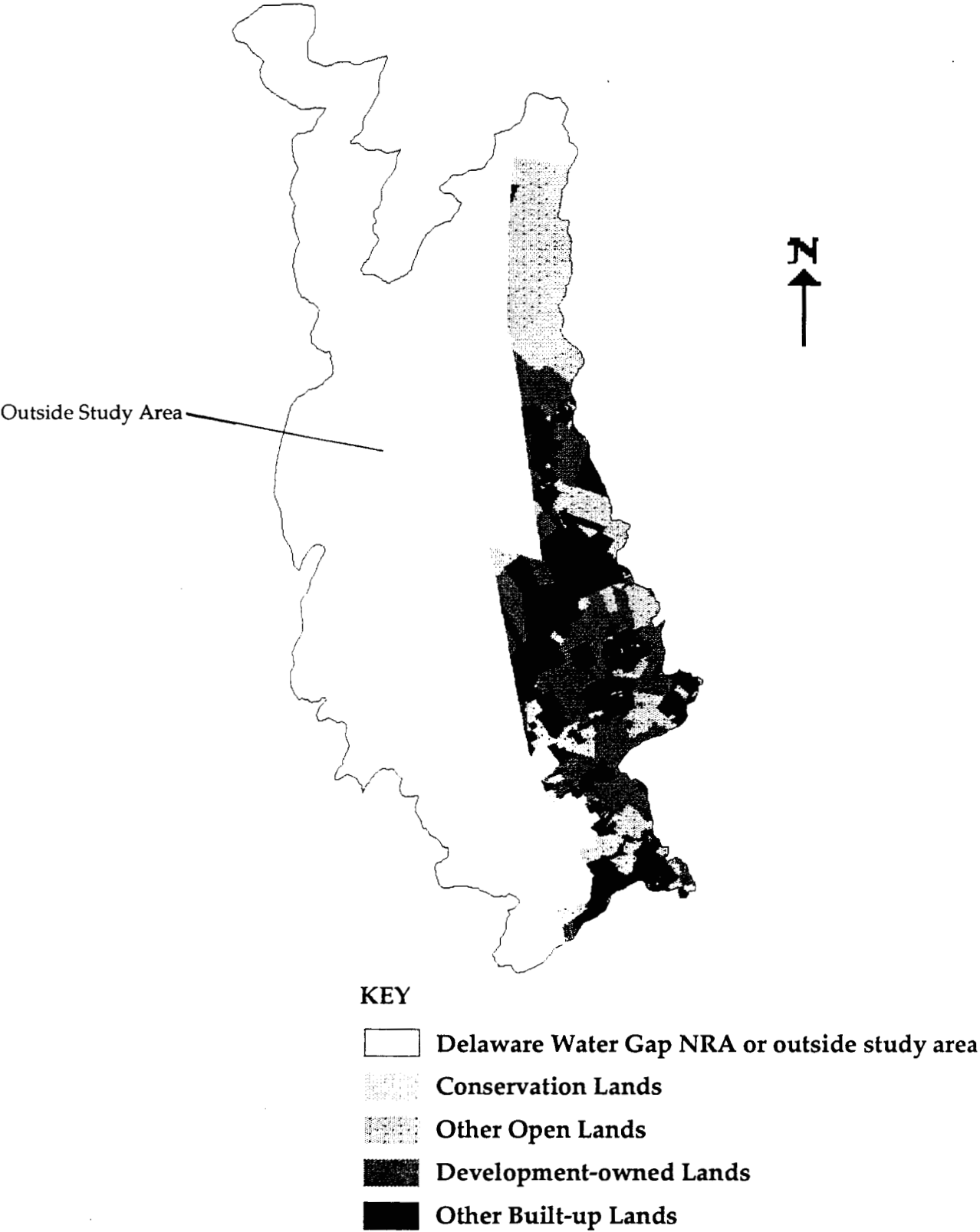


FIGURE 77: Land Use • Cherry Creek

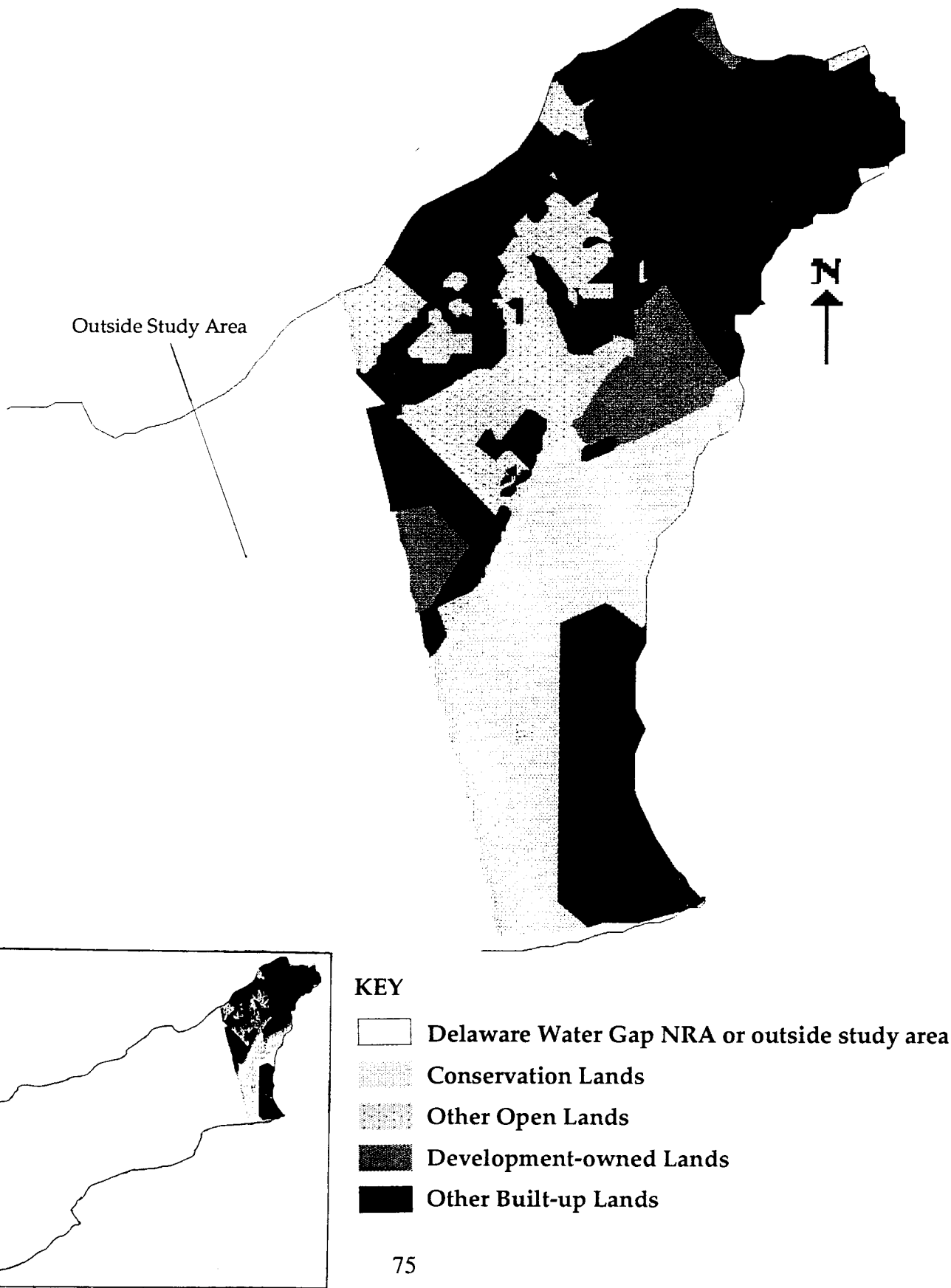


FIGURE 78: Acreage By Use Type • CHERRY CREEK

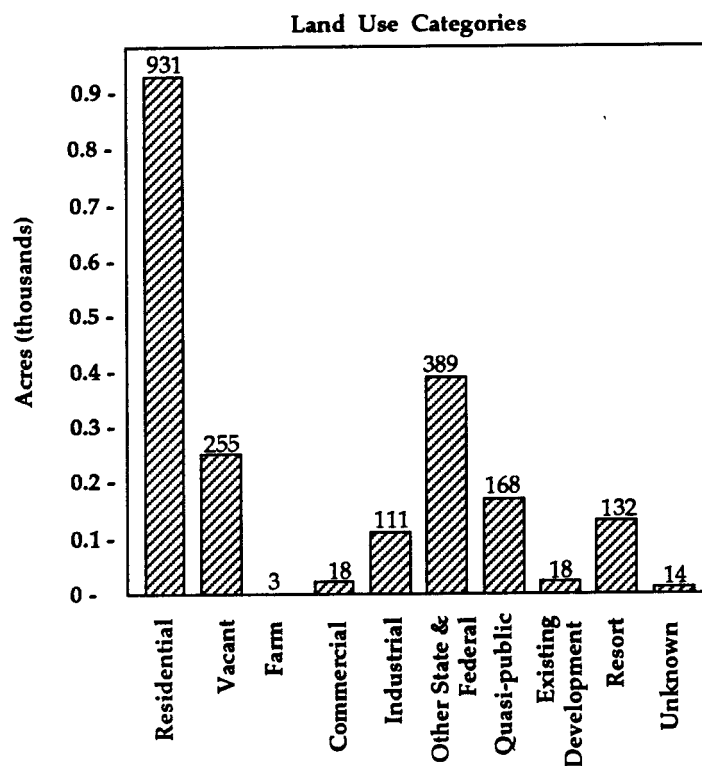


FIGURE 79: Acreage By Use Type • CALEDONIA CREEK

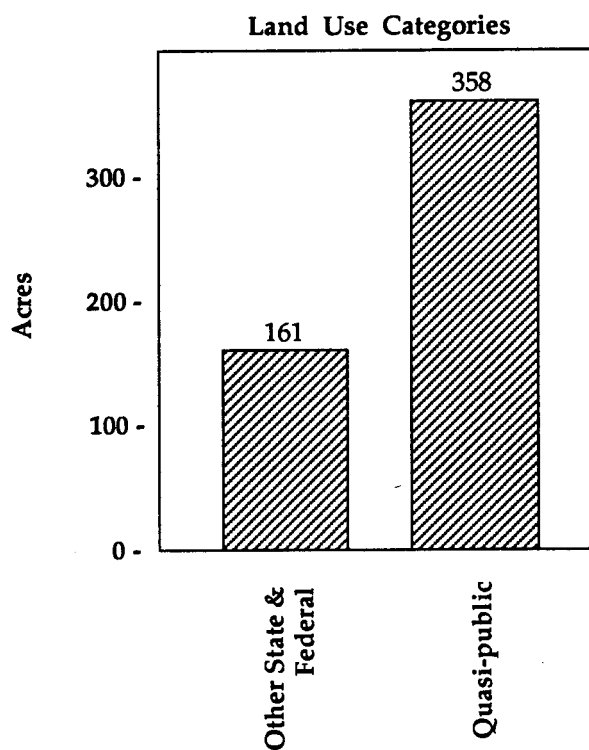


FIGURE 80: Land Use • Caledonia Creek

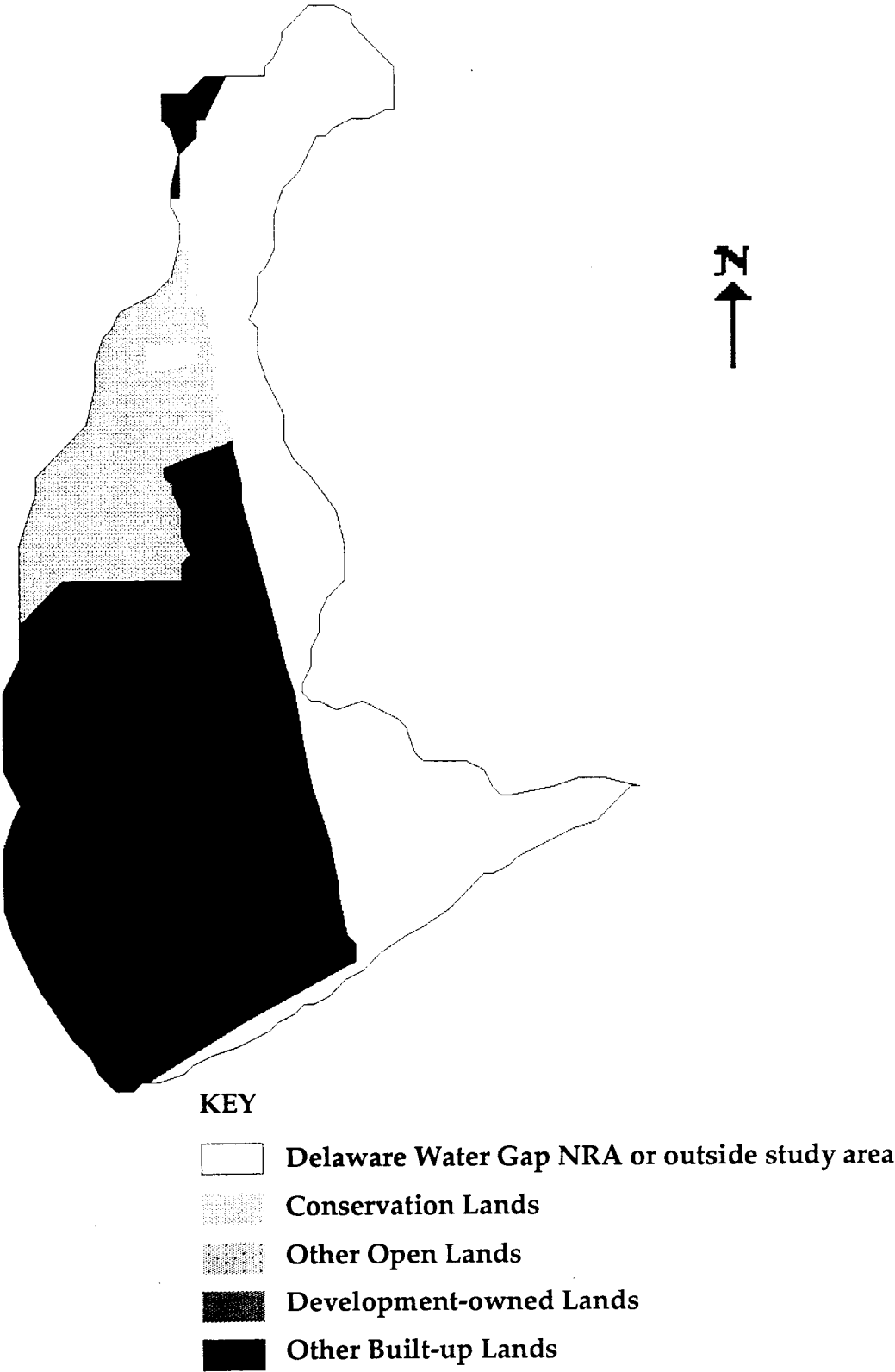


FIGURE 81: Land Use • Shimers Brook

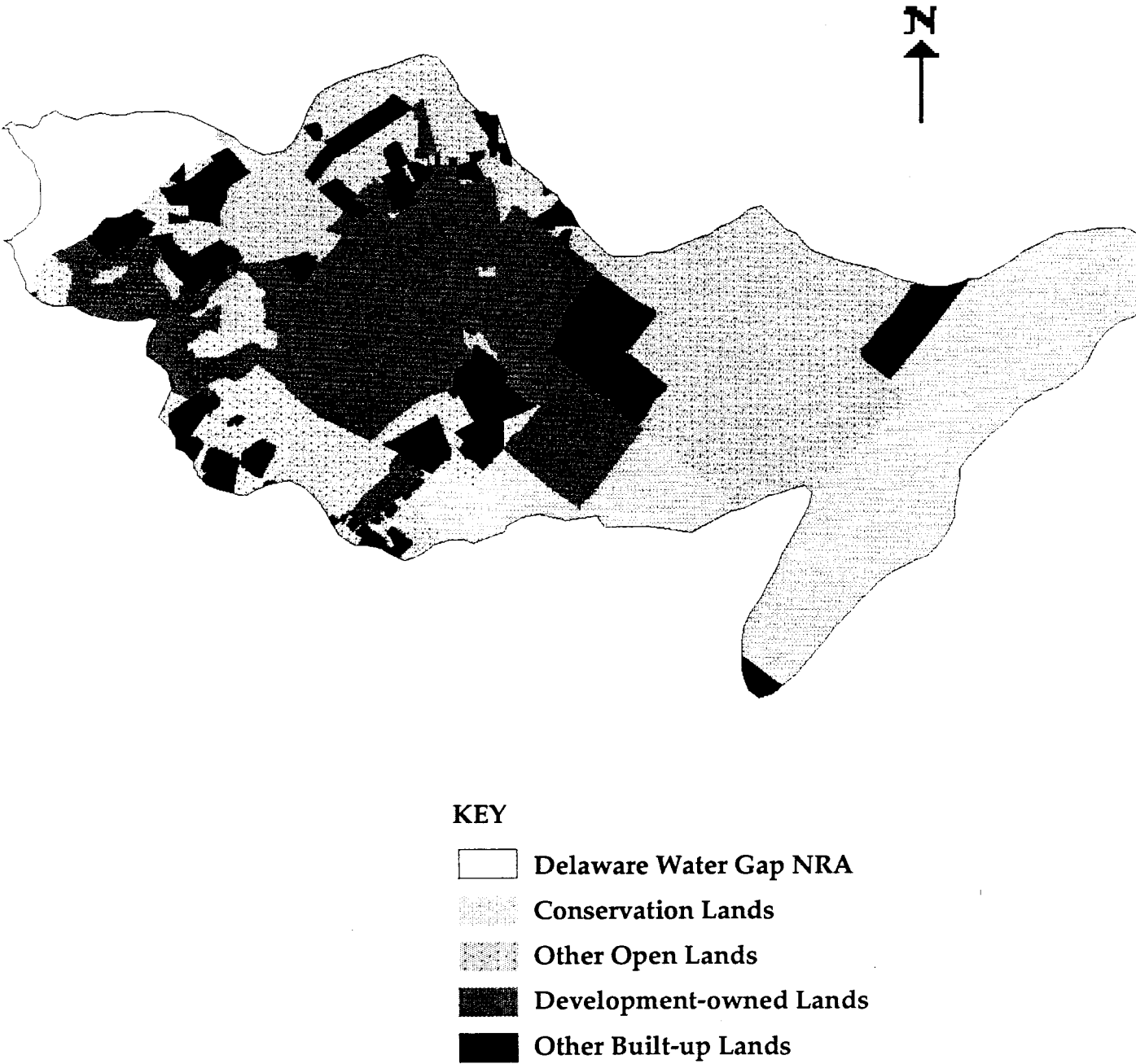


FIGURE 82: Acreage By Use Type ● SHIMERS BROOK

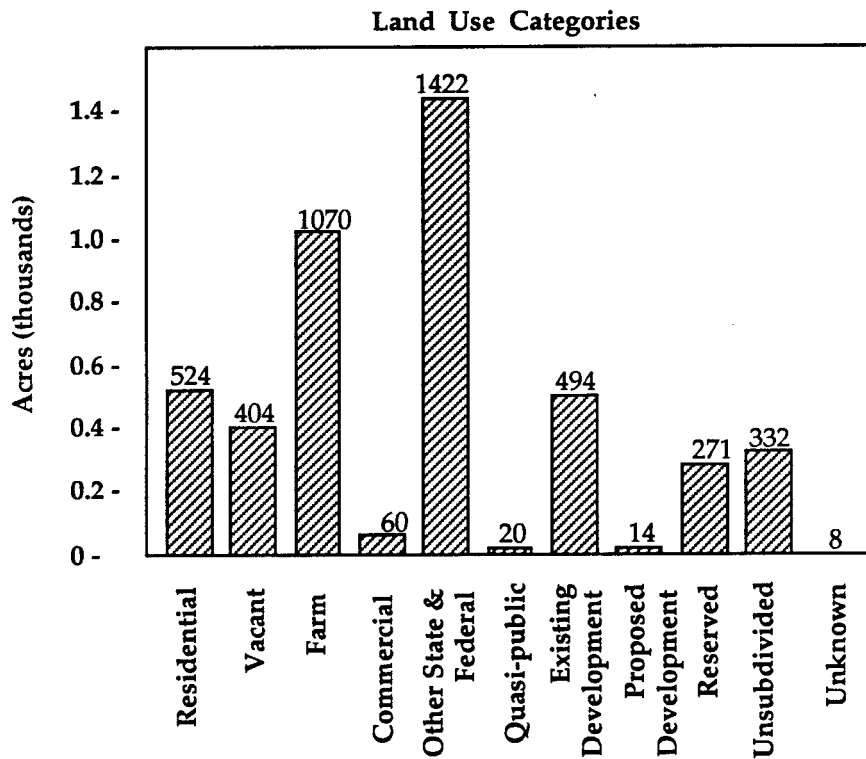


FIGURE 83: Acreage By Use Type ● WHITE BROOK

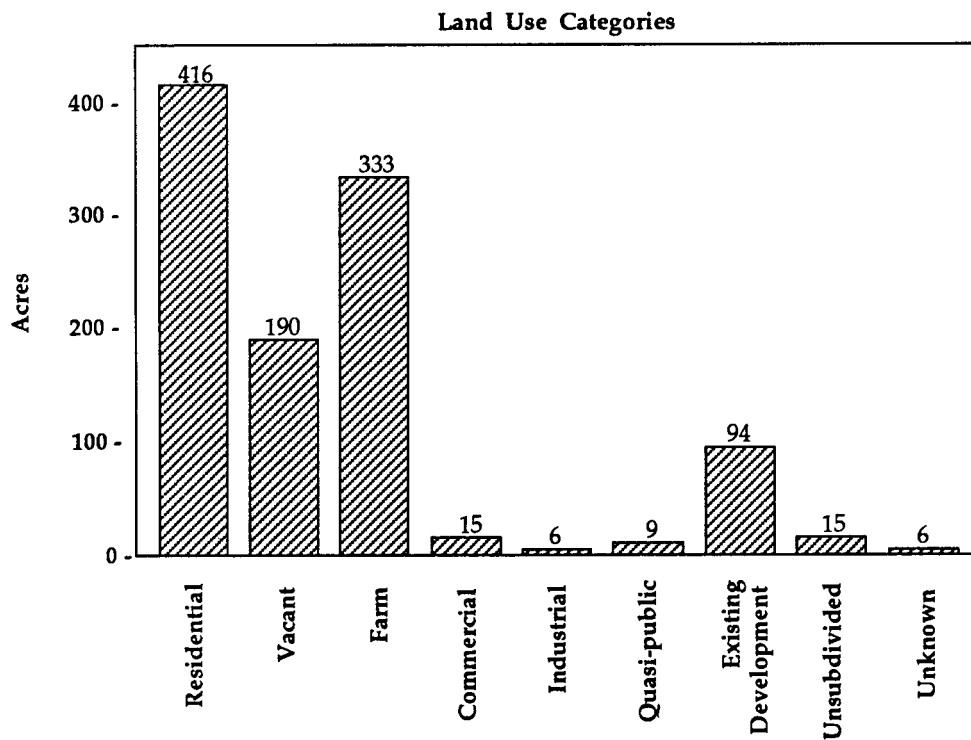


FIGURE 84: Land Use • White Brook



FIGURE 85: Land Use • Mill Brook

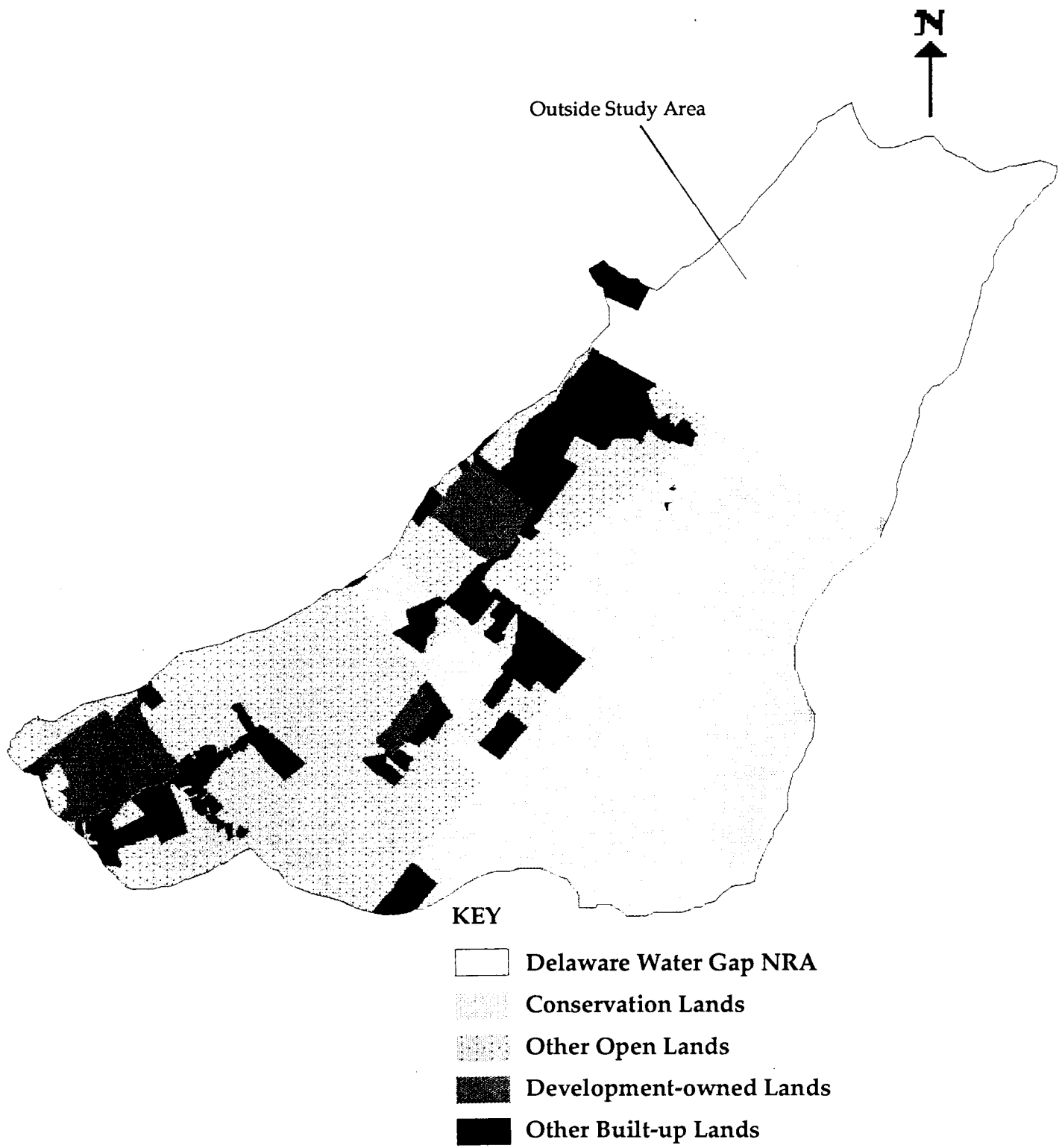


FIGURE 86: Acreage By Use Type ● MILL BROOK

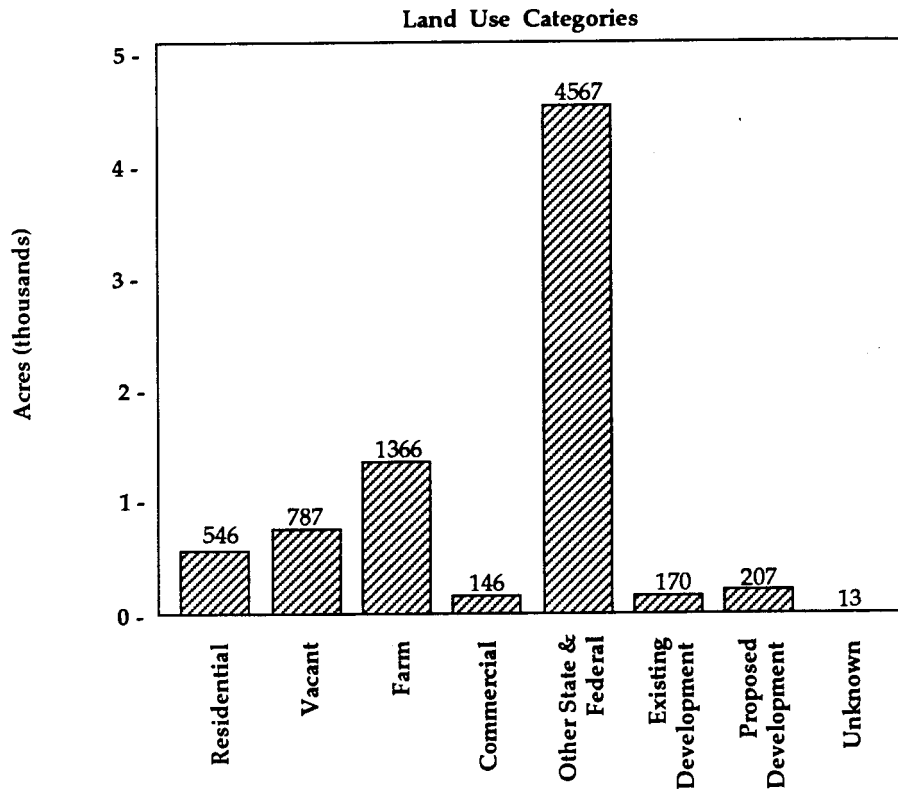


FIGURE 87: Acreage By Use Type ● LITTLE FLATBROOK

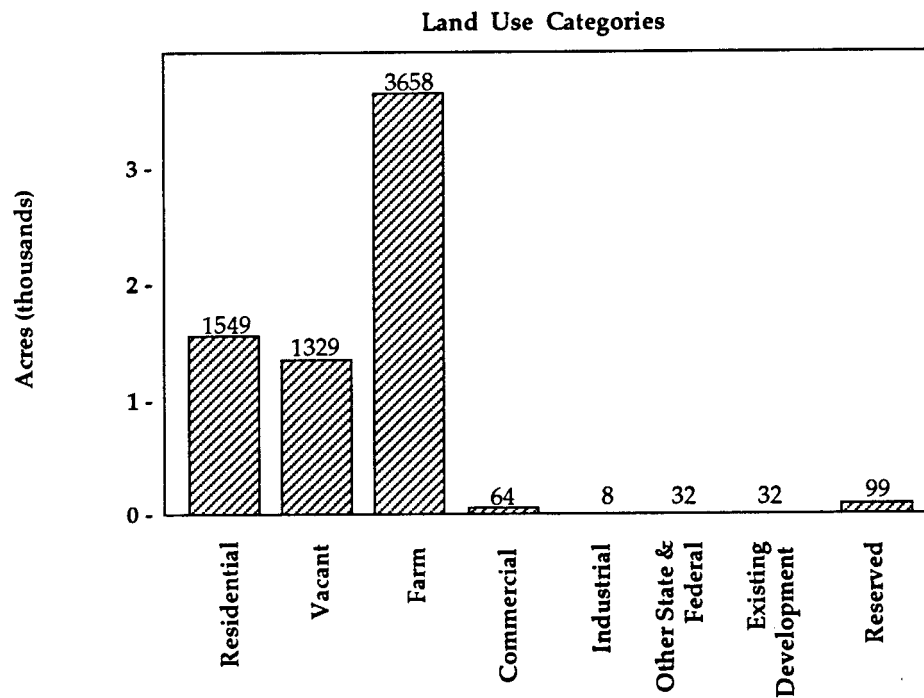
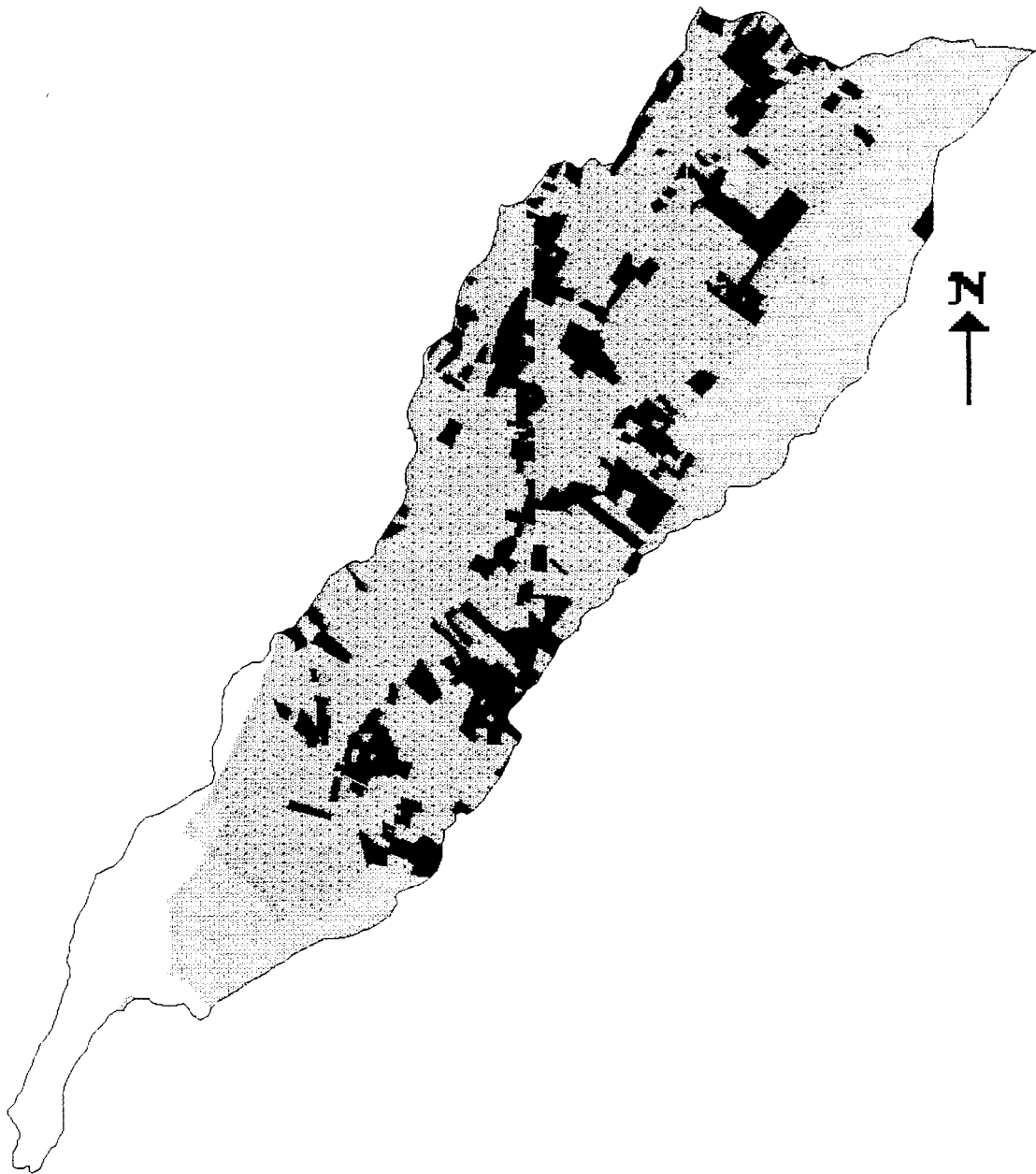


FIGURE 88: Land Use • Little Flatbrook



KEY

-  Delaware Water Gap NRA
-  Conservation Lands
-  Other Open Lands
-  Development-owned Lands
-  Other Built-up Lands

FIGURE 89: Land Use • Big Flatbrook

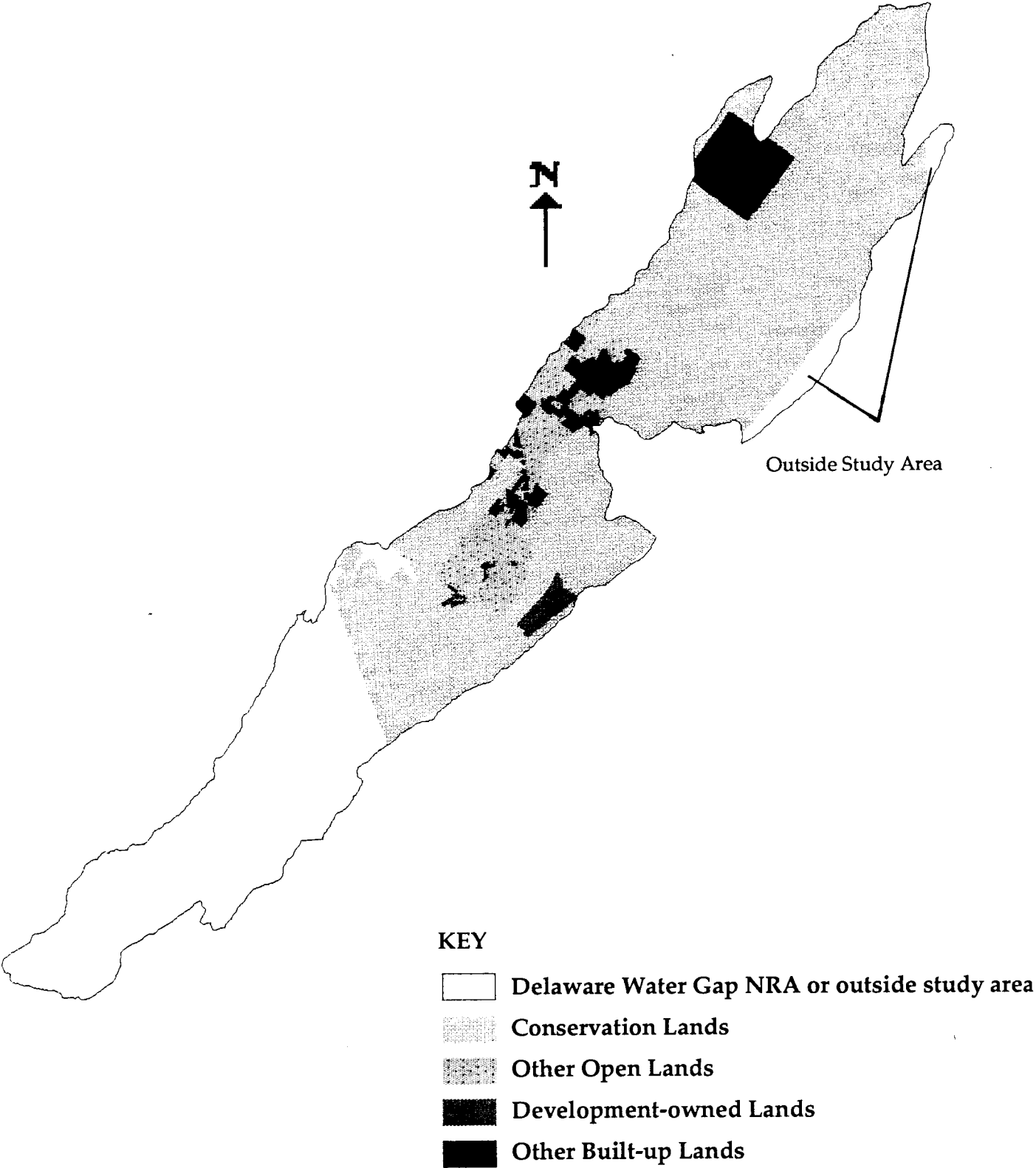
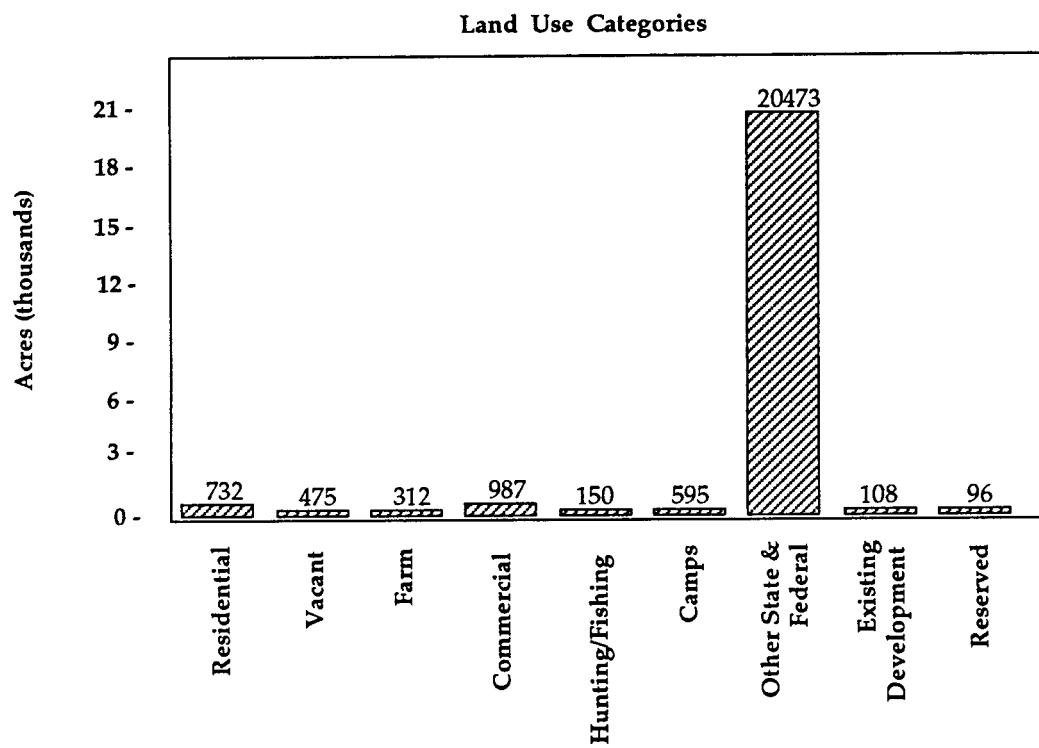


FIGURE 90: Acreage By Use Type ● BIG FLATBROOK



DISCUSSION

Land Use: Land use activity in the study area townships mirrors regional trends described earlier in the report. As the maps and database indicate, subdivision and resort development are the overwhelmingly dominant land use activities in the study area townships. Of the 234,009 total acres in the study area* one-third, or 80,613, are in state or federal ownership, and so unavailable for more intensive land uses. Of the remaining, privately-owned, lands (totalling 153,396 acres), almost 30% are built up in residential, commercial and industrial uses, and another 34% are presently owned by development interests. As an indication of the region's continued potential for tremendous growth, roughly 25% of this subdivision/resort-owned property is now in the planning stages for subdivision and an additional 37% is presently unsubdivided, but will most likely be developed at similar densities. Complete development of this additional land will result in doubling the total developed acreage in the study area.

TABLE 12: Development Status By County For Study Area Townships

	Pike	Monroe	Sussex	Total
No. developments	114	117	7	238
No. subdivided lots	31,183	13,261	1476	45,920
No. dwelling units	9500	4910	835	15,245

Note: table includes some development-owned land which has not yet been subdivided (i.e., large acreage containing only one lot).

Development pressure is particularly intense in the Pennsylvania portion of the study area, as shown in Table 12. The seven Pennsylvania townships contain 231 of the 238 named developments in the study area, and fourteen of the fifteen largest developments (Table 14, Figure 91). These fifteen developments, which range in size from 970 acres to 3255 acres, contain over half (53%) of the developing land, and 61% of the currently subdivided lots. Twelve of the fifteen are located in Pike County, two in Monroe County, and just one in New Jersey's Sussex County. Lot sizes in these developments are often one acre or less, and many of the resort developments contain time-share condominiums and townhouses which further increase development densities. When developing lands are factored in, the study area townships in Pike County contain 70% of the land undergoing active development, and Monroe County contains 27%. This information reinforces population figures described earlier in the report which show that the wave of urbanization moved first through Monroe County. A higher

* For analysis purposes, all lands within the perimeter of the study area townships were included (i.e., National Recreation Area lands and land in the five immediately adjacent boroughs of Matamoras, Milford, Delaware Water Gap, Stroudsburg and East Stroudsburg), though these were not officially a part of the study area.

proportion of that land is already built up, and the intensity of development activity in Monroe County has subsided somewhat. As Table 13 and Figure 91 show, Pike County has now become the focus of intense development in the area.

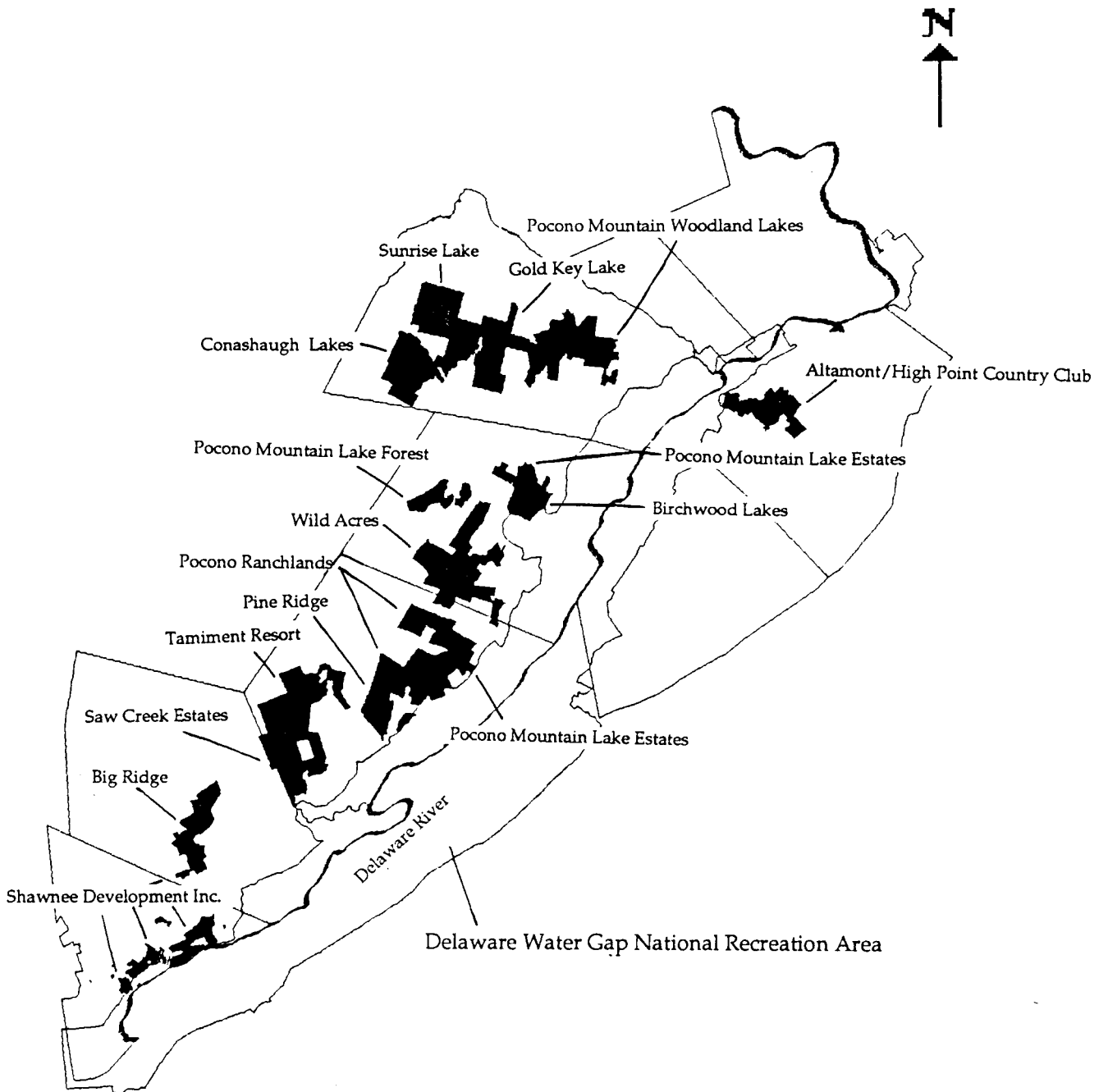
TABLE 13: Fifteen Largest Developments in Study Area

Name	County	Acres	Lots	% Built
Sunrise Lake	Pike	3255	1189	51
Pocono Mt. Lake Estates	Pike	3204	2626	17
Wild Acres	Pike	2991	4872	21
Pocono Mt. Woodland Lks.	Pike	2543	1676	18
Saw Creek Estates	Pike	2437	2741	61
Tamiment Resort	Pike	2300	452	18
Pocono Ranchlands	Pike	1900	2000	13
Conashaugh Lakes	Pike	1700	964	18
Shawnee Development	Monroe	1296	64	na
Altamont	Sussex	1228	999	55
Gold Key Lake	Pike	1200	2046	32
Pine Ridge	Pike	1100	1524	24
Pocono Mt. Lake Forest	Pike	1088	1085	13
Birchwood Lakes	Pike	1000	2517	30
Big Ridge	Monroe	970	3300	2

There continues to be a significant potential for growth in the area. Of the study area's 238 resorts and subdivisions, 184 are presently undergoing active development. Only twenty-two of the 231 Pennsylvania developments have been built out, and just 33% of all currently available lots have dwelling units built on them (see Table 12). In addition, mapped ownership patterns indicate that the developers of many of these properties own large amounts of as-yet unsubdivided land adjacent to these developments. This land will likely experience the same intensity of development in the near future.

The remaining 36% of privately-owned land represents hunting clubs, camps, farms, and other low-intensity land uses. Some of these large land holdings may be sold and subdivided in the future, and because of the uncertain future of these lands impacts projected in this report could be greatly underestimated.

FIGURE 91: Location of 15 Largest Developments in Study Area



Land use, growth and development activity can also be evaluated on a watershed basis. Point and non-point source pollution inputs will generally be delivered to the Middle Delaware via these drainage pathways. Projections of future loadings and their impacts can be made on the basis of acreage under various different land uses and anticipated future uses. Table 14 lists the ten most actively developing watersheds, ranked by number of acres undergoing active development.

TABLE 14: Ten Most Actively Developing Watersheds

Watershed	County	Acres Developed or Developing	Number of Developments
Raymondskill Creek	Pike	11,858	25
Marshalls Creek	Monroe	10,870	62
Dingmans Creek	Pike	6210	18
Brodhead Creek	Monroe	6047	36
Little Bushkill Creek	Pike	5537	13
Toms Creek	Pike	4963	6
Big Bushkill Creek	Monroe	4953	30
Sawkill Creek	Pike	4893	20
Saw Creek	Pike	4828	9
Hornbecks Creek	Pike	4575	7

Note: "Acres Developed or Developing" includes the following land use categories: Residential, Commercial, Industrial, Quasi-Public, Development - existing, Development - proposed/in progress, Development-owned, and Resorts.

Although some of the watersheds near the older, established boroughs and towns are still experiencing a certain amount of growth, open areas draining to the center of the Middle Delaware - particularly in Pike County - appear to have the greatest potential for impacting water quality because of increased point and non-point sources loadings accompanying urbanization. The level of impact generated by further development will depend on permitted densities and the types of land management and development practices employed. If centralized wastewater treatment becomes more widespread, development densities will likely increase, intensifying both point and non-point source development impacts.

Potential Water Quality Impacts in the Middle Delaware Watershed: The expanding regional population base has been accompanied by an increase in the total volume of domestic wastewater requiring treatment and disposal. In the nine study area townships, there are presently twenty-one centralized wastewater treatment plants to process sewage not treated on-lot via septic or sand mound systems. Of the twenty-one, seven are in the process of expanding to treat significantly larger volumes of wastewater.

Fourteen additional plants are currently in the proposal, permitting or construction phase. Figure 3 (page 6) identifies the locations of existing and proposed wastewater treatment facilities in the area around the National Recreation Area.

A few examples illustrate the explosive nature of growth in the region. A treatment plant serving Fernwood Resort now discharges 150,000 gallons per day (gpd) to Bushkill Creek immediately above the National Recreation Area boundary. The facility has recently received permit approvals to become a regional facility for Middle Smithfield Township, treating a total of one million gpd. The facility plans an ultimate expansion to 3.3 million gpd to accommodate growth in the lower Bushkill watershed. A wastewater treatment facility in Matamoras which now treats 45,000 gpd of wastewater generated by a hotel and a townhouse development is seeking approvals to construct an 820,000 gpd regional facility at the site, which lies just three miles above the National Recreation Area and the Middle Delaware. Downstream, inside the National Recreation Area, a feasibility study completed in 1990 has proposed locating three regional plants to service the Milford/Dingmans area, with a combined treatment capacity of three to four mgd. Continued growth and a lack of suitable soils for on-lot wastewater disposal will lead to further plans for construction of new plants or expansion of existing facilities.

Information from the land use database and the sewage treatment data file was used to develop estimates of present wastewater flows and projections of future wastewater generation in the study area townships and adjacent boroughs. These figures, summarized in Table 15 show that major increases to wastewater flows are on the immediate horizon. These will translate to substantially increased point source loadings if the state permitting agencies continue to approve wastewater discharge to surface waters under current standards.

Figures used to estimate wastewater flows are highly variable, both between the two states and between state and county. In Pennsylvania, estimates are made using flows of 60 gpd per person and 210 gpd per dwelling unit, assuming a full time, permanent occupancy rate of 3.5 people per dwelling unit. New Jersey values are slightly higher, with estimates of 65 gpd per person and 220 gpd per dwelling unit. Flow estimates made by two of the study area counties are considerably higher. The Monroe County Planning Commission uses figures of 100 gpd per person and 350 gpd per dwelling unit, and Sussex County uses a range of 75 to 100 gpd per person, and 300 to 400 gpd per dwelling unit.

Attempts to calculate wastewater flows are further complicated by number of occupants and type of residence. While the states both assume an average of 3.5 people per dwelling unit, the US Census Bureau reports an average family size in 1988 of 2.6 people. 1980 figures for Middle Smithfield and Smithfield report an average of 2.7 people per dwelling unit (Monroe County Planning Commission 1989). Further complicating wastewater flow estimates, some dwellings in the study area are occupied only seasonally and other units are time-shared with more than 3.5 people occupying the

residence on a full-time basis. Calculations made for the land use study assume permanent, full-time occupancy for all dwellings with no downward adjustment for seasonal/ weekend use or upward adjustment for time-sharing. A range of wastewater flows, from 150 to 300 gpd, is used for the study area townships to accomodate changing demographics and variability in occupancy.

TABLE 15: Estimates Of Existing And Potential Domestic Wastewater Loadings In The Lands Around Delaware Water Gap NRA
Values based on mgd (million gallons per day)

Municipality	Existing Flows	Flows Now Treated At STP's	Existing/ Proposed STP Flows	Near-Future Flows	Potential Ultimate Flows
Matamoras	0.2 – 0.6	-	-	0.2 – 0.6	0.2 – 0.6
Westfall	0.1 – 0.2	0.125	1.28	0.4 – 0.8	2.2 – 4.3
Milford Tsp	0.06 – 0.13	-	(w/Ding.)	0.2 – 0.4	1.0 – 2.1
Milford Boro	0.17 – 0.34	-	-	0.17 – 0.34	0.17 – 0.34
Dingmans	0.61 – 1.2	0.10	4.0	2.0 – 3.8	3.9 – 7.8
Delaware	0.4 – 0.9	0.20	0.2	2.0 – 4.1	3.2 – 6.4
Lehman	0.4 – 0.9	0.25	2.4	1.6 – 3.1	3.0 – 6.1
MidSmithfld	0.6 – 1.3	0.15	1.2	1.8 – 3.5	4.1 – 8.1
Smithfield	0.3 – 0.5	0.245	4.7	0.8 – 1.5	2.0 – 4.0
E.Stroudsbgb	1.3	1.3	2.25	2.25	2.25
Stroudsburg	0.8	0.8	3.2	3.2	3.2
DelWaterGap	0.18	0.18	0.18	0.18	0.18
Port Jervis	1.5	1.5	1.5	1.5	1.5
Montague	0.15 – 0.3	-	0.83	0.6 – 0.9	1.8 – 3.5
Sandyston	0.12 – 0.23	-	-	0.15 – 0.28	1.2 – 2.5
TOTAL	6.9 – 10.4	4.8	21.7	17 – 26	30 – 53

Notes: STP = Sewage Treatment Plant

Figures as of 12/90

In Table 15, the calculations of existing wastewater generation (Column 1) represent flows of 150-300 gpd per dwelling unit for the study area townships, regardless of whether wastewater is treated on-lot or at a central facility, and actual treatment plant flows for the boroughs of Delaware Water Gap, Stroudsburg, and East Stroudsburg. For Matamoras and Milford Boroughs, a value of 100 gpd was used to convert population figures to wastewater flows. Column 2 presents figures for wastewater flows now treated at existing facilities. Column 3 adds in treatment volumes for new or expanding plants that are in the planning or construction phase to provide an estimate of flows that will be centrally treated in near future. Flow information in Columns 2 and 3 was obtained from discharge permits and project approvals filed with the Pennsylvania Department of Environmental Resources and the Delaware River Basin Commission. Column 4 of Table 15 presents estimates of future wastewater flows, assuming buildout

only of land that is already subdivided and immediately available for development, and land that is known to be owned by development interests and so is likely to be developed in the near future. Calculations are based on 150 and 300 gpd for residential uses and 200 gpd for commercial structures. The five boroughs are assumed to represent a stable population except where additional treatment plant capacity becomes available, and the flow from Port Jervis is assumed to remain 1.5 mgd (however, as the Port Jervis plant has an actual constructed capacity of six mgd, future flows may be considerably higher).

Column 5 assumes build-out of all private land not now owned by development interests, in one-acre lots with flows calculated as described above. However, current development densities are generally less than one acre, and the provision of centralized wastewater treatment could conceivably result in increased densities, so this may result in underestimating flows. Estimates do not include projected increases in the proportion of residential to commercial/industrial or other land uses.

Current wastewater flows in the nine study area townships are estimated at 2.8 to 5.7 mgd. Of this, over one mgd is currently processed at central treatment facilities and discharged to surface waters. The remainder is treated via on-lot systems; frequent failure of these systems may force conversion to some form of centralized treatment. An additional 3.8 mgd is currently treated at municipal plants in Port Jervis, Stroudsburg, East Stroudsburg, and Delaware Water Gap. When these flows - and estimates of flows presently treated on-lot in Matamoras and Milford boroughs - are factored in, total wastewater generation in the immediate Middle Delaware region is almost seven mgd (using the low 2.8 mgd estimate for study area townships), with approximately five mgd of that processed at existing treatment plants.

A growing percentage of the area's wastewater flow is undergoing centralized treatment, thus reducing the volume disposed of via on-lot systems. Near-future (10 to 20 year time frame) projections (column 4, Table 15) place wastewater flows at 10 to 18 mgd in the townships immediately surrounding the National Recreation Area. Existing plants, and plants now in either the planning phase or under construction, will treat almost 15 mgd of that flow.

With the additional treatment capacity of the Port Jervis, Stroudsburg, East Stroudsburg, and Delaware Water Gap plants, the total volume of wastewater treated at area plants in the immediate future will be over 21 mgd. Complete build-out of all privately-owned lands in the area could generate flows in excess of 50 mgd. With full build-out, it is likely that much of the wastewater flow will be delivered to centralized treatment facilities for treatment and disposal. These totals do not include wastewater generated and/or treated at facilities located outside of the study area, but within the Middle Delaware drainage area (e.g., Brodhead Creek, the Upper Bushkill, and the Delaware River above Port Jervis). Development activity is intense in those areas as well, and it is anticipated that they will contribute to water quality impacts also.

Increased non-point source loadings in the Middle Delaware watershed are also

anticipated as a result of the intensifying development. New sources will principally be linked to increased stormwater runoff, the malfunctioning of existing on-lot wastewater treatment systems, and land clearing and development activity as the area's forested lands are converted to suburban and urban land uses. Preliminary models of projected non-point source loadings were developed from the land use study data during formulation of a water quality protection strategy for the Middle Delaware (DRBC/NPS 1990). Build-out of current developments in the Middle Delaware watershed could result in nitrogen loadings of up to 35,000 pounds per year, phosphorus values as high as 20,000 pounds per year, and Biochemical Oxygen Demand loadings in excess of 200,000 pounds per year.

Additional analyses were performed using the US Department of Agriculture AGNPS model to assess the effects of converting forested land to residential use. Three soil types and two slope conditions (3% and 15%) representative of the Pocono region were evaluated under a model storm event of a 1 inch rainfall. Peak runoff from the 1 inch storm increased over 600 percent, carrying with it nitrogen and phosphorus runoff that represent increases (in pounds per acre) of 2700 and 850 percent. Given that development is underway on 53,000 acres in the study area, with an additional 55,000 acres potentially available for acquisition and development, these preliminary models indicate a potential for enormous non-point source related water quality impacts. Non-point source loadings will increase significantly with full build-out of the study area. Without implementation of stringent controls, these loads could greatly exceed point source pollution loads anticipated from area wastewater treatment facilities.

The point and non-point source analyses described above represent low estimates of potential impacts. Because portions of some watersheds draining into the Middle Delaware (including the Delaware River above Port Jervis) lie outside the study area, their input was not factored in to projections of existing and future wastewater and non-point source loadings. However, these areas, too, are experiencing intense development activity, and both present and future impacts on water quality may be acute.

CONCLUSIONS

As the land use data show, changing land use patterns in the Middle Delaware watershed, and land management decisions that are now being made, have the potential for tremendous impacts on water quality. While the explosive growth rate experienced during the past decade may subside to some extent, the long term upward trend is expected to continue, bringing with it continued pressure on the region's resources.

Characterizing and quantifying land uses within Delaware Water Gap National Recreation Area watersheds through this land use study has assisted with identifying potential threats to water quality that accompany the intensifying development. Information from the study has been used in conjunction with water quality monitoring

data and an assessment of existing water resource management programs to develop recommendations for the enhanced protection of water resources within the National Recreation Area. A draft scenic rivers protection strategy has evolved out of this joint NPS/DRBC planning effort. It presents a range of options and alternatives for achieving the goal of preserving and enhancing water quality. Revisions to Commission antidegradation policies, water quality standards, and discharge regulations are proposed, and innovative yet proven alternatives to conventional wastewater treatment technologies are encouraged. Non-point source controls are recommended for new service areas. The plan also recommends expanding monitoring, enforcement, and technical assistance capabilities, with improved coordination between the many local, regional, state, and federal agencies that have water quality management responsibilities. Strategies proposed by the NPS/DRBC plan should provide greater protection through approaches that are technologically achievable, and will not unreasonably limit growth. It is anticipated that formal public hearings on the plan will take place in the fall of 1991.

While tighter controls and discharge regulations will go far toward substantially reducing point source pollution inputs, continued water quality degradation from non-point source inputs is likely unless a more comprehensive non-point source control program is developed. Successful control will require a multi-faceted regional or watershed-wide approach combining the use of Best Management Practices during construction, the establishment of buffer zones along unprotected stream reaches, use of septic management districts to reduce the rate of on-site system failure, development of natural features ordinances to provide protection for sensitive resources, etc.

In conjunction with expanding Geographic Information System capabilities at the National Recreation Area, future work will focus on expanding and refining the analysis of potential non-point source pollution inputs in the Middle Delaware watershed. In addition, work is underway to develop handbooks on Best Management Practices and innovative alternative wastewater treatment technologies applicable to this region in order to assist with finding effective means to achieve environmentally sustainable development in the lands surrounding the National Recreation Area. A balanced strategy focussed on controlling both point and non-point sources will be necessary in order to fully protect the region's exceptional water quality.

While the National Recreation Area land use study was developed initially to provide planning projections for formulation of a Middle Delaware water quality protection strategy, it has much wider applications. Information contained in the maps and relational database can be used both by park staff and by other local and regional government agencies for a variety of purposes, including planning to meet future wastewater disposal needs, emergency response coordination, safety and protection, projection of future community service and infrastructure needs, etc. It is hoped that the information will be used to assist with planning for the protection of the region's invaluable resources.

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APPENDIX: Land Use Categories

- (1) Residential: This category includes privately-owned houses, mobile homes and trailers, vacation houses, and developments with fewer than eight dwelling units. Condominiums, time-share units, townhouses, and apartments that are not part of a named development (see Categories 12 and 13) are also included.
- (2) Vacant: Commercial, industrial, and residential lands that have not yet been developed are considered to be vacant.
- (3) Farm: This category includes any type of farm land (e.g., croplands, pastures, orchards).
- (4) Commercial: This category contains all commercial use parcels, including hotels, motels, service stations, restaurants, stores, small businesses, shopping malls, etc.
- (5) Industrial: All industrial and manufacturing uses are included in this category.
- (6) Hunting and Fishing Clubs: These uses were assigned to a separate category because it was assumed that they would not be subject to development pressure and so would remain in their present open state.
- (7) Camps: This category includes boy/girl scout camps, summer camps, day camps, and special use (e.g., religious) camps. This category was created due to the seasonal nature of camp activities.
- (8) Campgrounds: This category includes commercial campgrounds; it is distinguished from the Camps category due to more intensive use of the land.
- (9) Golfcourses: Many golfcourses in the study area are the property of resorts or developments, however, they are classed separately because of intensive landscape management practices (including heavy fertilizer and pesticide applications) that have high potential for impacting water quality.
- (10) State Forest and Gamelands/Federal Lands: This category includes all open lands, excluding the National Recreation Area, that are owned by state or federal agencies.
- (11) Other Quasi-public Lands: This category includes public and private lands that are open to general use (e.g., schools, churches, cemeteries, municipal buildings, fire and rescue squad buildings, community centers).
- (12) Existing Developments: This category includes only those named developments in which all phases of construction have been completed, and a majority of the units have been purchased and are occupied on either a seasonal or year-round basis.

(13) Proposed or In-progress Developments: This includes those named developments in which construction may or may not have been initiated. While several phases of construction may be represented, developments remain in this category until a majority of the units are occupied.

(14) Resorts: This category includes all buildings, restaurants, guest accommodations, sports facilities, and associated grounds in a resort.

(15) Reserved Open Spaces Within Developments: This category includes all open areas within a development that have been set aside as unbuildable or for open space purposes. This acreage is differentiated from development acreage so that accurate density figures can be obtained for developments. Future development of these parcels is prohibited by deed covenant.

(16) Developer-owned Lands Not Yet Subdivided: This includes developer-owned property that has no subdivision plan to date.

(17) Lands With Use Unknown: This category includes parcels where information on land use was unobtainable.