

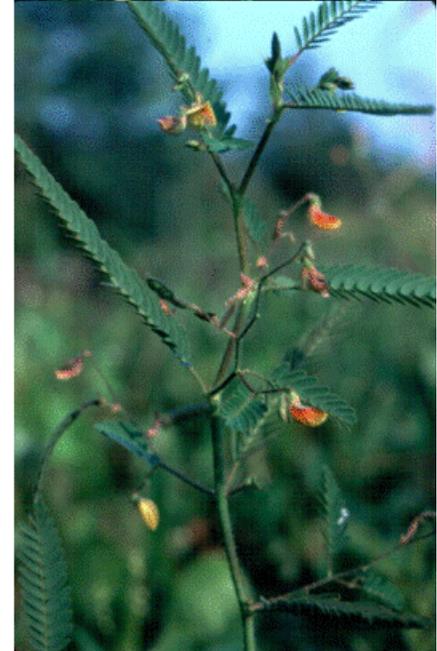


ENDANGERED PLANT
SPECIES POPULATIONS
IN NEW JERSEY:
HEALTH AND THREATS

Prepared for the State of New Jersey Department of Environmental Protection

Jon S. Corzine, Governor
Lisa P. Jackson, Commissioner

2006



Photos By:
David Snyder©, NJDEP, Office of Natural Lands Management

Top Left: Snowy orchid (*Platanthera nivea*)
Top Right: Hammond's yellow spring beauty (*Claytonia virginica* var. *Hammondiae*)
Bottom Left: Small white lady's slipper (*Cypripedium candidum*)
Bottom Right: Sensitive Joint Vetch (*Aeschynomene virginica*)

Background photo:
Northern blazing star (*Liatris scariosa* var. *novae-angliae*)





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JON S. CORZINE
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LISA P. JACKSON
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December 2006

Dear Reader,

New Jersey is a biologically diverse state with an extremely rich native flora of more than 2,100 plant species of flowers, trees, shrubs and grasses. Our State spans from the Ridge and Valley physiographic province in the north and west to the Outer Coastal Plain along the south and east, encompassing a wealth of different forested, wetland, grassland and coastal habitats. Geologic processes combined with hydrologic and topographic conditions have resulted in New Jersey's extraordinary botanical diversity. Many plant species also reach their northern and southern range limits in New Jersey.

As stewards of our State's natural resources, it is important that we periodically assess the status of our biodiversity and that we share this information with the public. This report, *Endangered Plant Species Populations in New Jersey: Heath and Threats*, provides the first comprehensive assessment of the status of New Jersey's endangered plant populations, the threats to their survival and geographic analyses of their distribution. The report also provides a foundation for continued development of environmental indicators for the assessment of endangered plant species population health and threats in New Jersey.

Biodiversity is the variability among living organisms and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. Biodiversity provides the conditions and processes that sustain our survival. These complex interactions provide for our food supply; natural pest control; maintenance of water, air and soil quality; waste decomposition and soil generation; nutrient cycling; pollination and crop production; climate regulation and stabilization; flood and erosion control; and medicines and pharmaceuticals. Biodiversity also provides for aesthetic resources of immeasurable value, which, in turn, provide for recreational and tourism opportunities.

Despite being an essential component of New Jersey's biodiversity, 339 plant species, or about fifteen percent of our native flora, are endangered because their survival in the State or the nation is in jeopardy. The extreme rarity of many of these species cannot be overemphasized. For example, the only known occurrence in the world of the delicate Hammond's yellow spring beauty is in New Jersey. Three additional plant species are also endemic to the State. Over one-half of the world's populations of swamp pink occur in New Jersey with remaining populations only found in seven other states along the East Coast.

It is vitally important to assess our endangered plant species populations so that we may better preserve them. Regulatory protection for endangered plant species is now provided in our coastal area, the Pinelands and the Highlands, and federally-listed species are protected in our freshwater wetlands. Over the coming years we will focus our efforts on a biodiversity inventory for the lands we manage. Together, these steps will help us provide a firmer foundation for the preservation of New Jersey's Natural Heritage.

Sincerely yours,

A handwritten signature in black ink, appearing to read "Lisa P. Jackson".

Lisa P. Jackson
Commissioner

ENDANGERED PLANT SPECIES POPULATIONS IN NEW JERSEY: HEALTH AND THREATS

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Executive Summary

The native flora of New Jersey is an important component of its biological diversity, which is continually diminished as species, populations, and habitats are lost from the state. Fifteen percent of New Jersey's native flora, which comprises more than 2100 species, is currently classified as endangered. In New Jersey, an endangered plant species is one whose survival within the State or the nation is in jeopardy. An endangered species requires immediate attention or extirpation within New Jersey is possible. This study attempts to uncover spatial patterns and data trends regarding the status and distribution of these species.

Populations of 331 vascular endangered plant species and 32 extirpated plant species in New Jersey were examined using the Natural Heritage Database (New Jersey Department of Environmental Protection). Endangered plants are monitored as populations of individuals that inhabit a given area. Thus, an endangered plant may have one or many populations. When only one or a few populations exist, loss of the entire species from the state is of heightened concern. For the purpose of this report, an extirpated species is a species that formerly occurred in New Jersey, but is not known to exist within the state today; an extirpated population is one that was historically documented in a specific area, but cannot be found today. Plant population occurrence data was verified and updated, and spatial analyses were conducted using GIS. Data describing threats to extant (i.e., currently existing) plant

populations and causes of plant population extirpation were examined, and landscape trends were determined by grouping populations according to species, physiographic region, and habitat type, as well as county, state, and watershed boundaries.

Methods

The Natural Heritage Database was originally designed to identify best examples of rare species to help target acquisition and preservation. For this project, the focus was redirected to target flora of New Jersey that were demonstrably vulnerable.

The Biological Conservation Databases of the Natural Heritage Network (BCD) was used in 1998 to uncover and explore patterns in the extirpations of and threats to endangered populations. The database was designed to encompass database management needs of identifying, protecting and managing biological diversity. The most frequently used BCD databases were: Element Occurrence (EOR), Element Ranking-state (ESR) and Plant Characterization Abstract (PCA).

Details regarding causative factors were culled from the database and used to label populations to create trend data. A GIS was used to determine landscape patterns of the trend data.

Endangered Plant Species Populations

Results

The summary and analysis of the information contained in the Natural Heritage Database showed the following with regard to the **status** of endangered plant populations and species in New Jersey:

- 35% of the populations have been assessed to be extant since 1980, 11% were extirpated, and 54% of the populations were undetermined. Ten percent of the total occurrences have been verified since 1990 and 2000.
- Development and urbanization account for the greatest number of extirpations. These activities, along with the construction and maintenance of transportation corridors, also present the greatest threats to extant populations of endangered species.
- More than half (188) of the 331 endangered plant species had only one to three confirmed extant occurrences (populations) in the state, and an additional 25% (84 species) had no known extant occurrences at all as of 2000.
- 30% of the population occurrences in the Natural Heritage Database were comprised of the five species that have the greatest number of populations in the state (*Helonias bullata*, *Eupatorium resinosum*, *Rhynchospora knieskernii*, *Juncus caesariensis*, and *Narthecium americanum*), due largely in

part to the increased survey efforts and resources devoted to these species in recent years.

- 74% of the extant species had no verified populations on state-protected lands, 16% had at least one population entirely on state lands, and 10% had verified populations partially located on state lands. Presence on state land facilitates implementation of DEP monitoring and protection programs.

The summary and analysis of the information contained in the Natural Heritage Database showed the following with regard to the **distribution** of endangered plant species in New Jersey:

- An analysis of distribution by habitat classes (estuarine, terrestrial, riverine, lacustrine, and palustrine) found that the majority of endangered plant species occurred in palustrine (freshwater wetland) and terrestrial habitats, with 71% and 37%, respectively (18% of the species were found in more than one kind of habitat). These habitats also contained occurrences of the majority of extirpated populations. (The high number of palustrine occurrences may be partially attributed to the fact that the five species that have the most abundant populations, which comprised 30% of the occurrences, were palustrine species.)

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- The Outer Coastal Plain physiographic province contained 59% of the extant endangered populations included in the study, followed by the Ridge and Valley (16%), Piedmont (12%), Inner Coastal Plain (12%), and Highlands (11%).
- More than half of the plant population extirpations occurred in the Piedmont and Inner Coastal Plain (27% and 25%, respectively), with the remainder divided relatively equally among the other three provinces. This follows patterns of urbanization, which were much higher in the Piedmont and Inner Coastal Plain.

Conclusions and Recommendations

Currently, only 26% of the endangered species in New Jersey have populations either wholly or partially located on state-protected lands. Given the threat of habitat destruction and degradation to current and historic populations of these species, the protection of habitats where these populations occur, as well as the larger ecological systems that they depend upon, must be a priority.

This project provides the foundation for future work involving the development of environmental indicators for the assessment of endangered plant species population health and threats in New Jersey. The effectiveness of most, if not all, of the indicators developed, however, is dependent upon a complete and current inventory of endangered plant species in the state. To date, no comprehensive survey has been done of the entire state.

Expanded and more frequent survey efforts are needed, as well as more intensive population monitoring and biological studies for a number of individual species, because little is known about their biology and natural history. Such basic information (i.e., identifying those factors that are relevant to their survival) is critical for the subsequent management of endangered species populations following the initial protection of the sites where they occur. The environment is in a constant state of change and, even in the absence of the more overt human threats, such as habitat destruction by development activities, subtle changes may be taking place that are detrimental to these species (e.g., invasive nonindigenous species, hydrological changes, etc.). Thus, long-term surveys, monitoring and management are essential.

The expanded survey, monitoring, and management efforts needed for the effective conservation of these species populations throughout the state may be more expeditiously achieved by enlisting the help of local volunteer groups (e.g., local students, botanical clubs and other citizens). In addition to significantly reducing the time and money that would otherwise be needed to accomplish these tasks, this could also help raise public awareness as to the existence of these species and habitats in local communities, as well as to foster a sense of stewardship regarding their continued well-being.

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Environmental Education

Given the sensitivity of many of these endangered plant species in New Jersey and the large number of human activities that can and do affect them, greater public awareness needs to be raised as to the existence and significance of these species and habitats in order to prevent further species extirpations. Such issues of environmental education and value (i.e., the extent to which our human-ecological actions and behaviors, both individual and institutional, come to be informed by a knowledge and concern for biodiversity and other local environmental issues), will undoubtedly determine the ultimate success of conservation efforts in the future.

Potential means to achieving these broader and more long-term goals might include curricular reforms in the public educational systems, increased media coverage, and greater consideration in planning, regulation, and policy-making activities.

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Introduction

New Jersey's Plant Diversity

New Jersey has a surprisingly high concentration of native plant and animal species relative to other states. Its native flora, comprised of more than 2,100 species, has representatives of more than 50% of the plant species found in the northeast from Pennsylvania to Maine (Fernald 1950 cf. Countryman 1977), despite the fact that it contains a mere 5% of the total land area of the region. Similarly, according to the 2000 U.S. Census, although it amounts to less than 0.26% of the total land area in the United States, and is the fourth smallest state in the nation, approximately 13% of the plant species in the U.S. can be found in New Jersey (Master et al. 2000).

In large part, this high diversity is due to the variety of habitats and landscapes that exist in New Jersey, from the mountainous Ridge and Valley in the north, to the Outer Coastal Plain in the south. Five such physiographic provinces can be found within the state, all within an hour's drive of each other, and the unique combination of geological, topographical, and hydrological features that each of these represents has given rise to a wide range of environmental conditions within them, and a tremendous diversity in the state overall (Collins and Anderson 1994).

These unique habitats, in turn, have provided the necessary conditions for a remarkable array of native species, communities and ecosystems.

Species such as cloud sedge (*Carex haydenii*) and hop-like sedge (*Carex lupuliformis*), for example, occur in calcareous habitats like the rare sinkhole ponds and marl fens of the Kittatinny Valley in the northern portions of the state (Walz et al. 2001) whereas others, like the bog asphodel (*Narthecium americanum*), are restricted to the riverside savannas found only in the Pine Barrens. This ecosystem itself, is of great global significance, containing not only rare species such as New Jersey rush (*Juncus caesariensis*), blazing star (*Liatris graminifolia* var. *lasia*), sand myrtle (*Leiophyllum buxifolium* var. *buxifolium*), and Knieskern's beaked-rush (*Rhynchospora knieskiernii* (Fairbrothers 1979), but entire communities of rare organisms that can be found nowhere else in the world.

The habitats and conditions that foster this diversity are themselves the cumulative result of natural processes that have been taking place for millions of years, and for this reason the current distribution of many species is closely tied to the geological history of the region. The ranges of species such as curly-grass fern (*Schizaea pusilla*) and broom crowberry (*Corema conradii*), for example, were formerly more widespread and abundant but now only exist in a few isolated populations from Delaware to Newfoundland, all in areas that were not covered in glaciers during the last ice age. Other species, such as Labrador tea (*Ledum groenlandicum*), occur in northern bogs that were actually formed by the scouring action and subsequent retreat of the glaciers. Because the northern portions of the state were covered in glaciers during the last ice age, New Jersey supports populations of many species influenced by glaciation.

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The ranges of many northern and southern species also converge in New Jersey, oftentimes reaching their geographic limit in the state. Species such as the snowy orchid (*Platanthera nivea*) and seabeach evening primrose (*Oenothera humifusa*), are more typical of the southern flora, but reach as far north as Cape May and Ocean Counties. Similarly, the ranges of northern species such as yellow-eyed grass (*Xyris montana*) have been found to extend as far south as the northern reaches of the state (Snyder 1989). Although these species are often less abundant in New Jersey than in the more central portions of their respective ranges, many have unique morphological or genetic characteristics, such as the single remaining population of American chaffseed (*Schwalbea americana*) in the northern part of its range (Godt and Hamrick 1995), due to their long-standing exposure to the unique set of environmental conditions present here.

Conservation Status and Concerns

Roughly 15% of the native plant species in New Jersey, however, are now at risk of extinction in the state, with a total of 331 vascular plant species listed as endangered and an additional 32 that have already been extirpated (NJDEP 1998). Of all the eastern states, only Florida has a greater percentage of its plant species at risk compared to New Jersey (Master et al. 2000). In general, vascular plant species comprise the vast majority of endangered species in the United States, amounting to more than 75% of the total species that have been assessed to date (Master et al. 2000). One of the challenging characteristics of this study is the constancy of change; population surveys continue, pressures that

result in population changes continue, and policies and programs for protection and restoration develop. Thus, the specific numbers in this study must be considered as indicators of trends rather than precise measurements.

Habitat loss or destruction is widely acknowledged as the leading cause of species extinction and endangerment both in the nation (Wilcove et al. 2000) and worldwide. Other major causes include the introduction of invasive nonindigenous species, overexploitation, pollution, and disease. Following these national and global trends, habitat destruction has been responsible for the majority of extirpations and threats to endangered plant populations in New Jersey as well, but to an even greater degree than is typically found elsewhere (Wilcove et al. 2000). This may be due to the longer history and greater intensity of development and other associated activities in New Jersey than in other states, along with the much higher densities of human population it supports.

With more than 8,410,000 people based on the 2000 U.S. Census Bureau, New Jersey has the ninth largest population of any state in the country, and one of the highest concentrations of people in the world. Set in the greater metropolitan area of both New York City and Philadelphia, this burgeoning human population has placed severe and chronic pressure on the ecological communities of the state throughout its history. The current expansion and escalation of many economic and other activities continue to degrade or destroy these habitats throughout

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the state, thus threatening the survival of these species, populations and communities at a pace and scale that rivals any time in history.

Our natural heritage is diminished when elements of this biological diversity are lost from the state, whether it be in the form of entire species, the individual populations of which they are comprised, or the habitats, communities and ecosystems of which they are a part (Wilson 1997). This diversity provides us with a wealth of economic, aesthetic, cultural, and other goods, and represents a tangible connection to our evolutionary past, and to the greater community of life that we are not only a part of, but are utterly dependent upon.

This legacy, which is the cumulative and ongoing result of millions of years of geological and biological history, provides a meaningful and essential context for our lives, and deserves to be protected for future generations, for ourselves, and for its own sake.

Environmental Indicators

In order to protect the state's biodiversity, the New Jersey Department of Environmental Protection's National Environmental Performance Partnership Agreement with the U.S. Environmental Protection Agency has initiated the development of environmental indicators to measure the health of our flora, in terms of its condition and threats, as well as the success of efforts taken to protect it (Whitman et al. 1997). These indicators fall within three types, including:

- Condition indicators that measure the health of a given environmental resource;

- Stress indicators that measure the threats to the resource; and
- Response indicators that track actions to improve conditions and mitigate stresses.

With the establishment of these indicators, efforts aimed at the maintenance or protection of these resources can be better evaluated over time. This study attempts to review the existing information available on endangered plant species in New Jersey in order to provide a foundation for the development of these environmental indicators in the future.

Endangered Plant Species Populations

Objectives

In order to monitor the health of endangered plant species in New Jersey, it is first necessary to determine the current status and distribution of these species in the state. The determination of extant from extirpated populations, for example, is essential to conservation biology research (Reveal 1981), as is the identification of threats to existing populations, and the reasons for extirpation of those that have been lost. Furthermore, a basic understanding of the diversity and distribution of these patterns across the landscape must be attained (Stein et al. 2000), as not only the species themselves, but also the land-use activities that threaten them, often follow broad patterns associated with particular physiographic provinces, habitats, geological features, or watersheds, as well as political boundaries such as counties, parks, and municipalities.

With the summary of geographic and other data provided in this report, it is hoped that attention and concern for populations of these endangered plant species may be raised in a manner sufficient to ensure their continued survival in the state. Detailed information will be provided as to the status and location of endangered plant species populations with respect to both counties and watersheds (Appendices A and B), in order to facilitate the incorporation of this information into the planning and regulatory activities of various state and local agencies.

Regulatory agencies, for example, can review the locations of endangered plant species populations to identify areas where more careful scrutiny of permit applications is needed. Planners can be

alerted to the need to gather data on endangered plant species as part of local natural resource inventories, and land managers can develop management activities that are compatible with the needs of these species, and mitigate or eliminate the individual threats that they face.

Detailed information at the watershed level is also provided, as it suggests an alternate vantage from which relationships between land use activities and the health of our environment may be more easily and directly observed (e.g., with regard to issues of water quality, aesthetic, recreational and other values). The streams, lakes wetlands, and other water resources of the state frequently cross political boundaries (as do the activities that threaten them, such as non-point source pollution). Watershed protection and planning therefore typically involves the convergence of multiple levels of government, and is increasingly being carried out by coalitions of governmental and non-governmental organizations as well. Information on endangered plant species provides additional considerations as to the value of particular areas, and can help identify aquatic systems and watersheds that are threatened or in need of further protection.

The protection of habitats for endangered plants in the state may require the adoption of comprehensive land-use planning and policy measures as well as the protection of individual tracts supporting rare plant populations. Several plans currently exist in which priority areas are identified and recommended for conservation; these will be evaluated to determine their adequacy in including habitats for endangered plant species as well.

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Finally, while the protection of habitats is necessary for the survival of these species, it is not necessarily sufficient to achieve this purpose in all cases. Significant natural and man-made changes may occur even after the locations have been protected, as has been witnessed in a number of National Parks (Bratton and White 1981). Site-specific monitoring information, along with an understanding of the biology of each species, is therefore of great importance for the subsequent management and maintenance of many of these populations. The availability and adequacy of such information will be assessed as well.

Status of Endangered Plant Species

Endangered Plant Species Inventory

In New Jersey, endangered plant species are native New Jersey plant species or subspecies whose survival in the state or nation is in jeopardy, including but not limited to plant species listed or proposed as endangered or threatened by the Federal government under the Endangered Species Act of 1973, any additional species known or believed to be rare throughout its worldwide range, and any species having five or fewer extant populations within the state. Those species that are no longer found in a certain geographic area, but which are not globally extinct, are referred to as extirpated. The primary source of information regarding such species in New Jersey is the Natural Heritage Database (Stein et al. 2000), which contains updated information on the taxonomy, rarity, threats, protection, location, and population data for all endangered species, species of concern, and extirpated plant species in New Jersey. Compiling such diverse sources of information as herbarium collections, records from scientific studies and field surveys, and reports from the public, this database has been officially recognized as the best source for information on the status of Endangered Plant Species and Plant Species of Concern in the state (N.J.A.C. – 7:5C-1.1 et seq.).

In order to determine the status of endangered plant species in New Jersey, each individual population occurrence found in the database was categorized as **Extant** (currently existing), **Extirpated** (locally

extinct), or **Undetermined**¹. Occurrences were considered **Extant** if they had been observed in the field by staff, contractors, or volunteers of the Natural Heritage Program. Occurrences were considered **Extirpated** if field examination concluded that the species was no longer present at the previously documented location, or if review of topographic maps and aerial photography concluded that the habitat was no longer present. Occurrences that had not been surveyed since 1980 were considered **Undetermined**. For the purposes of this study, undetermined occurrences were excluded from the majority of analyses. In order to assess whether or not the data were up-to-date, those occurrences documented to be extant were further examined to determine how many had been field checked between 1995 and 2000.

¹ Editors Note: The data in this report are based on information contained in the Natural Heritage Database that was largely collected prior to 1998. Additional data have been collected since that time and the Natural Heritage Database has been updated accordingly. As a result, the number of endangered plant populations determined to be extant or extirpated have changed, new threats have been identified, some species have been extirpated, and a few species once considered extirpated in New Jersey have been rediscovered. Therefore, certain statistics cited in this report may no longer reflect the most current data sets.

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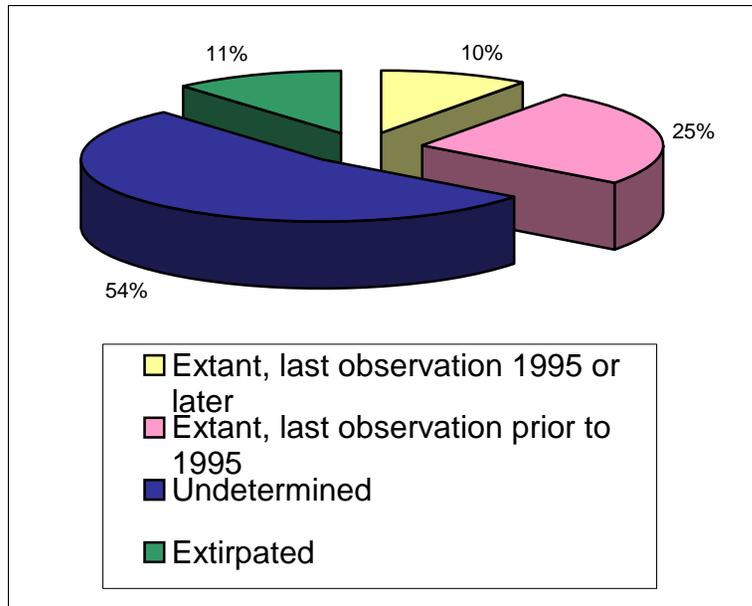


Figure 1. Extant, extirpated, and undetermined endangered plant species populations in the Natural Heritage Database.

A total of 339 endangered plant species were reported in the Natural Heritage Database (331 vascular plants, 8 nonvascular plants). Among the 331 vascular plant species that are the focus of this study, 778 populations were verified as extant (35%), 10% of which have been verified since 1995. A total of 295 (11%) populations were reported to have been extirpated, among 132 species. Fifty-four percent were Undetermined (Figure 1).

The five most frequently observed species accounted for approximately 30% of total occurrences in the database. *Helonias bullata* had more than 100 documented occurrences, and *Eupatorium resinosum*, *Rhynchospora knieskernii*, *Juncus caesariensis*, and *Nartheceium americanum*, each had more than 50 occurrences.

The majority of species that have been verified as extant since 1980 (188), however, have only three or fewer populations (Figure 2). This is extremely significant in that the risk of extinction tends to increase with smaller population size and number of populations. This risk is even greater given that the majority of these extant species (74%) had no populations on state lands (Figure 3). Only 16% (55 species) had at least one verified extant population entirely on state land, where populations might be protected and secured, and 10% (33 species) had verified extant populations partially, but not entirely, on state land.

Endangered Plant Species Populations

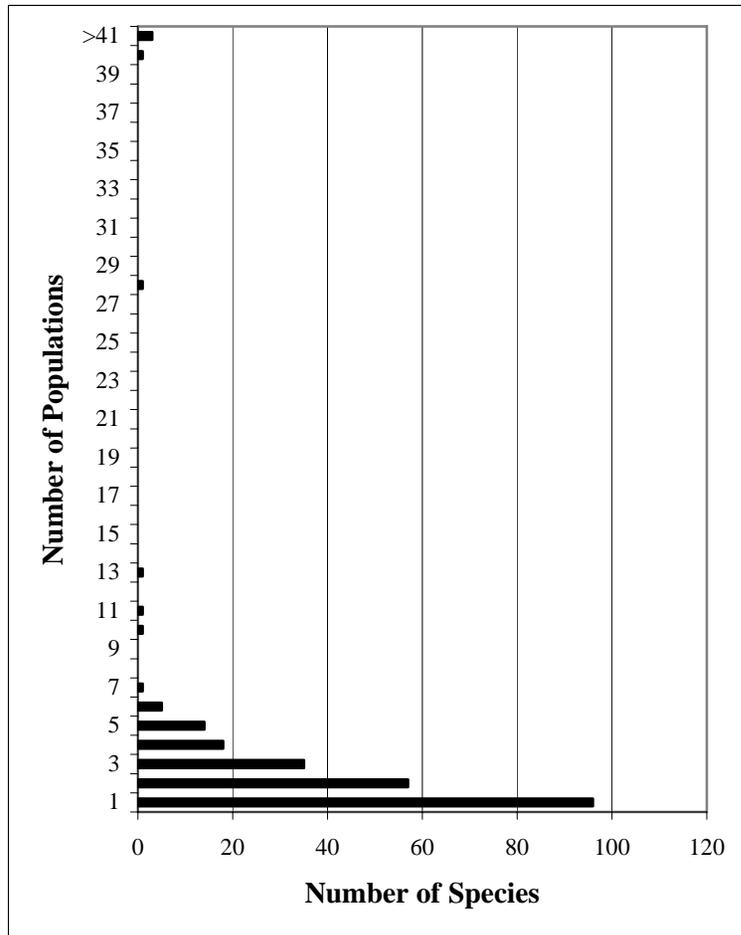


Figure 2. Frequency distribution of number of endangered plant species versus number of populations, based on 188 extant species verified after 1980.

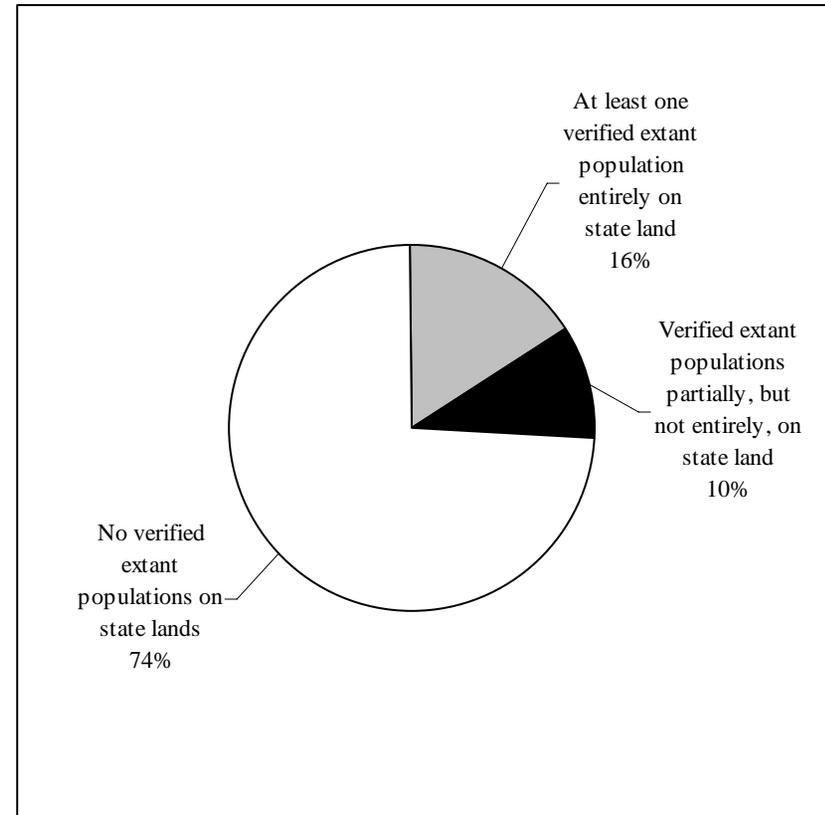


Figure 3. Endangered plant species on state-protected lands.

Endangered Plant Species Populations

Life Forms

Of the total vascular flora of New Jersey, 56% of species are forbs, 24% are graminoids, 15% are shrubs, and 5% are trees (Figure 4). Of the 331 endangered vascular plant species reported in the Natural Heritage Database, 63% are forbs (broad leaved herbaceous), 28% are graminoids, 6% are shrubs, and 3% are trees (Figure 5).

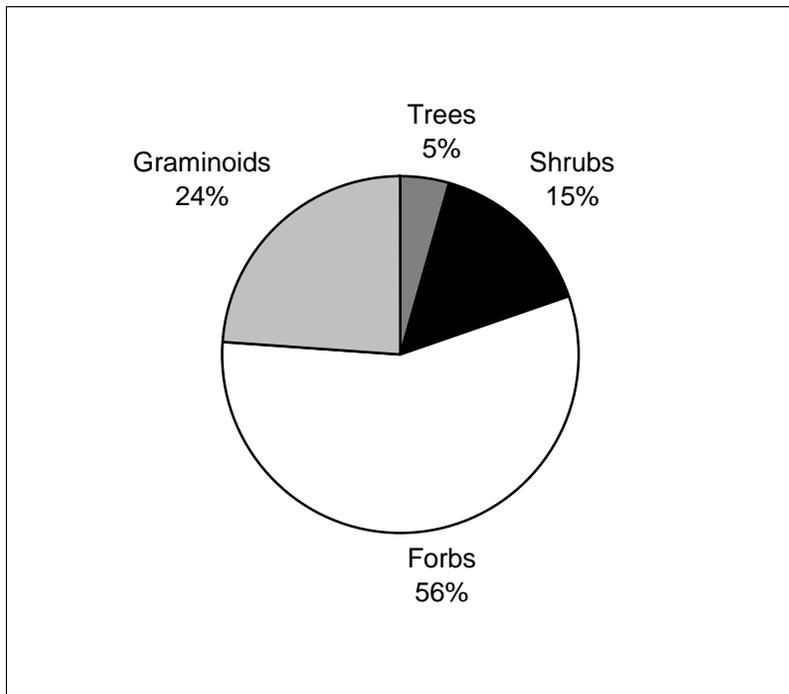


Figure 4. Proportion of functional forms in the total New Jersey vascular flora.

Thus, there is a greater percentage of forbs and graminoids and a lower percentage of trees and shrubs in the endangered flora of New Jersey than in the total flora of New Jersey. The data also indicate that there were relatively more extirpations of forb populations than of other life forms (as shown by extirpation bar in Figure 6).

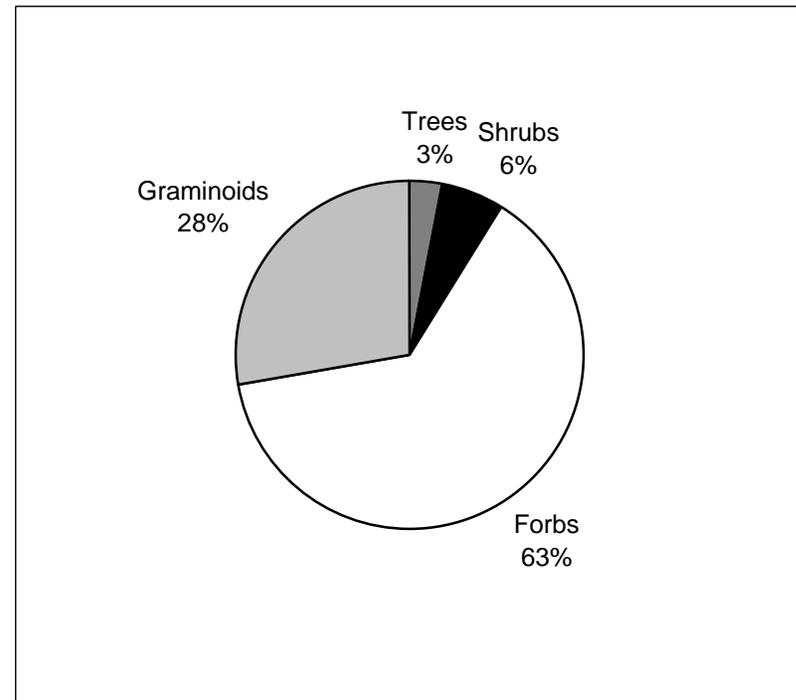


Figure 5. Proportion of functional forms in endangered New Jersey flora.

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The higher percentage of endangered species in the graminoids and forbs may be related to the higher diversity of these groups in general, and the greater number of species with more specialized growth forms, habitat preferences and reproductive strategies, which tend to be associated with high patterns of diversity within such groups.

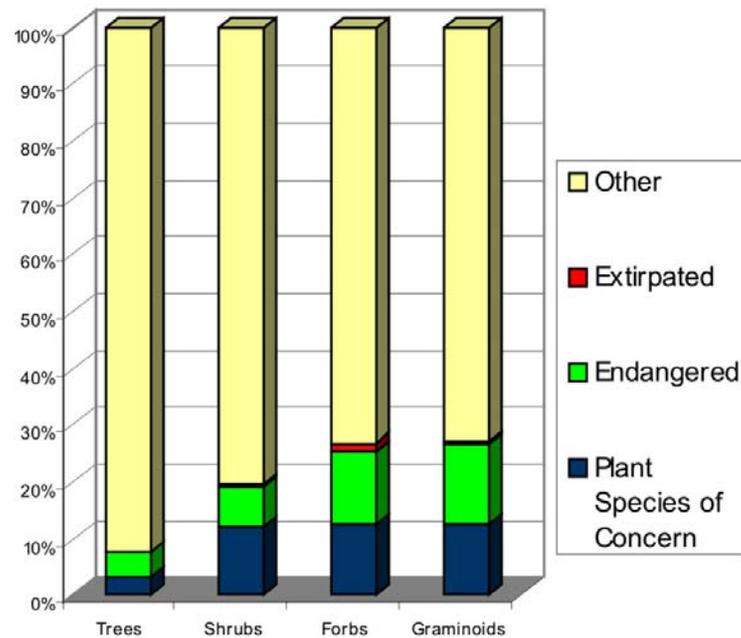


Figure 6. Proportion of extirpated, endangered, and plant species of concern by functional group.

Causes of Population Extirpations

The database occurrence records were also examined to determine the potential causes of population extirpations as well as to identify potential threats to extant populations. In most cases, this information was attained through direct observation by Natural Heritage Program staff, contractors, and volunteers, but additional sources such as topographic maps and aerial photography were also consulted in certain cases to draw these conclusions. This information was found to vary considerably in both quantity and kind in the database and was reduced by grouping causal factors according to more general keywords, thus simplifying the data and standardizing it for statistical comparisons.

There were 37 causes of extirpation identified for 295 extirpated populations (84%), which included 132 species. The causes of extirpation were unknown and/or not provided for the remaining 16% of these populations. The identified causes fell under 19 categories (Figure 7, Table 1), the most common of which were development, urbanization, succession, transportation, dams, bulkheads/fill, mines, and agriculture, respectively.

Development and Urbanization

Clearly, development has been the most significant cause of plant population extirpations in New Jersey. With 171 extirpations, it far exceeded any of the other causes listed in New Jersey. Combined with the related extirpation cause of urbanization, it becomes clear that the elimination and modification of habitat from these causes surpassed all

others. Furthermore, depending upon how broadly it is defined, many of the other causes of extirpation listed below may also fall within this category as well.

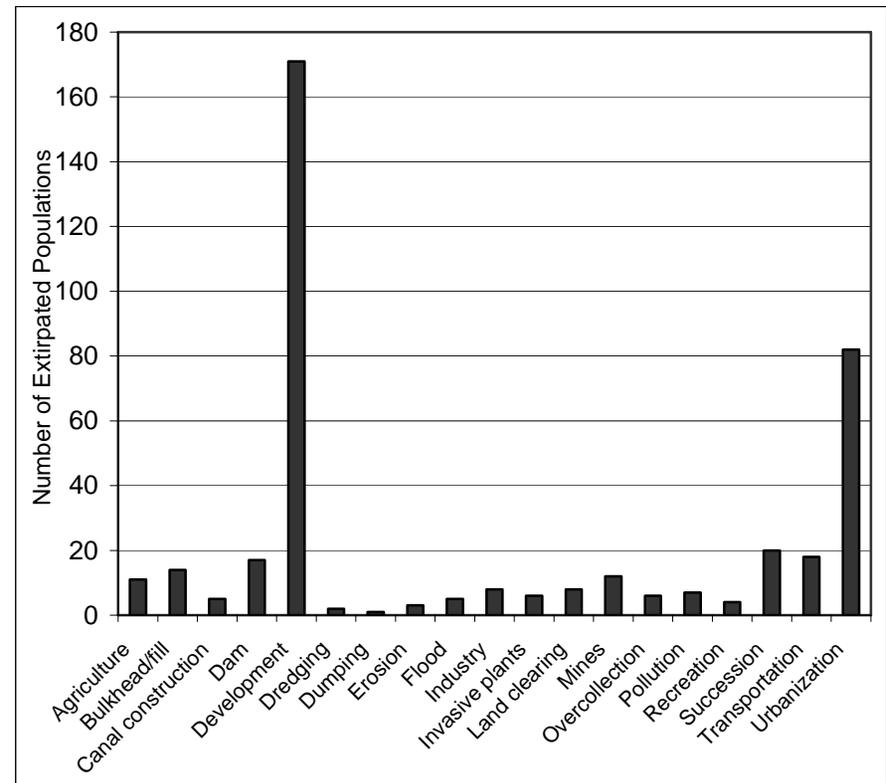


Figure 7. Common causes of extirpated plant populations in New Jersey.

These other activities were often cited along with development as the cause of individual extirpations (Table 1) and may merely represent the

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particular kinds of development activities that were found to be responsible in these cases. Others causes (e.g., erosion, flooding, invasive species, over collection, recreation), moreover, while not seeming to be directly related to development in any way, are known to result from such activities indirectly. Additional extirpations may therefore be traceable back to development as well, if more information was available.

Most of the cases where development was explicitly cited as the cause of extirpation were located in the vicinity of New York City, Philadelphia, and along the coast (Figure 8), where development pressures have historically been the greatest.

A particularly striking case is that of a Labrador tea (*Ledum groenlandicum*) occurrence, which was discovered by Kenneth K. MacKenzie in 1918. The spring-fed spruce-larch bog where it occurred in Morris County was an uncommon habitat in New Jersey, and it was the only place that Labrador tea had ever been documented in the state. MacKenzie wrote that, “Palmer’s bog, as I am calling this interesting locality, will in all probability remain permanently undisturbed.” Unfortunately, this place did not remain undisturbed. Palmer’s bog was destroyed by the construction of the Rockaway Mall, and the population of Labrador tea was lost along with it (Snyder 1989). Although this population may have been extirpated, the species has been found again within the state (Snyder, pers. comm. 2004).

Table 1. Causes of plant population extirpations and co-occurrence with development.

| Causes of Extirpation | Extirpated Populations | Co-occurrence with Development |
|-----------------------|------------------------|--------------------------------|
| Agriculture | 11 | 1 |
| Bulkhead/fill | 14 | 14 |
| Canal construction | 5 | 5 |
| Dam | 17 | 0 |
| Development | 171 | — |
| Dredging | 2 | 0 |
| Dumping | 1 | 1 |
| Erosion | 3 | 1 |
| Flood | 5 | 0 |
| Industry | 8 | 8 |
| Invasive plants | 6 | 4 |
| Land clearing | 8 | 4 |
| Mines | 12 | 0 |
| Overcollection | 6 | 1 |
| Pollution | 7 | 2 |
| Recreation | 4 | 0 |
| Succession | 20 | 5 |
| Transportation | 18 | 6 |
| Urbanization | 82 | 82 |

Transportation

The construction and maintenance of roads, right-of-ways, railroads and bridges, was responsible for a number of population extirpations. Four

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populations were speculated to be lost to the construction of the Garden State Parkway alone. Another is believed to have been lost due to the construction of the New Jersey Turnpike, one was destroyed by the construction of Route 78, and yet another by the construction and maintenance of Route 80. Several populations of American chaffseed (*Schwalbea americana*), a federally endangered plant species, were destroyed by the widening of smaller-scale highways in the state as well (Peters 1995).

Succession

There were 12 plant species populations that were lost to succession of habitat, most of which occurred in the southern part of the state (Figure 8). These species, such as bog asphodel (*Narthecium americanum*) and American chaffseed (*Schwalbea americana*), occur only in open habitats and depend upon floods, fires or other events to suppress the growth of trees and shrubs that will otherwise come to dominate the sites. Changes in the fire regime, flooding patterns, or depth of the water table throughout the state, and especially in places like the Pine Barrens, have changed the conditions necessary to prevent the growth of woody species, resulting in the loss of populations of successional species.

Dams

Dams frequently raise water levels in streams, ponds and lakes on which they are built, thus flooding surrounding areas. This may destroy plant habitat. A dam at White Lake in Sussex County, for example, is

associated with the extirpation of populations of three endangered plant species: wiry panic grass (*Panicum flexile*), capillary beaked rush (*Rhynchospora capillacea*), and rush aster (*Aster borealis*), which cannot survive under prolonged hydric conditions.

Mining

Mining activities were associated with 12 plant species extirpations. Five populations were lost to the Hyper Humus peat mine located north of Newton. Another three populations of endangered plants were lost to the Snake Hill Traprock Quarry in the Meadowlands.

Agriculture

Very few botanical records predate the late 1800s. Therefore, any losses of species to agricultural use of the land prior to the late 1800s have gone unrecorded. Still, there is documentation of 12 populations of several species that are believed to have been lost to farming since the late Nineteenth Century. Most of these populations were last seen prior to 1925. For example, bog asphodel and fringed yellow-eyed grass (*Xyris fimbriata*) were once documented at Jones Mill in Burlington County in 1903. Their habitat may have since been destroyed by the expansion of cranberry bogs. The majority of the agriculture-related extirpations occurred in the southern part of the state (Figure 8).

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Land Clearing

Eight plant species populations were lost in areas where land clearing activities occurred, most of which were related to logging. All of the plant species that were extirpated by these activities were last documented prior to 1900.

Pollution

Pollution, or the degradation of habitats by pollutants such as oil, fertilizers, industrial discharge, siltation or mining waste, was the presumed cause of seven extirpations. Several populations of swamp pink (*Helonias bullata*), for example, have been destroyed by siltation of wetland habitat. Also, one population of the state endangered lake cress (*Azorella lacustris*) is believed to have been destroyed by herbicide use.

Overcollection

There were six records in which overcollection of plant specimens was listed as the cause of species extirpation. One sensitive species of orchid (a species that is particularly susceptible to damage by over-collecting, trampling, or vandalism) was collected from an area in Warren County in the early 1970s and has not been found since.

Invasive plants

Seven populations of endangered plant species have been lost at least partially because of competition from invasive plant species. Five of

these population extirpations were due to the invasive common reed (*Phragmites australis*).

Flooding

Additional species populations have been destroyed by raised water levels that were not caused by dam building. More research may find that some of these water level rises were due to beavers or to an increased severity of flooding due to the development of upland areas.

Recreation

Intensive management, use, or development of recreation areas such as beaches, boat launches, parks, campgrounds, and parking areas often threaten to destroy endangered plant populations. Of the four plant populations believed to have been lost to recreational activities in New Jersey, one population was lost to a canoe launch and parking lot, two were lost to the creation of ball fields, and the fourth was destroyed by off-road traffic.

Erosion

There were three documented cases of endangered plant species being lost through beach erosion, the most striking of which perhaps was the population of seabeach amaranth (*Amaranthus pumilus*) formerly found on Tucker's Island, which itself no longer exists due to severe shoreline erosion occurring there in the early Twentieth Century.

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Dredging

The intermittent pond habitat for knotted spikerush (*Eleocharis equisetoides*) was destroyed when the pond was deepened by dredging. These activities can affect species not only by disturbing the habitats where the dredging occurs but also where the materials are deposited after dredging takes place.

Threats to Extant Populations

A total of 45 threats were identified for 420 extant endangered plant species populations. These were grouped according to the 21 categories shown in Table 2. Of the documented threats, the most common were: roadway construction/maintenance, habitat disturbance, development, succession, pollution, and recreation (Table 2, Figure 9). This information was lacking for the remaining 358 extant plant populations in this study, although many of these cited multiple threats.

The construction and maintenance of roadways was the most frequently documented threat to endangered plant populations across the state (118 of 420 or 28%) (Table 2). Together with railroads, highways, right-of-ways and bridges, these transportation corridors can, in fact, provide habitat for native species that require open areas (see section on “succession” above). Over 118 populations of 60 different threatened and endangered species were found to occur along roadways in New Jersey (Caiazza and Fairbrothers 1980). The construction, widening and/or maintenance of these corridors can severely threaten endangered plant species populations occurring there.

Habitat disturbance, or any other degradation of habitat, was documented as a threat for 21% of the subset of endangered populations. Development and habitat disturbance were often both documented as threats for a single population.

Table 2. Threats to extant populations of endangered plant species in New Jersey.

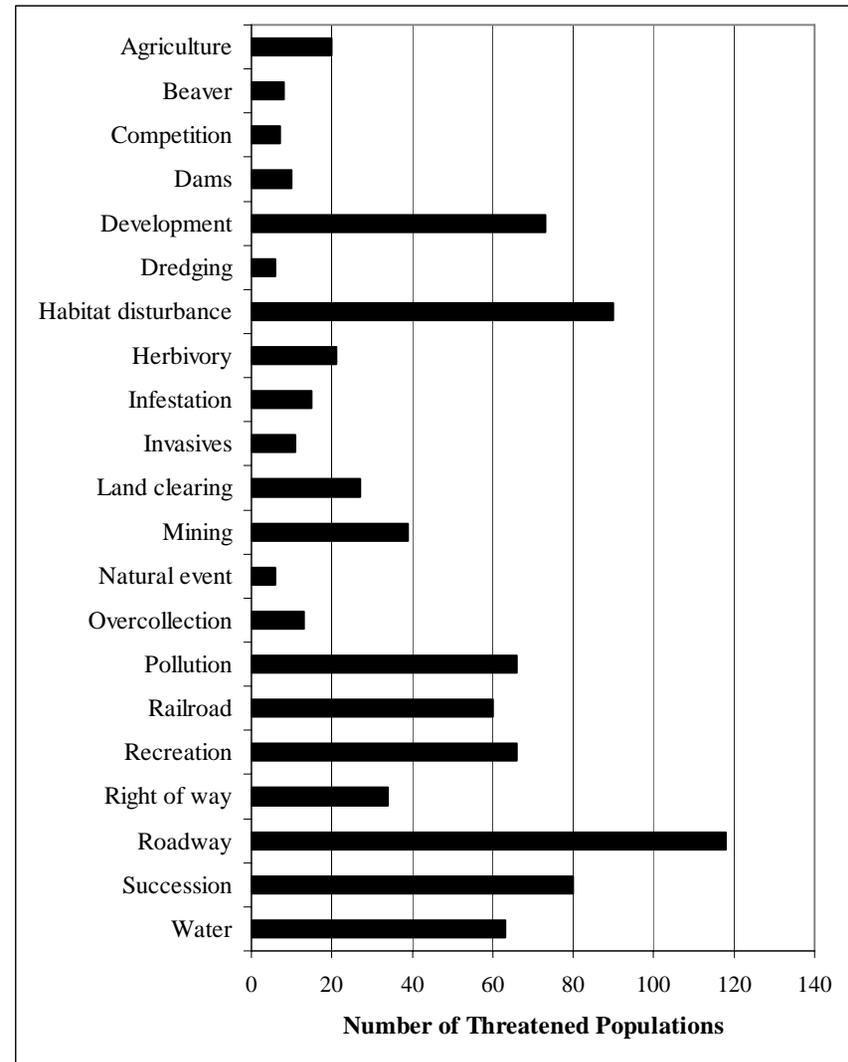
| Threats | Number of Threatened Populations |
|---------------------|----------------------------------|
| Agriculture | 20 |
| Beaver | 8 |
| Competition | 7 |
| Dams | 10 |
| Development | 73 |
| Dredging | 6 |
| Habitat disturbance | 90 |
| Herbivory | 21 |
| Infestation | 15 |
| Invasive plants | 11 |
| Land clearing | 27 |
| Mining | 39 |
| Natural event | 6 |
| Overcollection | 13 |
| Pollution | 66 |
| Railroad | 60 |
| Recreation | 66 |
| Right of way | 34 |
| Roadway | 118 |
| Succession | 80 |
| Water | 63 |
| Unknown | 358 |

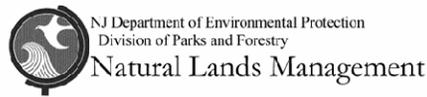
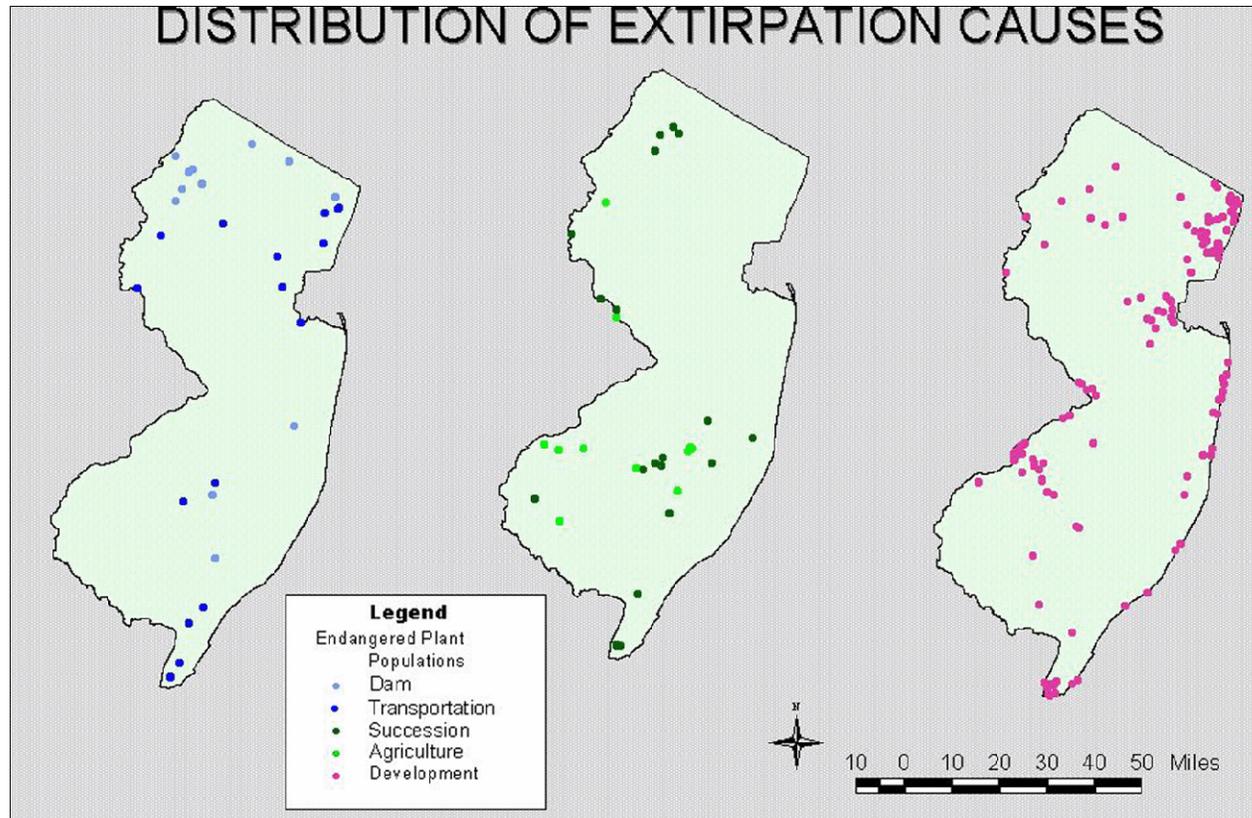
Endangered Plant Species Populations

Succession (80 of 420 or 19%) was the third most frequently documented threat to endangered plant species populations in New Jersey.

Recreational activities such as off-road vehicular (ORV) traffic, as well as the management of land for these purposes (e.g., beach raking; Kelly 2003), were threats to a large percentage of endangered plant species occurrences, as were pollution and water-related activities.

Figure 9. Number of threatened extant plant populations by threat.





Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Populations in NJ: Health and Threats.

Figure 8. Distribution of endangered plant population extirpations by cause across the State of New Jersey.

Temporal Trends

The database records were reviewed to try to determine temporal patterns in extirpations and the status of extant populations. Trends in extirpations of populations can provide data on where protection and stewardship efforts have been inadequate, and evidence of population increase or decline, and the causes thereof, can provide opportunities to prevent future losses.

However, the lack of necessary information made it impossible to discern such patterns with either the extirpated or extant populations. It was not possible, for example, to determine the exact date of the extirpation of most populations, and for many, more than 50 years had passed between the last recorded observation of the population and the point in time when the Natural Heritage Program determined it was extirpated.

With regard to extant populations, there was some notation of population decline, increase, or stability in 320 occurrence records in the database. The quality of these data was quite variable, however. In general, the lack of standardized baseline data made it difficult to identify clear trends in population sizes across species. Therefore, no further analysis was done on temporal population trends. Future monitoring efforts should include data that will be useful in this type of analysis.

Distribution of Endangered Plant Species

Habitats

Habitat type for each species occurrence was identified according to five broad classes, including:

- palustrine (freshwater wetlands)
- terrestrial (uplands)
- estuarine (tidally influenced)
- lacustrine (lakes and ponds)
- riverine (rivers and streams)

It was not possible to use more specific habitat typologies, such as the plant community classifications found in Breden et al. (2001), as the occurrence records did not always contain sufficiently detailed habitat information, and for many of the extirpated populations the habitats themselves no longer exist.

Table 4. Number of extant, extirpated, and undetermined populations by habitat type ².

| | Extant | Extirpated | Undetermined | Totals |
|--------------------|--------|------------|--------------|--------|
| Palustrine | 612 | 189 | 879 | 1680 |
| Terrestrial | 220 | 123 | 530 | 873 |
| Estuarine | 15 | 26 | 58 | 99 |
| Lacustrine | 23 | 7 | 54 | 84 |
| Riverine | 11 | 6 | 18 | 35 |

Of 778 total verified extant populations and 295 extirpated populations, 801 were classified as palustrine and 343 were

classified as terrestrial, whereas there were only 41 estuarine, 30 lacustrine, and 17 riverine populations (Table 4, Figure 10, Figure 11). A similar pattern was found among the undetermined populations, with a much higher number of palustrine and terrestrial populations (879 and 530, respectively) compared to the 58 estuarine, 54 lacustrine, and 18 riverine populations.

Palustrine

Of the palustrine populations that had been verified by the Natural Heritage Program, 76% were extant (Figure 13), and 54% of these were considered threatened. The largest threat was succession, with recreation, mining, development, and pollution also being common. Twenty-four of the populations that had been extirpated were associated with development, agriculture, mining, succession and roadways. The causes for several of these, however, were unknown.

Several factors may account for the numerous populations and the relatively low percentage of extirpations in this habitat compared to others. Unique plant species are often associated with freshwater wetlands in general, and these species comprise a large portion of the critically imperiled flora in New Jersey. The five most frequently observed species in the database (*Helonias bullata*, *Eupatorium resinosum*, *Rhynchospora knieskernii*, *Juncus caesariensis*, and *Nartheicum americanum*) each belong to this particular habitat category and are likely to account for a significant portion of the data. A large number of these occurrences, moreover, are found on state-

² Editors Note: Some species can occur in more than one habitat type.

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protected lands, where extirpations are much less likely to occur if management programs are in place to protect the plants. New Jersey legislation, in addition, affords some protection to palustrine habitats in general, and the combined protection and increased amount of surveys generated by this legislation may have led to an increase in the number of palustrine populations known and a simultaneous decrease in the number of extirpations.

Terrestrial

In contrast to palustrine populations, over one-third (36%) of terrestrial populations have been extirpated (Figure 13), and 56% of these were related to development. Other causes included dams, mining, roadways, succession, and agriculture. Of the extant populations, 56% were considered threatened.

Estuarine

Of estuarine populations, a very large percentage (63%) were extirpated (Figure 12), due in large part to the widespread destruction of this habitat by development. Of the extant populations, 73% were considered threatened. In addition to development, pollution, recreation, succession, and invasive species such as *Phragmites* also threaten these populations throughout the state.

Lacustrine

Less than one quarter (23%) of lacustrine populations were extirpated (Figure 12), due primarily to dams and development.

Extant populations (44%) were threatened by invasive plants, water quality, pollution, and recreation.

Riverine

Approximately 35% of riverine populations in New Jersey have been extirpated, mainly due to development (Figure 12). Of the extant riverine populations, 45% were considered threatened by changes in water quality and development.

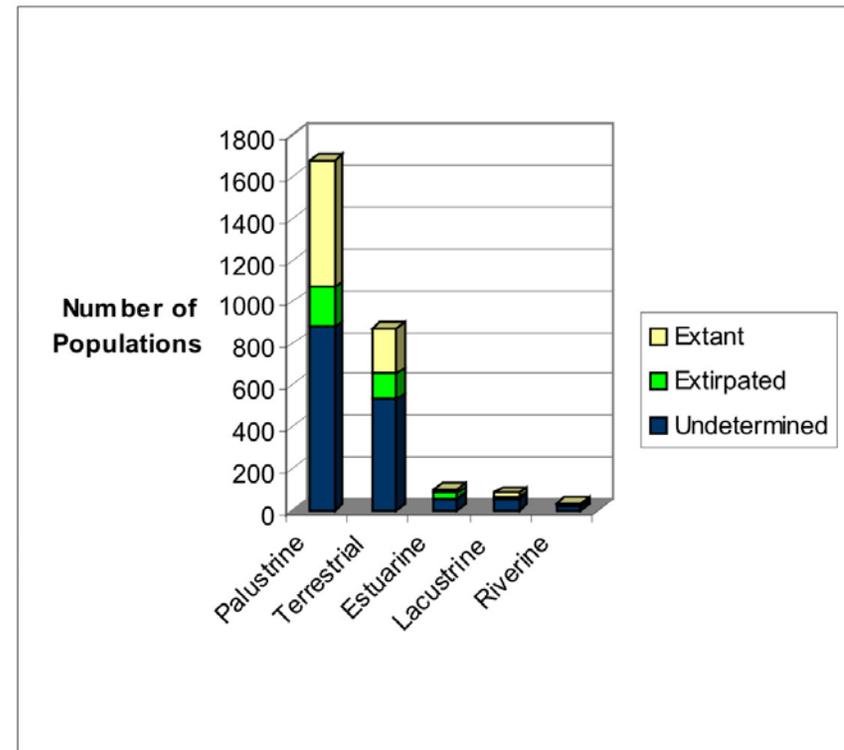
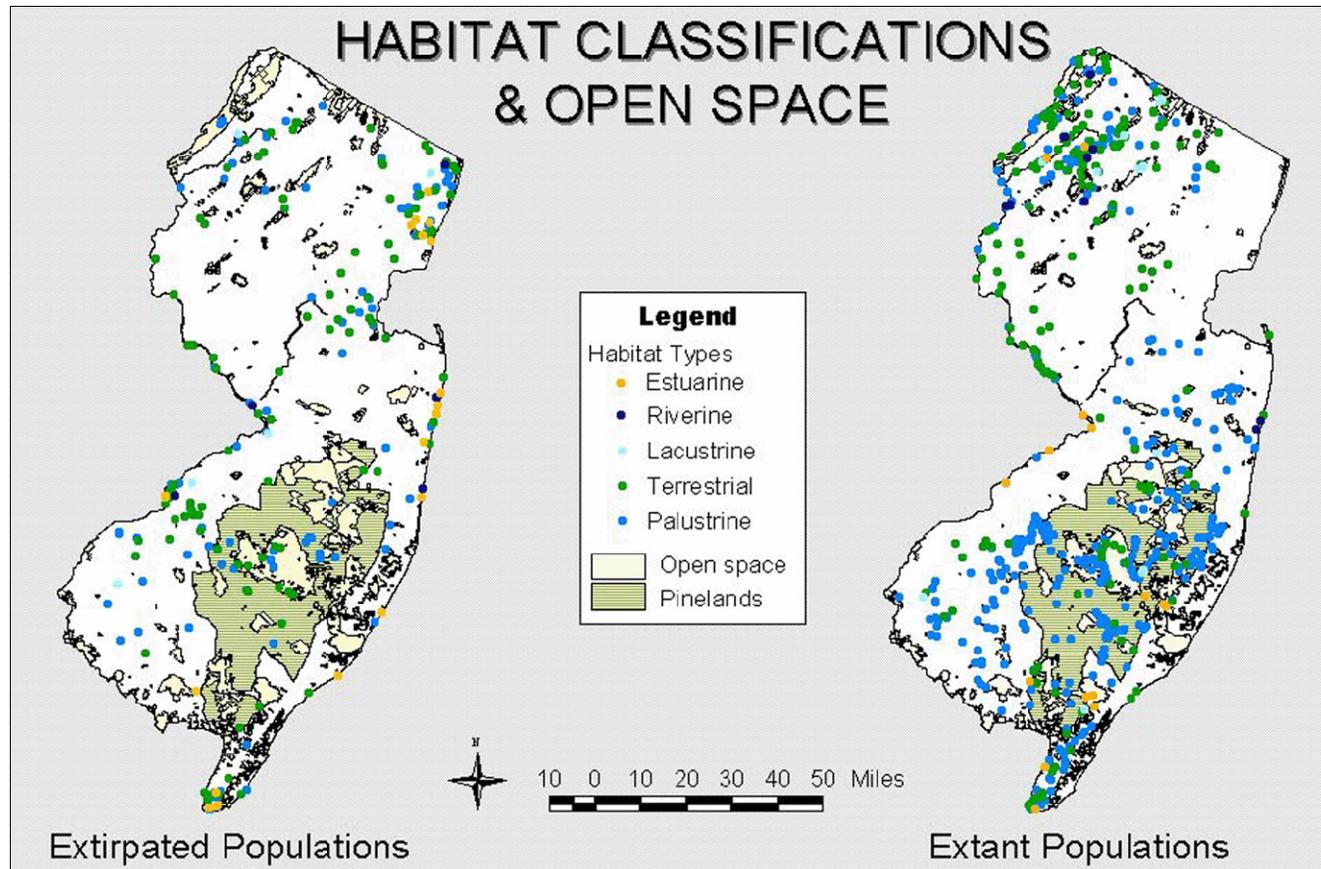
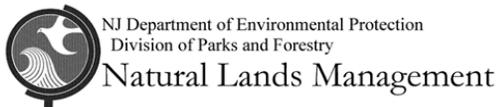
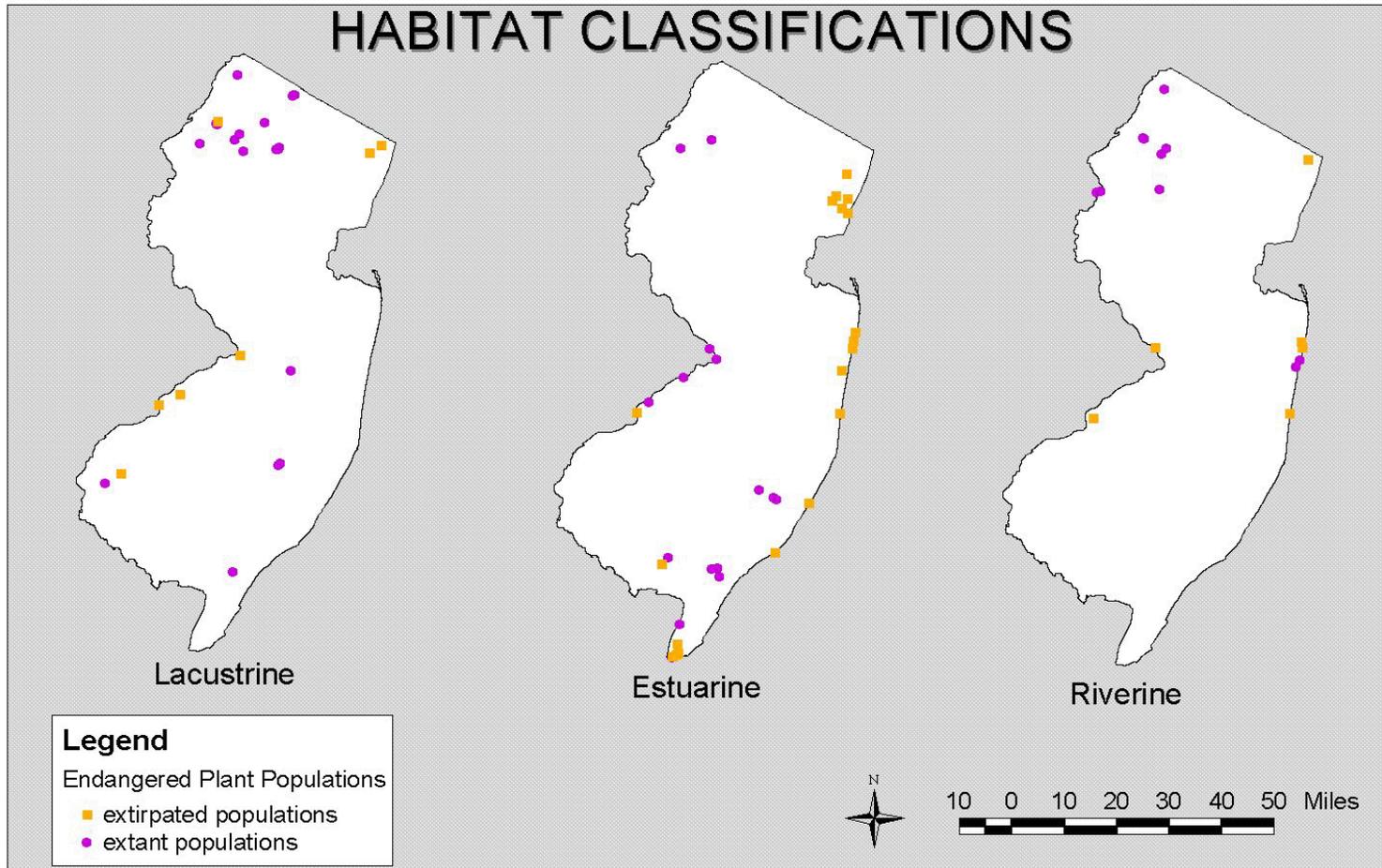


Figure 10. Number of extant, extirpated, and undetermined populations by habitat type.



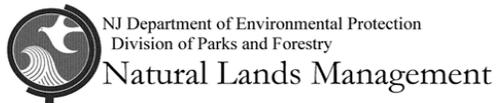
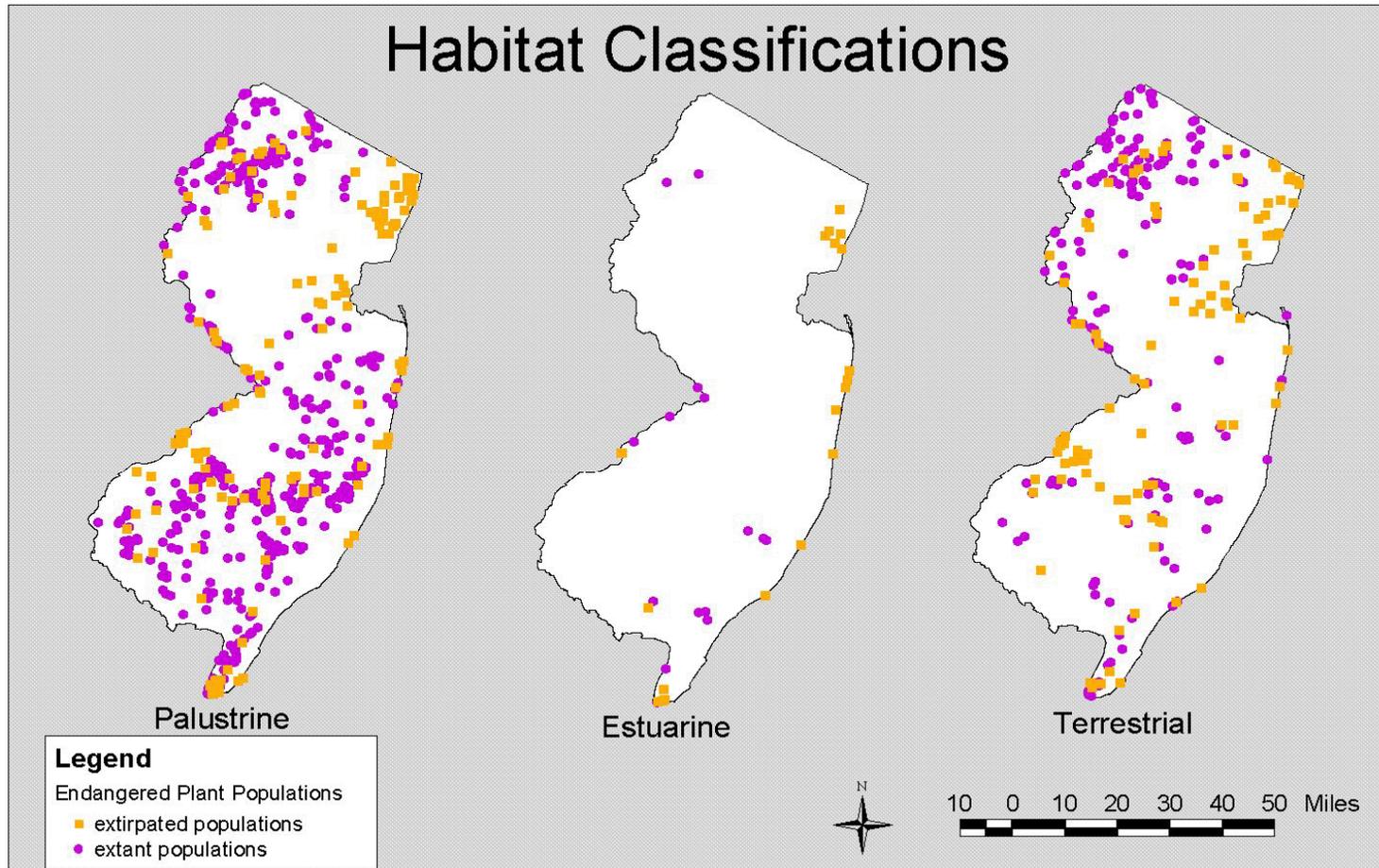
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Populations in NJ: Health and Threats.

Figure 11. Extant and extirpated plant populations by habitat type and open space/conservation lands. Open space includes federal and state public open space and recreation areas. Pinelands refers to the New Jersey Pinelands National Reserve as delineated in 1986.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Populations in NJ: Health and Threats.

Figure 12. Locations of extant and extirpated plant populations classified as lacustrine, estuarine, and riverine within the State of New Jersey.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Populations in NJ: Health and Threats.

Figure 13. Locations of extant and extirpated plant populations classified as palustrine, estuarine, and terrestrial within the State of New Jersey.

Physiographic Provinces

Many species distributions in the state follow broad patterns that concentrate in particular physiographic provinces, as do certain land use patterns, such as agricultural and urban development. The provinces themselves are based on similarities in geological and topographical characteristics of a given region. There are five such regions found in New Jersey including:

- Outer Coastal Plain
- Inner Coastal Plain
- Piedmont
- Highlands
- Ridge and Valley

Locations of Extant and Extirpated Populations within Physiographic Provinces

In New Jersey’s five physiographic regions, there were 778 extant populations, 295 extirpated populations, and 1298 undetermined populations (Table 5). Of the extant populations, the majority occurred in the Outer Coastal Plain (54%), followed by the Ridge and Valley section (24%) and the Highlands (12%). The Piedmont and Inner Coastal Plain Provinces had only 6% and 4% of the total extant occurrences, respectively (Table 5, Figure 14, Figure 15). The reader should remember that these proportions may be skewed by the relatively large number of occurrences of a few species that have been the subject of intense study (including *Helonias bullata*,

Eupatorium resinosum, *Rhynchospora knieskernii*, *Juncus caesariensis*, and *Nartheceum americanum*).

The Inner Coastal Plain (25%) and Piedmont (27%) also had higher proportions of regional populations that were extirpated. Less than 10% of the populations were extirpated in each of the remaining regions.

Table 5. Number of extant, extirpated, and undetermined populations by physiographic province.

| | Extant | Extirpated | Undetermined | Totals |
|---------------------|---------------|-------------------|---------------------|---------------|
| Outer Coastal Plain | 417 | 104 | 635 | 1156 |
| Inner Coastal Plain | 34 | 73 | 185 | 292 |
| Piedmont | 47 | 76 | 160 | 283 |
| Highlands | 91 | 17 | 154 | 262 |
| Ridge and Valley | 189 | 25 | 164 | 378 |
| Totals | 778 | 295 | 1298 | 2371 |

Threats to Extant Populations and Causes of Extirpation by Physiographic Province

Highlands

In the Highlands, the most common threats to extant populations included habitat disturbance, recreation, roadways, railroad, development, and wooly adelgid infestation. Development was the most common cause of population extirpation.

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Inner Coastal Plain

In the Inner Coastal Plain Province, habitat disturbance and invasive plants were the most common threats to extant populations. Development and urbanization were the most common causes of population extirpation in this province.

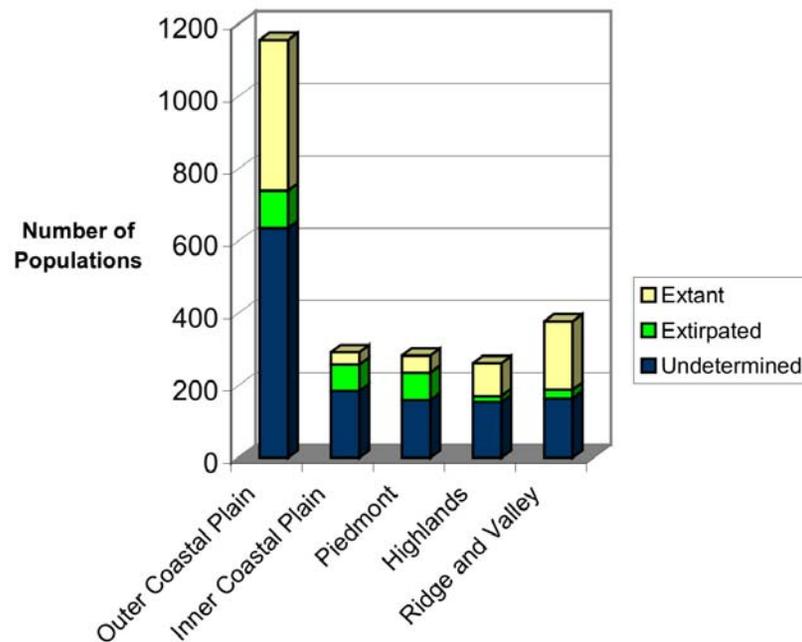


Figure 14. Number of extant, extirpated, and undetermined populations by physiographic province.

Outer Coastal Plain

The most common threats to extant plant populations in the Outer Coastal Plain included habitat disturbance, recreation, succession, water, roadways, and development. Development and succession were the most common causes of population extirpation.

Piedmont

In the Piedmont Province, succession, recreation, habitat disturbance, and roadways were the most common threats to extant endangered plant populations. Again, development and urbanization were the most common causes of population extirpation.

Ridge and Valley

Roadways, invasive plant species, recreation, and habitat disturbance were the most commonly cited threats to extant populations in the Ridge and Valley Province. The most common causes of population extirpation in this province were damming and mining.

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Additional GIS Coverages

In addition to habitat types and physiographic provinces, several other GIS database coverages were used to analyze and portray the geographical distribution of extirpated and extant populations of endangered plant species in New Jersey. These coverages included watersheds, land use/land cover, counties, and current and recommended conservation lands. Examples are shown in Figures 16, 17 and 18 with supplemental data in Tables 6 and 7 as well as the Appendices.

It should be noted, however, that the maps and tables shown below do not represent all of the Natural Heritage Database endangered plant species locations. The species locations represented in the maps are only a portion of the total number of endangered species locations in each county that were used for this analysis. For the purposes of this study, minute precision occurrences and historic ranked occurrences were not included in the analysis. Historic ranked occurrences are those that may very well still be present if suitable habitat exists, but which have yet to be verified.

Land Use and Land Cover

Distribution of Extant Populations by Land Use/Land Cover

An exact count of extant plant populations on each land use type was not possible given the nature of the land use data. However,

extant plant population patterns among land use types could be discerned (Figure 16). It was found that extant populations were rarely located on urban or agricultural land. However, extant populations were commonly found in forested and wetland areas.

Threats to Extant Populations and Causes of Extirpation by Land Use/Land Cover

Agricultural Land: Development, agriculture, roadways, and bulkhead/fill were the most common causes of population extirpation on agricultural land. The most common threats to extant populations included roadways, agriculture, and cranberry bogs.

Barren Land: Common causes of population extirpation on barren land included development, urbanization, and land clearing. Mining, habitat disturbance, and recreation were the most common threats to extant populations in this land type.

Forested Land: Development and urbanization were the most common causes of population extirpation on forested land. The most common threats to extant populations were succession, recreation, and roadways.

Urban Land: As on forested land, development and urbanization were the most common causes of endangered plant population extirpation on urban land. Development, habitat disturbance, and

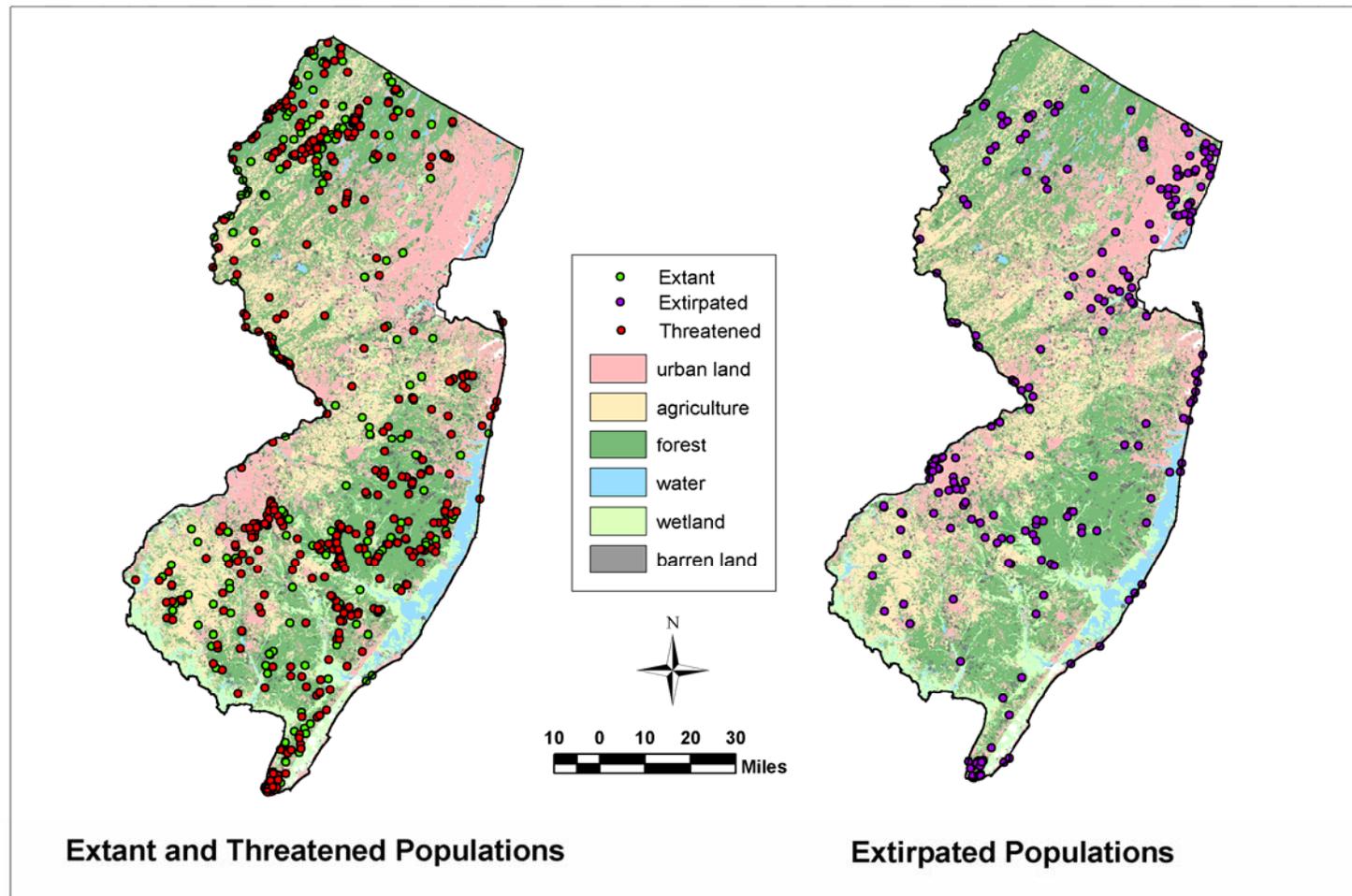
Endangered Plant Species Populations

recreation were cited as the most common threats to extant populations on this land use type.

Water: In water-influenced areas, development, dams, and canal construction were the most common causes of population extirpation. Common threats to extant populations included recreation, invasive plants, and habitat disturbance.

Wetlands: In wetland areas, common causes of population extirpation were development, urbanization, and land clearing. Habitat disturbance, water, recreation, and succession were the most common threats to extant populations.

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Division of Parks and Forestry

Natural Lands Management



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Populations in NJ: Health and Threats.

Figure 16. Extant, threatened, and extirpated endangered plant populations by land use/land cover in the State of New Jersey.

Endangered Plant Species Populations

Watersheds

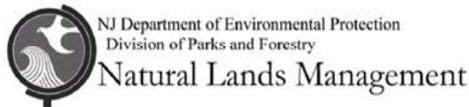
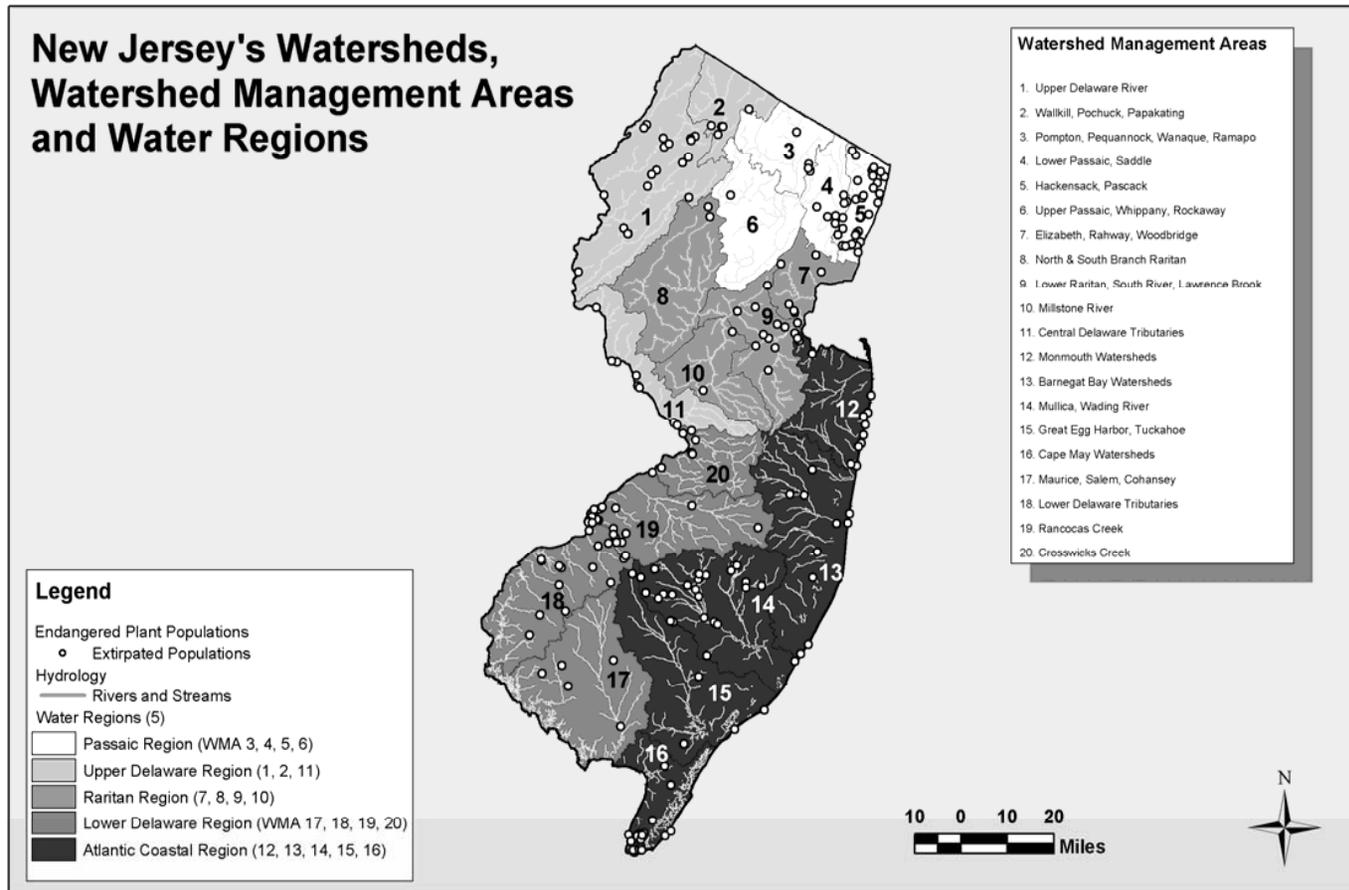
Number of endangered plant species, patterns of population extirpations, and extant population occurrences were examined in each watershed management area (Table 6). Occurrence of populations of undetermined status could not be examined since the database used classified populations according to outdated watershed management area (WMA) boundaries, while the GIS analysis could only be done with updated WMA boundaries.

The number of endangered plant species in each WMA ranged from 107 in the Upper Delaware River WMA to five in the Millstone River WMA. Number of extant populations ranged from 197 in the Upper Delaware River WMA to zero in the Hackensack, Pascack WMA and the Elizabeth, Rahway, Woodbridge WMA. The number of extirpated populations ranged from 45 in the Hackensack, Pascack WMA to two in the Upper Passaic, Whippany, Rockaway WMA, the North and South Branch Raritan WMA, and the Millstone River WMA. Ratio of extant to extirpated populations ranged from seven in the Upper Delaware River WMA to zero in watersheds with no extant populations. Overall, watersheds in and/or near urban areas, such as the Hackensack, Pascack WMA, and the Lower Passaic, Saddle WMA, had the greatest number of population extirpations and the fewest extant populations (Figures 17 and 18). More information for individual watershed management areas can be found in Appendix A.

Table 6. Number of species, and extant and extirpated populations by watershed management area.

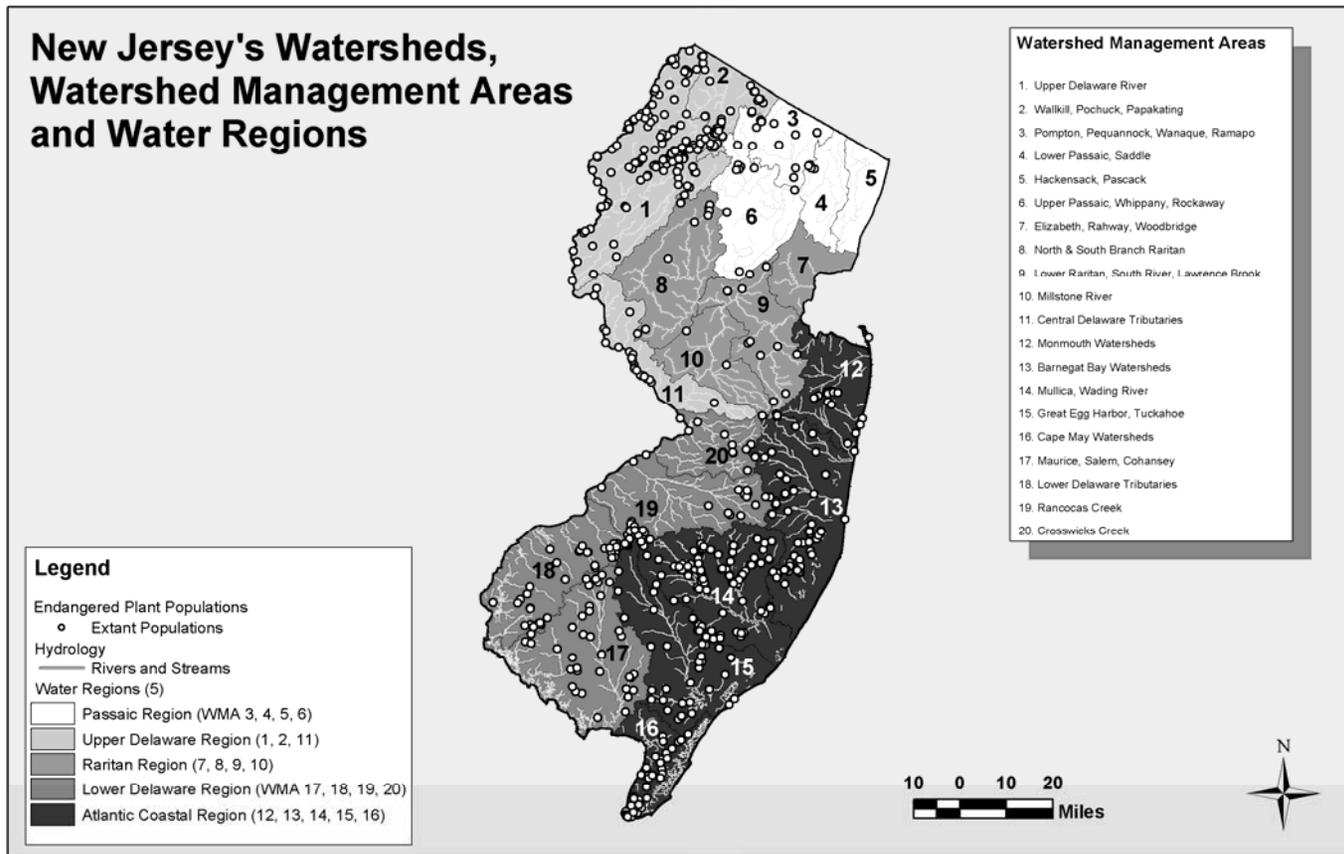
| | Watershed Management Area | Species | Extant Populations | Extirpated Populations |
|----|--|----------------|---------------------------|-------------------------------|
| 1 | Upper Delaware River | 107 | 197 | 28 |
| 2 | Wallkill, Pochuck, Papakating | 37 | 48 | 9 |
| 3 | Pompton, Pequannock, Wanaque, Ramapo | 19 | 19 | 4 |
| 4 | Lower Passaic, Saddle | 11 | 7 | 9 |
| 5 | Hackensack, Pascack | 34 | 0 | 45 |
| 6 | Upper Passaic, Whippany, Rockaway | 13 | 13 | 2 |
| 7 | Elizabeth, Rahway, Woodbridge | 8 | 0 | 8 |
| 8 | North & South Branch Raritan | 11 | 12 | 2 |
| 9 | Lower Raritan, South River, Lawrence Brook | 19 | 13 | 12 |
| 10 | Millstone River | 5 | 3 | 2 |
| 11 | Central Delaware Tributaries | 21 | 26 | 8 |
| 12 | Monmouth Watersheds | 13 | 18 | 14 |
| 13 | Barnegat Bay Watersheds | 20 | 61 | 12 |
| 14 | Mullica, Wading River | 34 | 137 | 26 |
| 15 | Great Egg Harbor, Tuckahoe | 24 | 44 | 7 |
| 16 | Cape May Watersheds | 47 | 64 | 30 |
| 17 | Maurice, Salem, Cohansey | 13 | 38 | 4 |
| 18 | Lower Delaware Tributaries | 37 | 41 | 29 |
| 19 | Rancocas Creek | 28 | 30 | 31 |
| 20 | Crosswicks Creek | 14 | 10 | 7 |

* Watershed Management Area names as per NJDEP (1997).



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Populations in NJ: Health and Threats.

Figure 17. Endangered plant population extirpations by water region and watershed management area in New Jersey.



NJ Department of Environmental Protection
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Natural Lands Management



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Populations in NJ: Health and Threats.

Figure 18. Extant endangered plant populations by water region and watershed management area in New Jersey

Endangered Plant Species Populations

Counties

Number of endangered plant species, patterns of population extirpations, extant population occurrences, and populations of undetermined status were examined in each of 21 counties in New Jersey (Table 7). The number of species in each county ranged from 142 in Sussex County to seven in Union County. This range in species number changed from a high of 102 species in Sussex County to a low of one species in Essex County when species of undetermined populations were omitted. The number of extant populations ranged from 188 in Sussex County to zero in Essex and Hudson counties. The number of extirpated populations ranged from 49 in Camden County to one in Essex and Somerset counties, and the ratio of extant to extirpated populations ranged from seven in Sussex County to zero in Essex and Hudson counties. The ratio of extant to undetermined populations ranged from 0.8 in Warren County to zero in Essex and Hudson counties.

The high number of species and extant populations in Sussex County can be partly attributed to the presence of the Delaware Water Gap National Recreation Area, a relatively high forest cover (See Appendix B19), and a relatively low human population density (276 people per square mile or 144,166 people in 521 square miles according to the 2000 US Census). Hudson and Essex counties, however, are highly urbanized counties with a relatively high population density (Essex County had

6,289 people per square mile or 793,633 people in 126 square miles and Hudson County had 12,957 people per square mile or 608,975 people in 47 square miles in the 2000 U.S. Census), thus explaining the low numbers of extant populations in these counties. More information for individual counties can be found in Appendix B.

Table 7. Number of species, extant and extirpated populations, and undetermined populations by county.

| County | Species | Extant Populations | Extirpated Populations | Undetermined Populations |
|------------|------------|--------------------|------------------------|--------------------------|
| Atlantic | 51 (30*) | 62 | 9 | 76 |
| Bergen | 47 (28*) | 3 | 38 | 41 |
| Burlington | 57 (31*) | 110 | 28 | 142 |
| Camden | 53 (38*) | 35 | 49 | 73 |
| Cape May | 80 (52*) | 71 | 33 | 190 |
| Cumberland | 33 (11*) | 22 | 5 | 61 |
| Essex | 9 (1*) | 0 | 1 | 10 |
| Gloucester | 44 (18*) | 22 | 10 | 77 |
| Hudson | 17 (15*) | 0 | 16 | 5 |
| Hunterdon | 46 (22*) | 22 | 4 | 42 |
| Mercer | 32 (15*) | 10 | 8 | 27 |
| Middlesex | 29 (20*) | 7 | 19 | 17 |
| Monmouth | 33 (15*) | 27 | 13 | 38 |
| Morris | 60 (24*) | 25 | 6 | 71 |
| Ocean | 54 (23*) | 71 | 13 | 97 |
| Passaic | 39 (19*) | 17 | 4 | 34 |
| Salem | 35 (12*) | 24 | 3 | 41 |
| Somerset | 20 (8*) | 7 | 1 | 21 |
| Sussex | 142 (102*) | 188 | 27 | 168 |
| Union | 7 (4*) | 1 | 3 | 3 |
| Warren | 83 (51*) | 58 | 8 | 70 |

* Number in parentheses represents the number of species of extant and extirpated populations, omitting species of undetermined populations.

Current and Recommended Conservation Lands

NJDEP Natural Heritage Grid

The NJDEP Natural Heritage Grid Map GIS coverage contains 100% of the extant endangered population occurrences and 89% of the species.

NJDEP Natural Heritage Priority Sites

The NJDEP, Natural Heritage Program, created Natural Heritage Priority Sites to, identify the best habitats for rare plant and animal species and natural communities through analysis of information in the Natural Heritage Database (NJDEP 1999). Each priority site is ranked according to its significance for biological diversity using a scale developed by The Nature Conservancy and natural heritage programs. GIS analysis of extant populations in the state showed that 603 of 778 extant populations in New Jersey are found within Priority Site boundaries.

NJDEP Green Acres Program

The NJDEP Green Acres Program helps non-profit organizations, counties, and municipalities acquire or develop land for outdoor recreation or conservation purposes. Analysis of the land included in the Green Acres public open space coverages (as of 1999) showed that 26% of extant populations in New Jersey are found on public open space.

NJDEP Landscape Project

The NJDEP Landscape Project, “identifies, delineates, and ranks (based on the conservation status of species present) critical ... habitat statewide” for wildlife. Critical habitat categories include: forest, beach, emergent wetlands, forested wetlands, and grasslands. Each site is coded for wildlife species present that are of special concern, are state-endangered, or are federally listed. It was found that 498 of 778 extant populations of plants in the state also fall in forest habitat. Three of 778 extant plant populations were found in beach habitat. In emergent wetland habitat, 85 of 778 extant populations were found. Three hundred and sixteen of 779 extant populations were found in forested wetlands habitat. Finally, in grasslands habitat, only 16 of 778 extant populations were found. In all, 77% of the extant plant population occurrences were also included in this GIS coverage.

Conclusions and Recommendations

The foregoing summary and analysis of the information contained in the Natural Heritage Database showed that of those populations that have been verified since 1980, 11% of the endangered plant species occurrences in New Jersey have been extirpated. More than half (188) of the 331 vascular plant species listed as endangered, moreover, had only one to three confirmed extant occurrences in the state, and 25% (84) had no known extant occurrences at all (i.e., historical).

Habitat Protection

Habitat destruction and degradation has been, and continues to be, the greatest threat to endangered plant species in New Jersey, the nation (Wilcove et al. 2000), and worldwide (Wilson 1997). The protection, monitoring, and management of the habitats where these populations occur is widely recognized as the best (and oftentimes the only) way of ensuring the survival of endangered plant species (Synge 1981), and therefore must be a priority. Currently, only 26% of the extant species in New Jersey have populations either wholly or partially located on state-protected lands. More endangered species habitat must be protected in order to ensure the survival of these species in the future.

Given the nature and scale of the problem, effective conservation of this resource is therefore likely to entail more comprehensive initiatives in addition to the preservation of individual populations and

habitats; i.e., incorporating endangered plant conservation into the planning and policy decisions of state and local agencies with regard to those lands within their purview.

Existing open space frameworks were found to vary in their effectiveness at assigning priority sites for conservation. The Natural Heritage Grid Maps, which contained 100% of the extant species occurrences and 89% of the species, was by far the most comprehensive for these purposes. The DEP Natural Heritage Priority Sites included 78% of the known populations in recommended areas, and the DEP Landscape Project critical animal habitat designations contained many of these as well (77%). In selecting priority sites, however, it is important to not only seek protection for the greatest number of populations, but to ensure that representative populations of each particular endangered plant species are included in these measures.

Furthermore, attention must be given not merely to particular areas where plant populations occur, but to adjacent and other sites as well, if both the habitats and the associated ecological systems that maintain them are to be adequately protected. The amount of land actually occupied by a particular population may be very small, whereas the ecological processes that they depend upon, such as pollination and dispersal, often extend well beyond these boundaries. Consequently, changes in the forest structure, water table, or other aspects in adjacent areas may be detrimental to these populations as well.

Endangered Plant Species Populations

Population Monitoring

As great a challenge as the protection of these habitats may be, land preservation alone is not likely to be sufficient to ensure the survival of these species in the state. Habitat conditions continue to change even after overt threats such as development have been eliminated, as has been seen in a number of national parks (Bratton and White 1981). Many of these changes – such as woody plant succession - already threaten a number of endangered plant populations in the state, such as American chaffseed (*Schwalbea americana*) and bog asphodel (*Narthecium americanum*). Systematic monitoring of populations is therefore likely to be needed in many cases in order for effective management of these habitats to take place.

Little is known about the biological requirements of a great many of these species, however, making it difficult to determine what changes may be detrimental to populations, or what actions should be taken to manage and maintain them. Persistent declines, especially in large populations, for example, may indicate such a changed ecological context. However, normal fluctuations in the populations of these species are also known to occur. The anecdotal accounts of population trends currently comprising the majority of information in the Natural Heritage Database cannot distinguish among these possibilities and are therefore inadequate to indicate or identify a serious downturn in the health of many of these populations. The only way to distinguish between these phenomena is by conducting long-term, site-specific ecological studies (Sarker

1996), which must therefore be the basis of conservation planning and management activities.

Endangered Species Inventory

Although more intensive population monitoring will undoubtedly be needed for many endangered species populations in the future, of more immediate concern is the need to update the status of these populations within the existing inventory framework. No information exists as to the current status of more than 50% of the total known endangered plant species occurrences in New Jersey since 1980, and only 10% have been verified since 1990. Such basic information as to whether these populations are extant or extirpated is required in order to formulate sound policy and planning at the statewide level.

The population occurrence records in the Natural Heritage Database consist of an assemblage of diverse records compiled over more than 100 years, and the current undetermined status of many populations was due to the lack of information as to the whereabouts of these occurrences in these historical records. Some, for example, are no more specific than identifying the county in which these occurrences were found, and a great deal of potentially suitable habitat must therefore be searched in order to satisfactorily determine their status.

Efforts by the Natural Heritage Program staff, volunteers, and contractors have in fact been remarkably successful in recent years

Endangered Plant Species Populations

in updating the database, resulting in the discovery of more than 100 extremely rare species (Snyder 2000) and the identification of more than 300 high quality sites for conservation (NJDEP 1999). Similarly, the five species that were responsible for 30% of the occurrences in the database were so abundant in part because so much more survey effort and funding was devoted to them, due to either their status as federally listed species (e.g., *Rhynchospora knieskiernii*, *Narthecium americanum*), or their occurrence in the same areas as these species (e.g., *Juncus caesariensis*).

The many new occurrences recently discovered for other federally listed species, such as the threatened seabeach amaranth (*Amaranthus pumilus*; Kelly 2003) and bog turtle (*Clemmys muhlenburgii*; Tesauro 2002), also support this pattern, as do the recent findings by remote sensing of more than 13,000 potential vernal pools in New Jersey, which are important habitats for a number of endangered amphibian species in the state (NJDEP 2003).

While the success of recent efforts suggests reason for hope, more work is needed to adequately determine the status of these endangered plant species in New Jersey. To date, no comprehensive survey has been done of the entire state, and additional funding for staff and resources will undoubtedly be needed in order to complete the endangered species inventory, and to continue to update and maintain it with information sufficient to match the pace and scale of changes that effect them.

The expanded survey, monitoring, and management efforts needed for the effective conservation of these species populations throughout the state might be more expeditiously achieved by enlisting the help of local volunteer groups (e.g., local students, botanical clubs and other citizens). In addition to significantly reducing the time and money that would otherwise be needed to accomplish these tasks, these less conventional methods could also help raise public awareness as to the existence of these species and habitats in local communities, as well as foster a sense of stewardship regarding their well-being.

Environmental Education

Such issues of environmental knowledge and values, and the extent to which they come to inform our human-ecological actions and behaviors, will undoubtedly determine the ultimate success of conservation efforts in the future. Perhaps the most striking aspect of past extirpations and the existing threats to these species is the tremendous and consistent incongruity between the intentions and consequences of the actions that bring about their demise. Even more striking perhaps is the fact that, whatever the motives, the vast majority of extinctions by human hands to date have in fact been entirely unintentional. In most cases, the road to extinction has been paved with numerous individual human actions incrementally changing the populations or habitats of these species over time. Most people, however, are unaware of the very existence of these species at all, never mind the consequences of actions which may

Endangered Plant Species Populations

impact them. In cases where the species are in fact being directly and intentionally exploited, moreover, it is rarely done with their larger evolutionary significance, or the thought of extinction, in mind.

Given the sensitivity of many of these species in New Jersey and the large number of human activities that can and do affect them, greater public awareness as to the existence and significance of these species and their habitats may be in order to preserve New Jersey's native flora for future generations.

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Appendix A: Watershed Management Areas (WMA)

| | |
|---|----|
| Upper Delaware River WMA | 2 |
| Walkill, Pochuck, Papakating WMA | 6 |
| Pompton, Pequannock, Wanaque, Ramapo WMA | 8 |
| Lower Passaic, Saddle WMA | 9 |
| Hackensack, Pascack WMA | 10 |
| Upper Passaic, Whippany, Rockaway WMA | 12 |
| Elizabeth, Rahway, Woodbridge WMA | 13 |
| North and South Branch Raritan WMA | 14 |
| Lower Raritan, South River, Lawrence Brook WMA | 15 |
| Millstone River WMA | 16 |
| Central Delaware Tributaries WMA | 17 |
| Monmouth Watersheds WMA | 18 |
| Barnegat Bay Watersheds WMA | 19 |
| Mullica, Wading River WMA | 20 |
| Great Egg Harbor, Tuckahoe WMA | 22 |
| Cape May Watersheds WMA | 23 |
| Maurice, Salem, Cohansey WMA | 25 |
| Lower Delaware Tributaries WMA | 26 |
| Rancocas Creek WMA | 28 |
| Crosswicks Creek WMA | 30 |

Upper Delaware River WMA

One hundred and seven species were recorded in the Upper Delaware River WMA (Table A1.1). There were 197 extant populations found, which were threatened by a variety of factors. Twenty-eight extirpations in this WMA were caused mainly by mining, peat mining, damming, development, flood, beavers, and succession.

Table A1.1. Species populations in the Upper Delaware River WMA.

| SPECIES | POPULATIONS |
|-------------------------------------|------------------------|
| ALISMA TRIVIALE | 1 extant |
| ANDROMEDA GLAUCOPHYLLA | 4 extant, 1 extirpated |
| ANTENNARIA NEGLECTA var. CANADENSIS | 1 extant |
| ARCEUTHOBIUM PUSILLUM | 3 extant |
| ARMORACIA LACUSTRIS | 1 extirpated |
| ASTER BOREALIS | 4 extant, 1 extirpated |
| ASTRAGALUS CANADENSIS | 1 extirpated |
| BIDENS BECKII | 1 extant |
| BOTRYCHIUM MULTIFIDUM | 1 extant |
| BOUTELOUA CURTIPENDULA | 1 extant |
| CARDAMINE ROTUNDIFOLIA | 1 extant |
| CAREX ALBURSINA | 1 extant |
| CAREX ALOPECOIDEA | 1 extirpated |
| CAREX ARCTATA | 1 extant |
| CAREX BRUNNESCENS | 1 extirpated |
| CAREX CRAWEI | 1 extant, 1 extirpated |
| CAREX DEWEYANA | 2 extant |
| CAREX HAYDENII | 2 extant |
| CAREX LEPTONERVIA | 2 extant |
| CAREX LIMOSA | 1 extant, 1 extirpated |
| CAREX LUPULIFORMIS | 2 extant |
| CAREX OLIGOCARPA | 3 extant |
| CAREX POLYMORPHA | 1 extirpated |
| CAREX PSEUDOCYPERUS | 1 extant |
| CINNA LATIFOLIA | 1 extant |

| | |
|--------------------------------|------------------------|
| CONIOSELINUM CHINENSE | 3 extant |
| CORNUS AMOMUM var. SCHUETZEANA | 2 extant |
| CRATAEGUS CALPODENDRON | 3 extant |
| CRATAEGUS SUCCULENTA | 1 extant |
| ELEOCHARIS COMPRESSA | 4 extant |
| ELEOCHARIS PAUCIFLORA | 2 extant, 1 extirpated |
| EQUISETUM VARIEGATUM | 2 extant |
| GALIUM LABRADORICUM | 3 extant |
| GALIUM TRIFIDUM | 4 extant |
| GLYCERIA GRANDIS | 2 extant |
| HIERACIUM KALMII | 1 extant |
| HYBANTHUS CONCOLOR | 1 extant |
| HYDROPHYLLUM CANADENSE | 4 extant |
| HYPERICUM MAJUS | 3 extant, 1 extirpated |
| HYPERICUM PROLIFICUM | 3 extant |
| ILEX MONTANA | 1 extant |
| ISANTHUS BRACHIATUS | 1 extant |
| KALMIA POLIFOLIA | 4 extant, 1 extirpated |
| KUHNIA EUPATORIoidES | 1 extirpated |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| MUHLENBERGIA CAPILLARIS | 1 extant |
| NELUMBO LUTEA | 1 extant |
| ORYZOPSIS ASPERIFOLIA | 5 extant |
| PANICUM FLEXILE | 4 extant, 2 extirpated |
| PHLOX PILOSA | 1 extirpated |
| POLEMONIUM VANBRUNTIAE | 1 extirpated |
| POLYMNIA UVEDALIA | 1 extant |
| POTAMOGETON ALPINUS | 3 extant |
| POTAMOGETON CONFERVOIDES | 1 extant |
| POTAMOGETON ILLINOENSIS | 3 extant |
| POTAMOGETON PRAELONGUS | 1 extant |
| POTAMOGETON ZOSTERIFORMIS | 1 extant |
| RANUNCULUS FASCICULARIS | 2 extant |
| RHYNCHOSPORA CAPILLACEA | 5 extant, 1 extirpated |
| RUBUS CANADENSIS | 2 extant |

| | |
|------------------------|------------------------|
| RUDBECKIA FULGIDA | 1 extant |
| SAGITTARIA CUNEATA | 5 extant |
| SALIX PEDICELLARIS | 6 extant, 1 extirpated |
| SANICULA TRIFOLIATA | 1 extant |
| SCHOENOPLECTUS TORREYI | 1 extant |
| SCIRPUS MICROCARPUS | 5 extant |
| SCLERIA VERTICILLATA | 1 extant, 1 extirpated |
| SILENE NIVEA | 4 extant |
| SISYRINCHIUM MONTANUM | 3 extant |
| SPARGANIUM MINIMUM | 1 extant |
| SPOROBOLUS NEGLECTUS | 3 extant |
| STREPTOPUS ROSEUS | 1 extant |
| THUJA OCCIDENTALIS | 1 extant |
| TIARELLA CORDIFOLIA | 2 extant |
| UTRICULARIA MINOR | 4 extant |
| VIOLA CANADENSIS | 1 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 3 extant |
| SENSITIVE SPECIES* | 6 extant, 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 2 extant, 2 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |

| | |
|--------------------|------------------------|
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant, 1 extirpated |
| SENSITIVE SPECIES* | 3 extant |
| SENSITIVE SPECIES* | 1 extant, 1 extirpated |
| SENSITIVE SPECIES* | 7 extant, 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 2 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Walkill, Pochuck, Papakating WMA

Thirty-seven species were recorded in this WMA (Table A2.1). Forty-eight extant populations were found, which were mainly threatened by mining, roadways, right of ways, habitat disturbance, invasive plants, recreation, pollution, and railroads. The nine population extirpations in this WMA were caused by development, recreation, succession, and damming.

Table A2.1. Species populations in the Walkill, Pochuck, Papakating WMA.

| SPECIES | POPULATIONS |
|-----------------------------|------------------------|
| ANEMONE CYLINDRICA | 5 extant, 1 extirpated |
| BIDENS BECKII | 1 extirpated |
| BOUTELOUA CURTIPENDULA | 4 extant, 1 extirpated |
| CALYSTEGIA SPITHAMAEA | 1 extant |
| CAREX DEWEYANA | 1 extant |
| CAREX HAYDENII | 1 extant |
| CONIOSELINUM CHINENSE | 1 extant |
| ELYMUS TRACHYCAULUS | 1 extant |
| GALIUM TRIFIDUM | 1 extant |
| HYPERICUM PROLIFICUM | 1 extant |
| KALMIA POLIFOLIA | 1 extant |
| KUHNIA EUPATORIoidES | 2 extant |
| LINUM SULCATUM | 3 extant |
| LONICERA CANADENSIS | 1 extant |
| LYCOPODIUM ANNOTINUM | 1 extant |
| MELANTHIUM VIRGINICUM | 1 extant, 1 extirpated |
| ONOSMODIUM VIRGINIANUM | 1 extant |
| PLATANThERA HYPERBOREA | 1 extant |
| POTAMOGETON PRAELONGUS | 1 extant |
| POTAMOGETON ROBBINSII | 2 extant |
| PYCNANTHEMUM CLINOPODIOIDES | 1 extant |
| RANUNCULUS FASCICULARIS | 1 extant, 1 extirpated |
| RHYNCHOSPORA CAPILLACEA | 1 extirpated |
| SALIX PEDICELLARIS | 1 extirpated |
| STREPTOPUS ROSEUS | 1 extant |
| VITIS NOVAE-ANGLIAE | 1 extant |

| | |
|--------------------|------------------------|
| SENSITIVE SPECIES* | 2 extant, 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 3 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 1 extant |

* *Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.*

Pompton, Pequannock, Wanaque, Ramapo WMA

There were 19 endangered species recorded in this WMA (Table A3.1). Nineteen extant populations were found. These populations were commonly threatened by recreation, succession, mining, roadways, development, and wooly adelgid infestation. There were four population extirpations that were caused by pollution, dumping, development, damming, invasive plants, and *Phragmites*.

Table A3.1. Species populations in the Pompton, Pequannock, Wanaque, Ramapo WMA.

| SPECIES | POPULATIONS |
|------------------------|------------------------|
| ANDROMEDA GLAUCOPHYLLA | 1 extant |
| CAREX BRUNNESCENS | 1 extant |
| CAREX DEWEYANA | 1 extirpated |
| CONIOSELINUM CHINENSE | 1 extant |
| EQUISETUM VARIEGATUM | 2 extant |
| GAULTHERIA HISPIDULA | 1 extant |
| HEMICARPHA MICRANTHA | 2 extant |
| ILEX MONTANA | 1 extant |
| LECHEA TENUIFOLIA | 1 extant, 1 extirpated |
| LONICERA CANADENSIS | 1 extant |
| PYCNANTHEMUM TORREI | 1 extant |
| SCHOENOPLECTUS TORREYI | 1 extirpated |
| SCUTELLARIA LEONARDII | 1 extant |
| STELLARIA BOREALIS | 1 extant |
| STREPTOPUS ROSEUS | 1 extant |
| VIBURNUM ALNIFOLIUM | 1 extant |
| VIOLA SEPTENTRIONALIS | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant, 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Lower Passaic, Saddle WMA

There were 11 species recorded in the Lower Passaic, Saddle WMA, seven populations of which were extant and nine populations of which were extirpated (Table A4.1). The most common threats to extant populations included succession, recreation, trails, and invasive plants. Causes of extirpation included development, urbanization, roadway, and roadway construction.

Table A4.1. Species populations in the Lower Passaic, Saddle WMA.

| SPECIES | POPULATIONS |
|-----------------------------|------------------------|
| CERCIS CANADENSIS | 1 extirpated |
| DRYOPTERIS CELSA | 1 extirpated |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| MUHLENBERGIA CAPILLARIS | 1 extant |
| PYCNANTHEMUM CLINOPODIOIDES | 1 extant |
| PYCNANTHEMUM TORREI | 1 extant |
| SANICULA TRIFOLIATA | 1 extant |
| SCUTELLARIA LEONARDII | 2 extant |
| VERBENA SIMPLEX | 1 extant, 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 4 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Hackensack, Pascack WMA

Thirty-four species in 45 populations were recorded in the Hackensack, Pascack WMA. All 45 populations of these endangered species were extirpated (Table A5.1). Development and urbanization were the most common causes of extirpation, along with mining, quarry, roadway, roadway construction, land clearing, invasive plants, and *Phragmites*.

Table A5.1. Species populations in the Hackensack, Pascack WMA.

| SPECIES | POPULATIONS |
|-------------------------|--------------|
| AMMANNIA LATIFOLIA | 1 extirpated |
| BOUPELLOU CURTIPENDULA | 1 extirpated |
| CHENOPODIUM RUBRUM | 1 extirpated |
| CLITORIA MARIANA | 1 extirpated |
| DRYOPTERIS CELSA | 1 extirpated |
| ERIOPHORUM GRACILE | 1 extirpated |
| GAULTHERIA HISPIDULA | 1 extirpated |
| HIERACIUM KALMII | 1 extirpated |
| HOTTONIA INFLATA | 1 extirpated |
| HYPERICUM ADPRESSUM | 2 extirpated |
| HYPERICUM MAJUS | 2 extirpated |
| LEMNA VALDIVIANA | 1 extirpated |
| LINNAEA BOREALIS | 1 extirpated |
| LUZULA ACUMINATA | 1 extirpated |
| LYTHRUM HYSSOPIFOLIA | 1 extirpated |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| MUHLENBERGIA CAPILLARIS | 1 extirpated |
| NUPHAR MICROPHYLLUM | 1 extirpated |
| ONOSMODIUM VIRGINIANUM | 1 extirpated |
| PLATANHERA HYPERBOREA | 1 extirpated |
| POLYMNIA UVEDALIA | 1 extirpated |
| PRENANTHES RACEMOSA | 4 extirpated |
| SCIRPUS MARITIMUS | 2 extirpated |
| SCLERIA VERTICILLATA | 1 extirpated |
| VERBENA SIMPLEX | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |

| | |
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| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 2 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 2 extirpated |
| SENSITIVE SPECIES* | 4 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Upper Passaic, Whippany, Rockaway WMA

Thirteen species were recorded in the Upper Passaic, Whippany, Rockaway WMA (Table A6.1). Thirteen extant populations were found that were threatened mainly by roadways, roadway maintenance, woolly adelgid infestation, recreation, off-road vehicles, trails, mining, right of ways, invasive plants, and habitat disturbance. There were two population extirpations caused by development.

Table A6.1. Species populations in the Upper Passaic, Whippany, Rockaway WMA.

| SPECIES | POPULATIONS |
|------------------------|--------------------|
| ANDROMEDA GLAUCOPHYLLA | 1 extirpated |
| ASTER PRAEALTUS | 1 extant |
| CAREX LEPTONERVIA | 1 extant |
| CUSCUTA CEPHALANTHI | 1 extant |
| EQUISETUM VARIEGATUM | 1 extant |
| HOTTONIA INFLATA | 2 extant |
| ILEX MONTANA | 1 extant |
| LEDUM GROENLANDICUM | 1 extirpated |
| MELANTHIUM VIRGINICUM | 1 extant |
| POTAMOGETON ROBBINSII | 1 extant |
| SPARGANIUM MINIMUM | 2 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Elizabeth, Rahway, Woodbridge WMA

Eight species were recorded in the Elizabeth, Rahway, Woodbridge WMA (Table A7.1). One population of each of these species was found to have been extirpated, and there were no other records of endangered species populations in this WMA. Causes for extirpations included development, urbanization, roadway, road construction, and industry.

Table A7.1. Species populations in the Elizabeth, Rahway, Woodbridge WMA.

| SPECIES | POPULATIONS |
|-------------------------------------|--------------------|
| AGALINIS AURICULATA | 1 extirpated |
| CRATAEGUS CALPODENDRON | 1 extirpated |
| HELONIAS BULLATA | 1 extirpated |
| HOTTONIA INFLATA | 1 extirpated |
| LIATRIS SCARIOSA var. NOVAE-ANGLIAE | 1 extirpated |
| MONARDA CLINOPODIA | 1 extirpated |
| SANICULA TRIFOLIATA | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

North and South Branch Raritan WMA

Eleven species were recorded in this WMA (Table A8.1). There were 12 extant populations, which were threatened mainly by succession, development, invasive plants, and recreation. There were only two population extirpations caused by development and roadways.

Table A8.1. Species populations in the North and South Branch WMA.

| SPECIES | POPULATIONS |
|--------------------------|--------------|
| ASTER RADULA | 1 extant |
| CAREX POLYMORPHA | 2 extant |
| CAREX SICCATA | 1 extant |
| HELONIAS BULLATA | 2 extant |
| POTAMOGETON OBTUSIFOLIUS | 1 extant |
| SMILACINA TRIFOLIA | 1 extant |
| SENSITIVE SPECIES* | 2 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Lower Raritan, South River, Lawrence Brook WMA

There were nineteen species recorded in the Lower Raritan, South River, Lawrence Brook WMA (Table A9.1). There were 13 extant populations found and 12 population extirpations. Threats to extant populations included invasive plants, *Phragmites*, development, damming, water, hydrology, recreation, and trails. Development, urbanization and industry were the most common causes of extirpation.

Table A9.1. Species populations in the Lower Raritan, South River, Lawrence Brook WMA.

| SPECIES | POPULATIONS |
|---------------------------|------------------------|
| ASTER RADULA | 1 extant, 1 extirpated |
| BOUTELOUA CURTIPENDULA | 1 extant |
| CAREX POLYMORPHA | 3 extirpated |
| CERCIS CANADENSIS | 1 extant |
| HELONIAS BULLATA | 2 extant, 1 extirpated |
| HYDROCOTYLE RANUNCULOIDES | 1 extant |
| LATHYRUS OCHROLEUCUS | 1 extirpated |
| LUZULA ACUMINATA | 1 extant |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| MUHLENBERGIA CAPILLARIS | 1 extant |
| POLYGONUM GLAUCUM | 2 extirpated |
| SANICULA TRIFOLIATA | 1 extant |
| SCUTELLARIA LEONARDII | 1 extant |
| TRIOSTEUM ANGUSTIFOLIUM | 1 extant |
| ZIGADENUS LEIMANTHOIDES | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Millstone River WMA

There were five species recorded in Millstone River WMA, of which three populations were extant and two populations were extirpated (Table A10.1). Extant populations were threatened by roadway, roadway construction, succession, ditch construction, habitat disturbance, and right of ways. Causes of extirpations were uncertain.

Table A10.1. Species populations in the Millstone River WMA.

| SPECIES | POPULATIONS |
|-----------------------|--------------------|
| CACALIA SUAVEOLENS | 1 extirpated |
| CALYSTEZIA SPITHAMAEA | 1 extirpated |
| MYRIOPHYLLUM TENELLUM | 1 extant |
| SAGITTARIA AUSTRALIS | 1 extant |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Central Delaware Tributaries WMA

Twenty-one species were recorded in the Central Delaware Tributaries WMA (Table A11.1). There were 26 extant populations, and eight population extirpations. Causes of population extirpation varied and included agriculture, mining, quarry, recreation, development, urbanization, railroad, and succession. The most common threats to extant populations were succession, mining, quarry, and roadways.

Table A11.1. Species populations in the Central Delaware Tributaries WMA.

| SPECIES | POPULATIONS |
|-------------------------|------------------------|
| ASIMINA TRILOBA | 1 extant |
| ASTER PRAEALTUS | 1 extant |
| CAREX BUSHII | 2 extant |
| CERCIS CANADENSIS | 1 extant |
| CUSCUTA CEPHALANTHI | 3 extant |
| ELLISIA NYCTELEA | 2 extant, 1 extirpated |
| HYBANTHUS CONCOLOR | 3 extant |
| LATHYRUS VENOSUS | 1 extirpated |
| LIMOSELLA SUBULATA | 1 extirpated |
| MONARDA CLINOPODIA | 1 extant |
| ONOSMODIUM VIRGINIANUM | 1 extirpated |
| PENSTEMON LAEVIGATUS | 2 extant |
| PTELEA TRIFOLIATA | 1 extant |
| RIBES MISSOURIENSE | 1 extant |
| RUDBECKIA FULGIDA | 1 extant |
| ZIGADENUS LEIMANTHOIDES | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 2 extant, 1 extirpated |
| SENSITIVE SPECIES* | 1 extant, 1 extirpated |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 2 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Monmouth Watersheds WMA

There were 13 species recorded in the Monmouth Watersheds WMA (Table A12.1). Eighteen extant populations were found, and there were 14 population extirpations. Common threats to extant populations included right of ways, habitat disturbance, development, and pollution.

Table A12.1. Species populations in the Monmouth Watersheds WMA.

| SPECIES | POPULATIONS |
|-------------------------------------|------------------------|
| CALAMAGROSTIS PICKERINGII | 1 extant |
| DRABA REPTANS | 1 extirpated |
| GLAUX MARITIMA | 1 extirpated |
| HELONIAS BULLATA | 3 extant, 1 extirpated |
| JUNCUS CAESARIENSIS | 7 extant |
| LIATRIS SCARIOSA var. NOVAE-ANGLIAE | 1 extirpated |
| LIMOSELLA SUBULATA | 2 extant, 2 extirpated |
| MYRIOPHYLLUM TENELLUM | 1 extirpated |
| POLYGONUM GLAUCUM | 2 extant, 1 extirpated |
| RANUNCULUS CYMBALARIA | 3 extirpated |
| RHYNCHOSPORA KNIESKERNII | 3 extant |
| SCIRPUS MARITIMUS | 2 extirpated |
| VERBENA SIMPLEX | 1 extirpated |

Barnegat Bay Watersheds WMA

There were 20 species recorded in the Barnegat Bay Watersheds WMA (Table A13.1). Sixty-one extant populations were found, and there were 12 population extirpations. Development was the most commonly recorded cause of extirpation. Threats to extant populations included recreation, roadway, habitat disturbance, succession, and development.

Table A13.1. Species populations in the Barnegat Bay Watersheds WMA.

| SPECIES | POPULATIONS |
|--------------------------------------|-------------------------|
| AMARANTHUS PUMILUS | 1 extirpated |
| COREMA CONRADII | 2 extant |
| ELEOCHARIS TORTILIS | 1 extirpated |
| EUPATORIUM RESINOSUM | 4 extant |
| HEDYOTIS LONGIFOLIA | 1 extirpated |
| HELONIAS BULLATA | 23 extant, 1 extirpated |
| JUNCUS CAESARIENSIS | 4 extant |
| LIMOSELLA SUBULATA | 1 extirpated |
| LUDWIGIA BREVIPES | 1 extirpated |
| MYRIOPHYLLUM TENELLUM | 1 extant |
| NARTHECIUM AMERICANUM | 9 extant, 2 extirpated |
| PLANTAGO PUSILLA | 1 extirpated |
| POLYGONUM GLAUCUM | 1 extant |
| RHYNCHOSPORA KNIESKERNII | 12 extant |
| SCIRPUS LONGII | 1 extant |
| SCIRPUS MARITIMUS | 2 extirpated |
| STYLISMA PICKERINGII VAR PICKERINGII | 2 extant |
| UTRICULARIA BIFLORA | 1 extant |
| ZIGADENUS LEIMANTHOIDES | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Mullica, Wading River WMA

There were 34 species recorded in Mullica, Wading River WMA (Table A14.1). There were 137 extant populations with a wide variety of threats.

Twenty-six populations were extirpated. Major causes of population extirpation included development, urbanization, succession, agriculture, roadways, and recreation.

Table A14.1. Species populations in the Mullica, Wading River WMA.

| SPECIES | POPULATIONS |
|---------------------------------------|-------------------------|
| AESCHYNOMENE VIRGINICA | 1 extant |
| CALAMAGROSTIS PICKERINGII | 4 extant |
| CLITORIA MARIANA | 1 extirpated |
| CYPERUS POLYSTACHYOS | 1 extant |
| ELEOCHARIS EQUISETOIDES | 1 extant |
| ERYNGIUM YUCCIFOLIUM | 1 extirpated |
| EUPATORIUM RESINOSUM | 7 extant |
| HELONIAS BULLATA | 3 extant, 3 extirpated |
| HIERACIUM KALMII | 1 extirpated |
| JUNCUS CAESARIENSIS | 24 extant |
| KUHNIA EUPATORIOIDES | 2 extirpated |
| LINUM INTERCURSUM | 1 extant |
| LOBELIA BOYKINII | 3 extant |
| MUHLENBERGIA CAPILLARIS | 1 extirpated |
| NARTHECIUM AMERICANUM | 34 extant, 7 extirpated |
| RHEXIA ARISTOSA | 1 extant |
| RHODODENDRON ATLANTICUM | 1 extant |
| RHYNCHOSPORA KNIESKERNII | 16 extant |
| RHYNCHOSPORA MICROCEPHALA | 1 extant |
| SAGITTARIA TERES | 3 extant |
| SCIRPUS LONGII | 9 extant |
| STYLISMA PICKERINGII var. PICKERINGII | 6 extant, 4 extirpated |
| TOFIELDIA RACEMOSA | 5 extant |
| UTRICULARIA RESUPINATA | 2 extant |
| VERBENA SIMPLEX | 1 extirpated |
| XYRIS CAROLINIANA | 3 extant |

| | |
|--------------------|------------------------|
| XYRIS FIMBRIATA | 2 extant, 1 extirpated |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 3 extant, 1 extirpated |
| SENSITIVE SPECIES* | 3 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Great Egg Harbor, Tuckahoe WMA

There were 24 species recorded in the Great Egg Harbor, Tuckahoe WMA (Table A15.1). There were 44 extant populations found, and these populations were threatened mainly by habitat disturbance, land clearing, development, right of ways, mining, and roadways. The seven population extirpations in this WMA were caused primarily by development, erosion, roadways, roadway maintenance, damming, and urbanization.

Table A15.1. Species populations in the Great Egg Harbor, Tuckahoe WMA.

| SPECIES | POPULATIONS |
|---------------------------|------------------------|
| AMMANNIA LATIFOLIA | 2 extant |
| CHENOPODIUM RUBRUM | 1 extant |
| COELORACHIS RUGOSA | 1 extant |
| COREMA CONRADII | 1 extant |
| CYPERUS SCHWEINITZII | 1 extant |
| EUPATORIUM CAPILLIFOLIUM | 1 extant, 1 extirpated |
| EUPATORIUM RESINOSUM | 11 extant |
| HELONIAS BULLATA | 3 extant |
| JUNCUS CAESARIENSIS | 2 extant |
| LINUM INTERCURSUM | 1 extant |
| OENOTHERA HUMIFUSA | 2 extant |
| POLYGONUM GLAUCUM | 1 extirpated |
| RANUNCULUS CYMBALARIA | 1 extirpated |
| RHEXIA ARISTOSA | 1 extant |
| RHYNCHOSPORA KNIESKERNII | 8 extant, 1 extirpated |
| RHYNCHOSPORA MICROCEPHALA | 3 extant |
| RUMEX HASTATULUS | 1 extirpated |
| SAGITTARIA TERES | 2 extant |
| SCHEUCHZERIA PALUSTRIS | 1 extirpated |
| SCIRPUS LONGII | 1 extant |
| UTRICULARIA RESUPINATA | 1 extant |
| VERBENA SIMPLEX | 1 extant |
| VULPIA ELLIOTEA | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Cape May Watersheds WMA

Forty-seven species were recorded in the Cape May Watersheds WMA (Table A16.1). There were 64 extant populations, which were most commonly threatened by succession, habitat disturbance, recreation, and mining. Thirty population extirpations were mainly caused by development and canal construction.

Table A16.1. Species populations in the Cape May Watersheds WMA.

| SPECIES | POPULATIONS |
|---|------------------------|
| AESCHYNOMENE VIRGINICA | 1 extirpated |
| BOLTONIA ASTEROIDES var. GLASTIFOLIA | 2 extant |
| CLITORIA MARIANA | 1 extant |
| COELORACHIS RUGOSA | 1 extant |
| CYPERUS POLYSTACHYOS | 1 extant |
| DIODIA VIRGINIANA | 2 extant, 1 extirpated |
| ELEOCHARIS BRITTONII | 1 extant |
| ELEOCHARIS MELANOCARPA | 1 extant, 1 extirpated |
| ELEOCHARIS TORTILIS | 1 extant, 1 extirpated |
| EUPATORIUM CAPILLIFOLIUM | 4 extant |
| FRAXINUS PROFUNDA | 1 extant |
| GALIUM HISPIDULUM | 2 extant, 1 extirpated |
| GYMNOPOGON BREVIFOLIUS | 1 extant, 1 extirpated |
| HELONIAS BULLATA | 11 extant |
| HOTTONIA INFLATA | 2 extant |
| HYPERICUM ADPRESSUM | 3 extant, 2 extirpated |
| ISOETES MELANOPODA | 1 extirpated |
| JUNCUS BRACHYCARPUS | 4 extirpated |
| JUNCUS CORIACEUS | 4 extant, 2 extirpated |
| OENOTHERA HUMIFUSA | 1 extant |
| OPHIOGLOSSUM VULGATUM var.PYCNOSTICHUM | 1 extirpated |
| PANICUM ACICULARE | 1 extant, 1 extirpated |
| PHYLA LANCEOLATA | 1 extirpated |
| POLYGALA RAMOSA | 1 extirpated |
| POLYGONUM DENSIFLORUM | 1 extant |
| PRUNUS ANGUSTIFOLIA | 1 extant |
| RHEXIA INTERIOR | 5 extant |

| | |
|-------------------------|------------------------|
| RHODODENDRON ATLANTICUM | 1 extant |
| RHYNCHOSPORA FILIFOLIA | 1 extant |
| RHYNCHOSPORA GLOBULARIS | 1 extant, 1 extirpated |
| RUELLIA CAROLINIENSIS | 1 extirpated |
| SACCIOLEPIS STRIATA | 1 extant |
| SCLERIA VERTICILLATA | 1 extirpated |
| TRIADENUM WALTERI | 4 extant |
| VALERIANELLA RADIATA | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant, 2 extirpated |
| SENSITIVE SPECIES* | 1 extant, 2 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Maurice, Salem, Cohansey WMA

There were 13 species recorded in the Maurice, Salem, Cohansey WMA (Table A17.1). Thirty-eight extant populations were found, which were mainly threatened by habitat disturbance, roadways, roadway maintenance, pollution, dumping, water, right of ways, and invasive plants. Five populations were extirpated in this county, and causes of extirpation were varied.

Table A17.1. Species populations in the Maurice, Salem, Cohansey WMA.

| SPECIES | POPULATIONS |
|--------------------------|-------------------------|
| AESCHYNOMENE VIRGINICA | 1 extant, 1 extirpated |
| CLITORIA MARIANA | 1 extant |
| ELEOCHARIS EQUISETOIDES | 1 extirpated |
| ELEOCHARIS MELANOCARPA | 1 extant |
| EUPATORIUM CAPILLIFOLIUM | 1 extant |
| EUPATORIUM RESINOSUM | 4 extant |
| GENTIANA VILLOSA | 1 extirpated |
| HELONIAS BULLATA | 24 extant, 2 extirpated |
| HYPERICUM ADPRESSUM | 2 extant |
| JUNCUS CAESARIENSIS | 1 extant |
| ONOSMODIUM VIRGINIANUM | 1 extant |
| QUERCUS NIGRA | 1 extant |
| RHODODENDRON ATLANTICUM | 1 extant |

Lower Delaware Tributaries WMA

Thirty-seven species were recorded in the Lower Delaware Tributaries WMA (Table A18.1). There were 41 extant populations found and 29 population extirpations. Common threats to extant populations included agriculture, habitat disturbance, invasive plants, recreation, and development. Development and urbanization were the most common causes of extirpation.

Table A18.1. Species populations in the Lower Delaware Tributaries WMA.

| SPECIES | POPULATIONS |
|---------------------------|-------------------------|
| AESCHYNOMENE VIRGINICA | 1 extirpated |
| ASIMINA TRILOBA | 1 extant |
| ASTER RADULA | 1 extirpated |
| BIDENS BIDENTOIDES | 1 extirpated |
| BOUPELLOUA CURTIPENDULA | 1 extirpated |
| CAREX LIMOSA | 1 extirpated |
| CAREX POLYMORPHA | 1 extirpated |
| CASTANEA PUMILA | 2 extant |
| CERCIS CANADENSIS | 1 extirpated |
| CHENOPODIUM RUBRUM | 1 extirpated |
| DIODIA VIRGINIANA | 1 extirpated |
| DRABA REPTANS | 1 extirpated |
| ELEOCHARIS EQUISETOIDES | 1 extirpated |
| ERIOPHORUM GRACILE | 1 extirpated |
| HELONIAS BULLATA | 24 extant, 2 extirpated |
| HEMICARPHA MICRANTHA | 1 extirpated |
| HOTTONIA INFLATA | 1 extant |
| HYDROCOTYLE RANUNCULOIDES | 1 extant |
| KUHNIA EUPATORIOIDES | 1 extirpated |
| LUZULA ACUMINATA | 3 extant |
| LYTHRUM HYSSOPIFOLIA | 1 extirpated |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| NELUMBO LUTEA | 1 extant, 2 extirpated |
| ONOSMODIUM VIRGINIANUM | 3 extirpated |
| POLEMONIUM REPTANS | 2 extant |
| PRUNUS ANGUSTIFOLIA | 1 extant |

| | |
|-----------------------------|--------------|
| PYCNANTHEMUM CLINOPODIOIDES | 1 extirpated |
| QUERCUS LYRATA | 1 extant |
| SCHEUCHZERIA PALUSTRIS | 1 extirpated |
| SCIRPUS MARITIMUS | 1 extirpated |
| VERNONIA GLAUCA | 1 extant |
| WOLFFIELLA FLORIDANA | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Rancocas Creek WMA

Twenty-eight species were recorded in the Rancocas Creek WMA (Table A19.1). There were 30 extant populations found. These populations were commonly threatened by pollution, habitat disturbance, invasive plants, succession, roadways, roadway maintenance, land clearing, recreation, trails, and dumping. There were 32 population extirpations, and development, urbanization, and industry were the most common causes of population extirpation.

* *Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.*

Table A19.1. Species populations in the Rancocas Creek WMA.

| SPECIES | POPULATIONS |
|--------------------------|------------------------|
| ARISTIDA LANOSA | 1 extirpated |
| BIDENS BIDENTOIDES | 2 extant |
| BUCHNERA AMERICANA | 1 extirpated |
| CACALIA MUEHLENBERGII | 1 extirpated |
| CYPERUS RETROFRACTUS | 3 extirpated |
| DRABA REPTANS | 3 extirpated |
| EUPATORIUM RESINOSUM | 2 extant |
| HELONIAS BULLATA | 18 extant |
| HEMICARPHA MICRANTHA | 1 extirpated |
| HYPERICUM ADPRESSUM | 1 extant |
| JUNCUS CAESARIENSIS | 1 extant, 2 extirpated |
| KUHNIA EUPATORIOIDES | 3 extirpated |
| LIMOSELLA SUBULATA | 1 extirpated |
| MELANTHIUM VIRGINICUM | 2 extirpated |
| MYRIOPHYLLUM TENELLUM | 1 extirpated |
| NARTHECIUM AMERICANUM | 1 extirpated |
| NUPHAR MICROPHYLLUM | 1 extirpated |
| ONOSMODIUM VIRGINIANUM | 2 extirpated |
| PLANTAGO PUSILLA | 1 extirpated |
| POLYGALA INCARNATA | 2 extirpated |
| RHYNCHOSPORA GLOBULARIS | 2 extirpated |
| RHYNCHOSPORA KNIESKERNII | 1 extant |

| | |
|---------------------------------------|------------------------|
| STELLARIA PUBERA | 1 extirpated |
| STYLISMA PICKERINGII var. PICKERINGII | 3 extant |
| UVULARIA PUBERULA var. NITIDA | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant, 1 extirpated |

Crosswicks Creek WMA

There were 14 species recorded in the Crosswicks Creek WMA (Table A20.1). There were ten extant populations found, which were threatened mainly by recreation and development. The seven population extirpations in this WMA were caused by development and urbanization.

Table A20.1. Species populations in the Crosswicks Creek WMA.

| SPECIES | POPULATIONS |
|------------------------|--------------------|
| BIDENS BIDENTOIDES | 2 extant |
| CACALIA ATRIPLICIFOLIA | 1 extant |
| CALYSTEGIA SPITHAMAEA | 1 extirpated |
| ERIOPHORUM GRACILE | 1 extirpated |
| FRAXINUS PROFUNDA | 2 extant |
| HELONIAS BULLATA | 2 extant |
| HYPERICUM ADPRESSUM | 1 extirpated |
| JUNCUS CAESARIENSIS | 1 extant |
| LUZULA ACUMINATA | 1 extant |
| NELUMBO LUTEA | 1 extirpated |
| POLEMONIUM REPTANS | 1 extirpated |
| SAGITTARIA AUSTRALIS | 1 extant |
| VALERIANELLA RADIATA | 1 extirpated |
| VERBENA SIMPLEX | 1 extirpated |

Appendix B: County Summaries

| | |
|--------------------------------|-----|
| Atlantic County | 2 |
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| Burlington County | 14 |
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| Salem County | 90 |
| Somerset County | 95 |
| Sussex County | 100 |
| Union County | 108 |
| Warren County | 112 |

Atlantic County

There were 30 extant and extirpated species, including 62 extant populations and nine extirpated populations (Table B1.1). The majority (45%) were found in wetland areas (Table B1.2, Figure B1.1). The most common cause of extirpation in this county was development. Common threats to extant populations included habitat disturbance, land clearing, and herbivory.

Portions of the Mullica, Wading River WMA, Maurice, Salem, Cohansey WMA, and the Great Egg Harbor, Tuckahoe WMA are found within Atlantic County. A large number of population extirpations occurred along the border of the Mullica, Wading River WMA and the Great Egg Harbor, Tuckahoe WMA (Figure B1.2). This border was underlain by the Cohansey sand geologic formation.

Soils of Atlantic County include six types of sand, five types of sandy loam, two types of loamy sand, and muck (Figure B1.3). The majority of the county was sandy loam, and the majority of population extirpations occurred on this soil type.

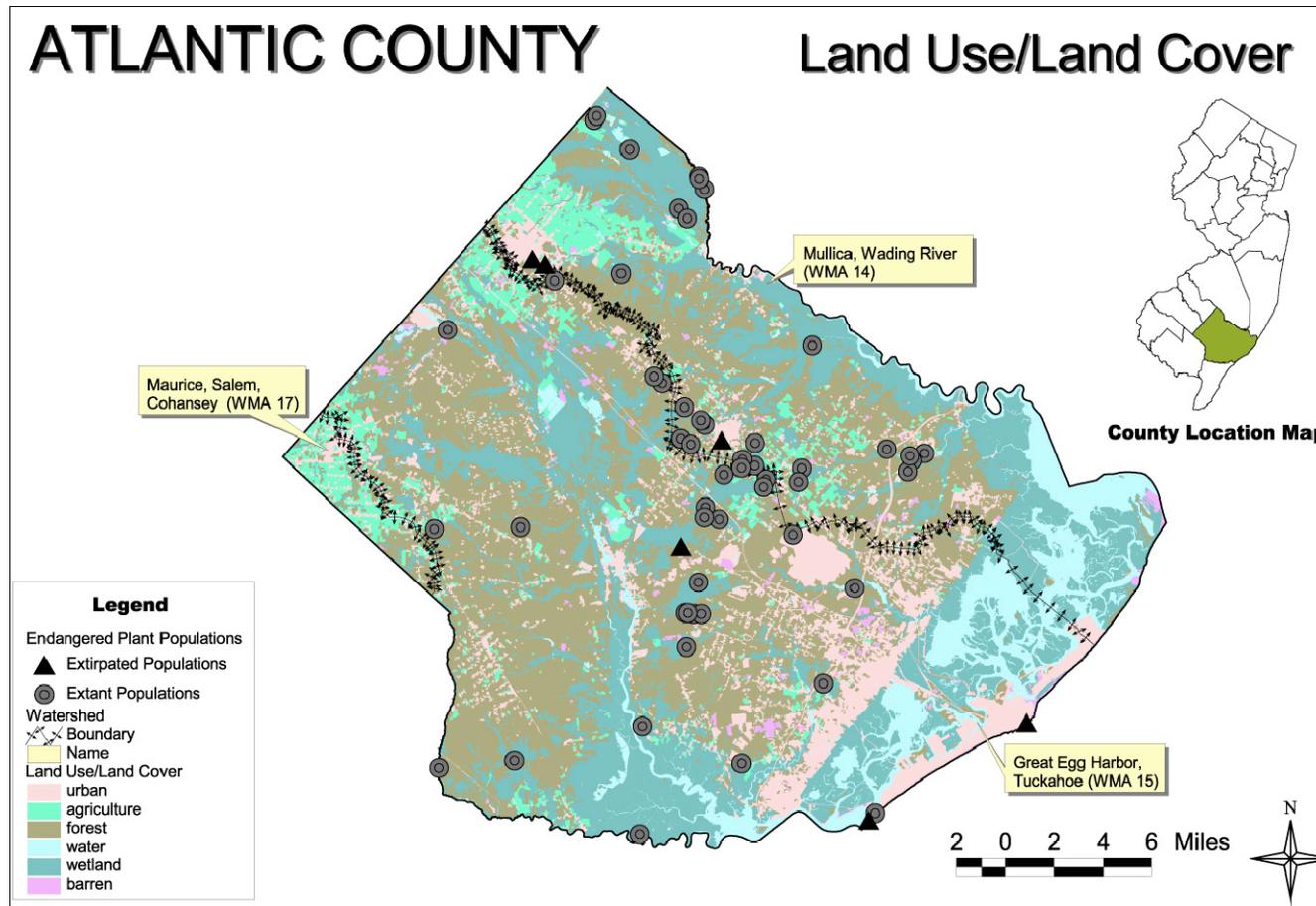
Table B1.1. Plant species populations in Atlantic County.

| SPECIES | POPULATIONS |
|---------------------------|-------------------------|
| CHENOPODIUM RUBRUM | 1 extant |
| CLITORIA MARIANA | 1 extirpated |
| COELORACHIS RUGOSA | 1 extant |
| COREMA CONRADII | 1 extant |
| CYPERUS POLYSTACHYOS | 1 extant |
| CYPERUS SCHWEINITZII | 1 extant |
| ELEOCHARIS EQUISETOIDES | 1 extant |
| EUPATORIUM RESINOSUM | 8 extant |
| HELONIAS BULLATA | 2 extant |
| HIERACIUM KALMII | 1 extirpated |
| JUNCUS CAESARIENSIS | 5 extant |
| KUHNIA EUPATORIODES | 1 extirpated |
| LOBELIA BOYKINII | 3 extant |
| MUHLENBERGIA CAPILLARIS | 1 extirpated |
| NARTHECIUM AMERICANUM | 6 extant |
| OENOTHERA HUMIFUSA | 1 extant |
| POLYGONUM GLAUCUM | 1 extirpated |
| RANUNCULUS CYMBALARIA | 1 extirpated |
| RHEXIA ARISTOSA | 1 extant |
| RHYNCHOSPORA KNIESKERNII | 14 extant, 1 extirpated |
| RHYNCHOSPORA MICROCEPHALA | 4 extant |
| RUMEX HASTATULUS | 1 extirpated |
| SAGITTARIA TERES | 4 extant |
| SCIRPUS LONGII | 3 extant |
| VERBENA SIMPLEX | 1 extant |
| VULPIA ELLIOTEA | 1 extirpated |
| XYRIS CAROLINIANA | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |

Table B1.2. Extant plant populations in Atlantic County by land use.

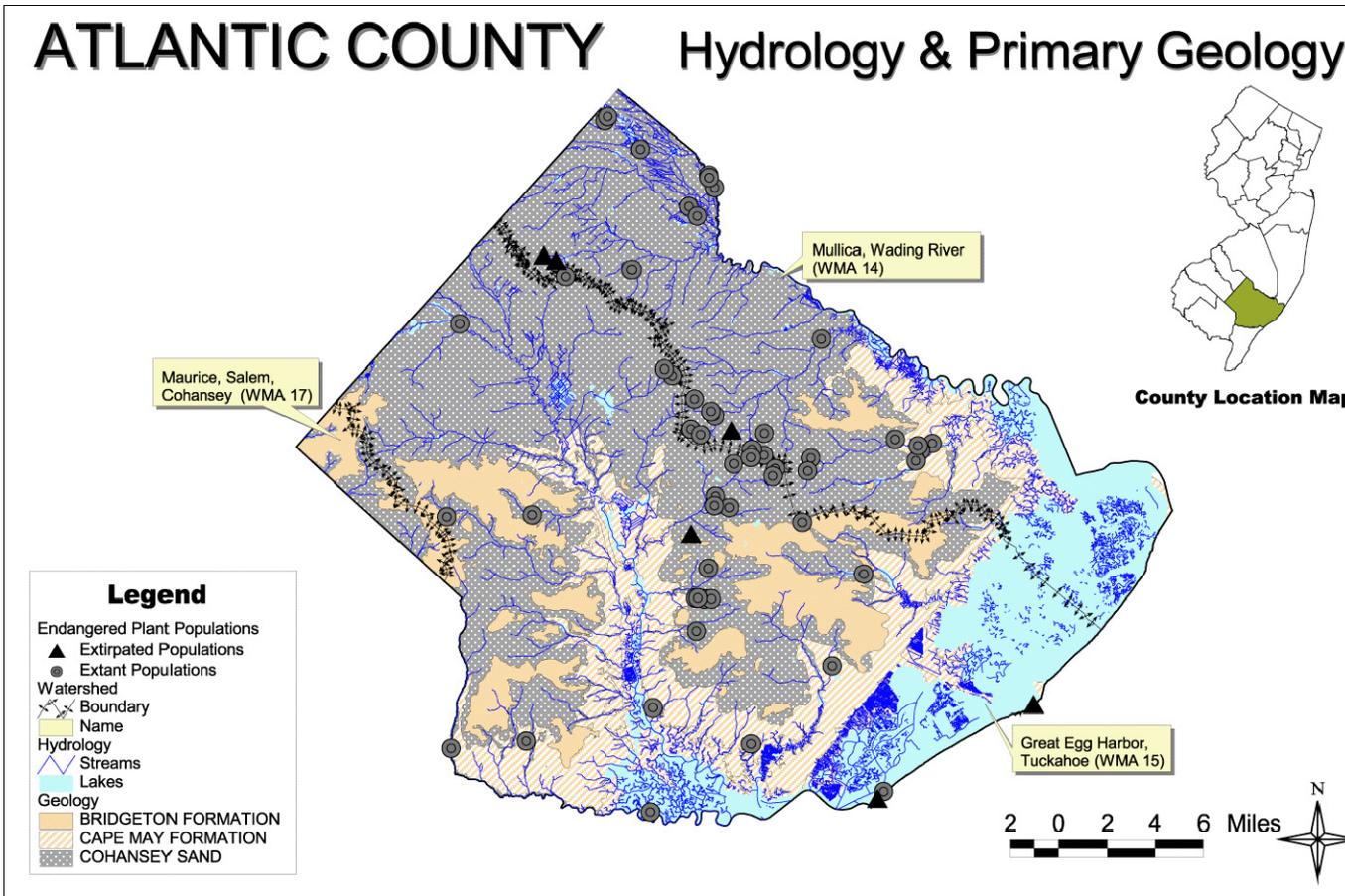
| ATLANTIC COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 3 |
| Agriculture | 2 |
| Forest | 16 |
| Water | 11 |
| Wetlands | 28 |
| Barren | 1 |
| Undetermined | 1 |
| Total number of populations | 62 |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.



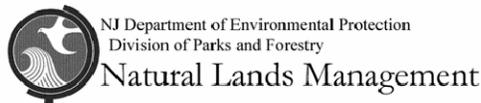
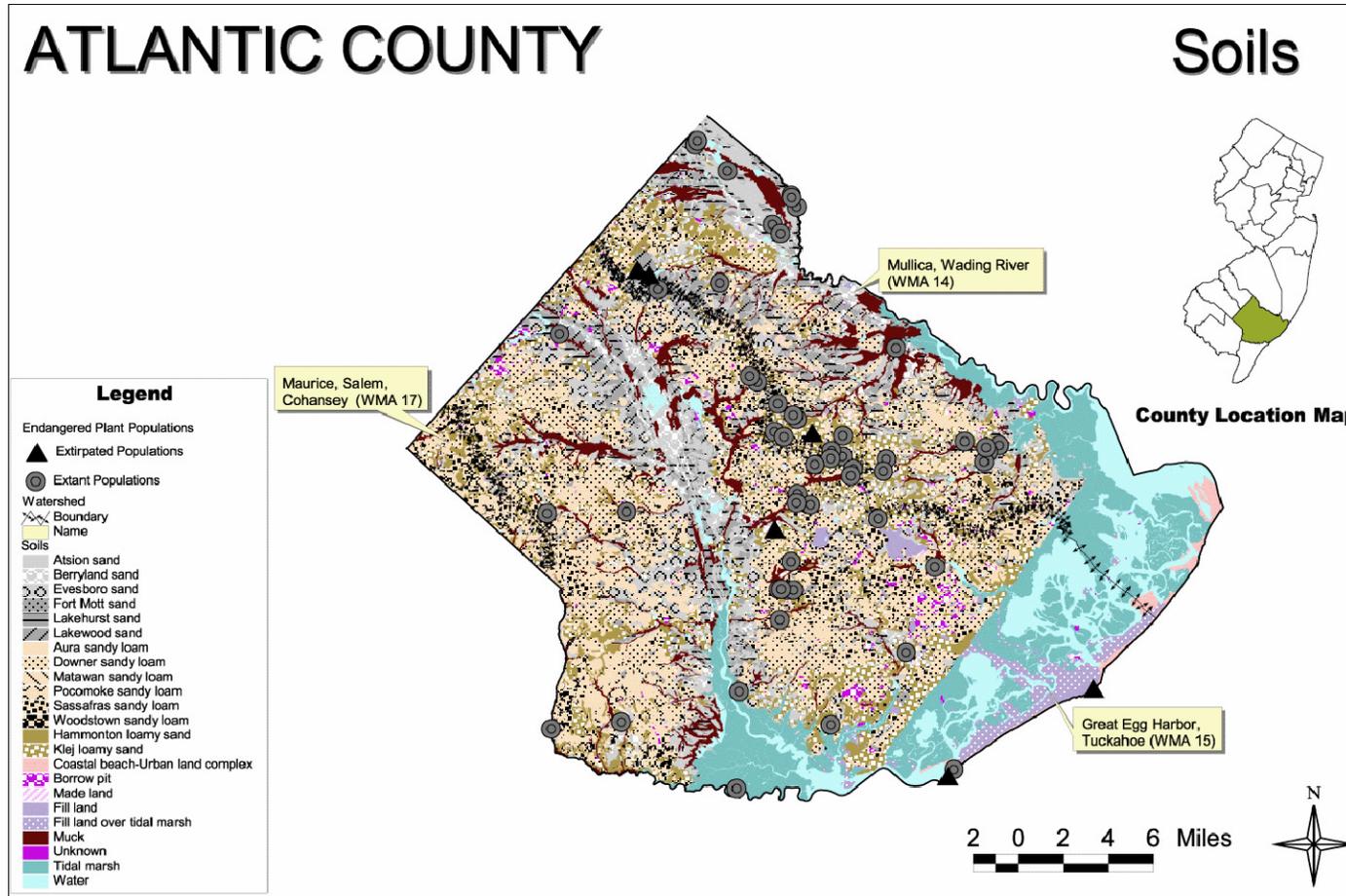
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B1.1. Extant and extirpated plant populations by land use/land cover in Atlantic County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B1.2. Extant and extirpated plant populations by hydrology and primary geology in Atlantic County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B1.3. Extant and extirpated plant populations by soil type in Atlantic County.

Bergen County

There were 28 extant and extirpated species in Bergen County, including three extant populations and 38 extirpated populations. Extant populations were found on forested, water-covered, and urban land (Table B2.2, Figure B2.1). Threats to extant populations included development, succession, roadway construction, habitat disturbance, recreation, and mining. Major causes of extirpation included development and urbanization.

Portions of the Pompton, Pequannock, Wanaque, Ramapo WMA, the Lower Passaic, Saddle WMA, and the Hackensack, Pascack WMA are found within Bergen County (Figure B2.2). The majority of population extirpations in Bergen County occurred in areas underlain by the Brunswick geologic formation.

Although there are numerous soil types found in Bergen County, the majority of the county is urban land/complexes, and the majority of population extirpations occurred in these areas (Figure B2.3).

Table B2.1. Species plant populations in Bergen County.

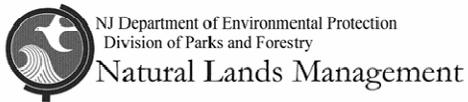
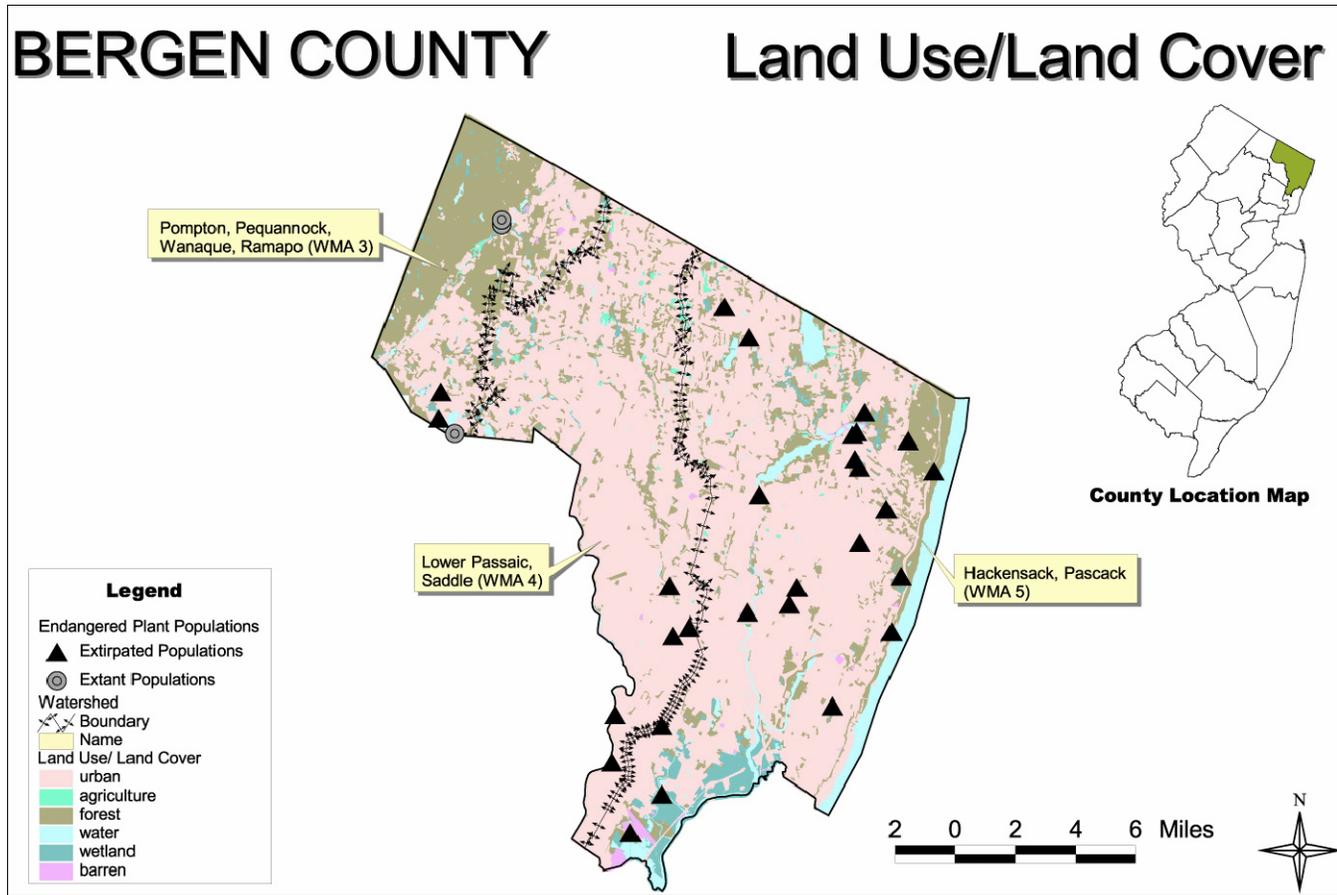
| SPECIES | POPULATIONS |
|------------------------|--------------------|
| AMMANNIA LATIFOLIA | 1 extirpated |
| BOUTELOUA CURTIPENDULA | 1 extirpated |
| CERCIS CANADENSIS | 1 extirpated |
| DRYOPTERIS CELSA | 2 extirpated |
| ERIOPHORUM GRACILE | 1 extirpated |
| HEMICARPHA MICRANTHA | 1 extant |
| HYPERICUM ADPRESSUM | 2 extirpated |
| HYPERICUM MAJUS | 1 extirpated |
| LEMNA VALDIVIANA | 1 extirpated |
| LUZULA ACUMINATA | 1 extirpated |
| MELANTHIUM VIRGINICUM | 2 extirpated |
| NUPHAR MICROPHYLLUM | 1 extirpated |
| PLATANThERA HYPERBOREA | 1 extirpated |
| PRENANTHES RACEMOSA | 2 extirpated |
| PYCNANTHEMUM TORREI | 1 extant |
| SCHOENOPECTUS TORREYI | 1 extirpated |
| SCIRPUS MARITIMUS | 1 extirpated |
| SCLERIA VERTICILLATA | 1 extirpated |
| SCUTELLARIA LEONARDII | 1 extant |
| VERBENA SIMPLEX | 2 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 2 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 2 extirpated |
| SENSITIVE SPECIES* | 7 extirpated |

Table B2.2. Extant plant populations in Bergen County by land use.

| BERGEN COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-------------------------------|-------------------------------------|
|-------------------------------|-------------------------------------|

| | |
|-----------------------------|---|
| Urban | 1 |
| Agriculture | 0 |
| Forest | 1 |
| Water | 1 |
| Wetlands | 0 |
| Barren | 0 |
| Total number of populations | 3 |

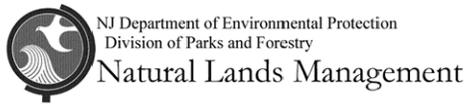
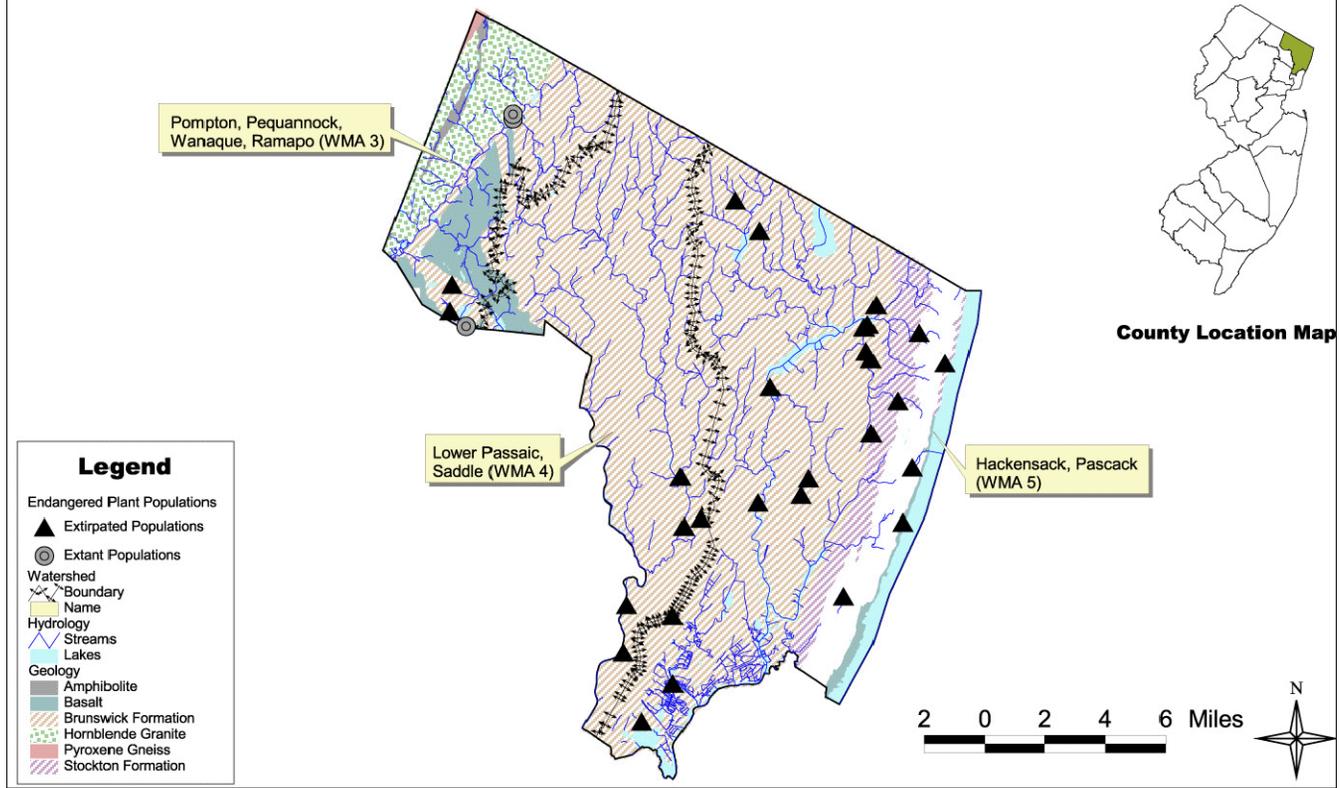
* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B2.1. Extant and extirpated plant populations by land use/land cover in Bergen County.

BERGEN COUNTY Hydrology & Primary Geology



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B2.2. Extant and extirpated plant populations by hydrology and primary geology in Bergen County.

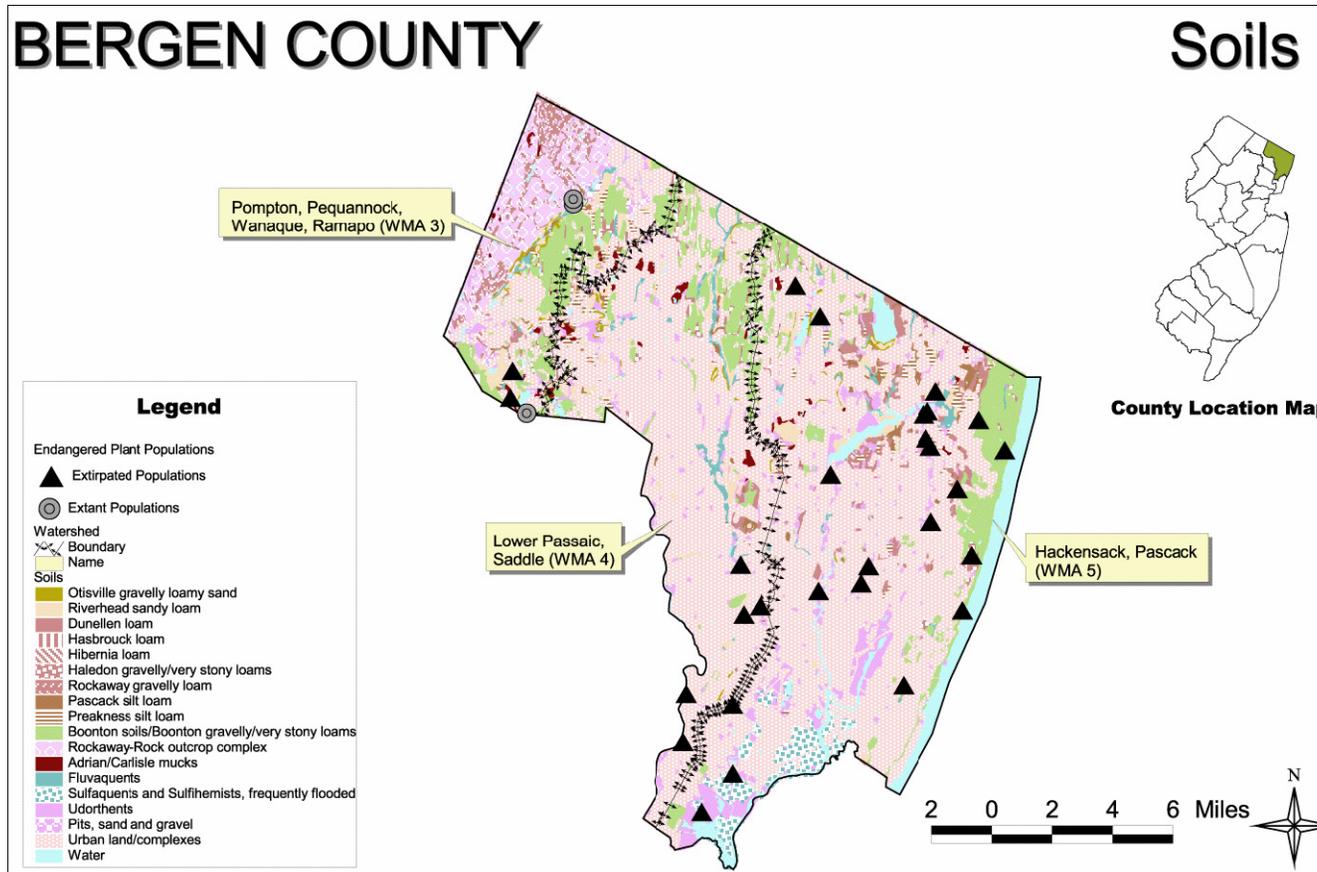


Figure B2.3. Extirpated and extant plant populations by soil type in Bergen County.

Burlington County

There were 31 extant and extirpated species in Burlington County, including 110 extant populations and 28 extirpated populations (Table B3.1). Extant populations were found mainly in forested and wetland areas (Table B3.2, Figure B3.1). Common threats to extant populations were overcollection, succession, agriculture, roadways, and recreation. Major causes of extirpation included development, urbanization, agriculture, cranberry bogs, and recreation.

Portions of the Crosswicks Creek, Rancocas Creek, Barnegat Bay, and Mullica, Wading River WMA's are found within Burlington County (Figure B3.2). The majority of extant and extirpated populations in this county are found in the Mullica, Wading River WMA, which is underlain by the Cohansey Sand geologic formation.

Soil types in Burlington County include ten sand types, 12 sandy loams, seven loams, one loamy sand, and marsh/muck (Figure B3.3). There were no clear patterns of plant population occurrence by soil type.

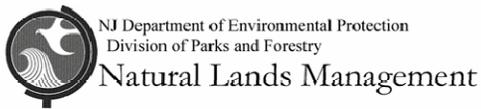
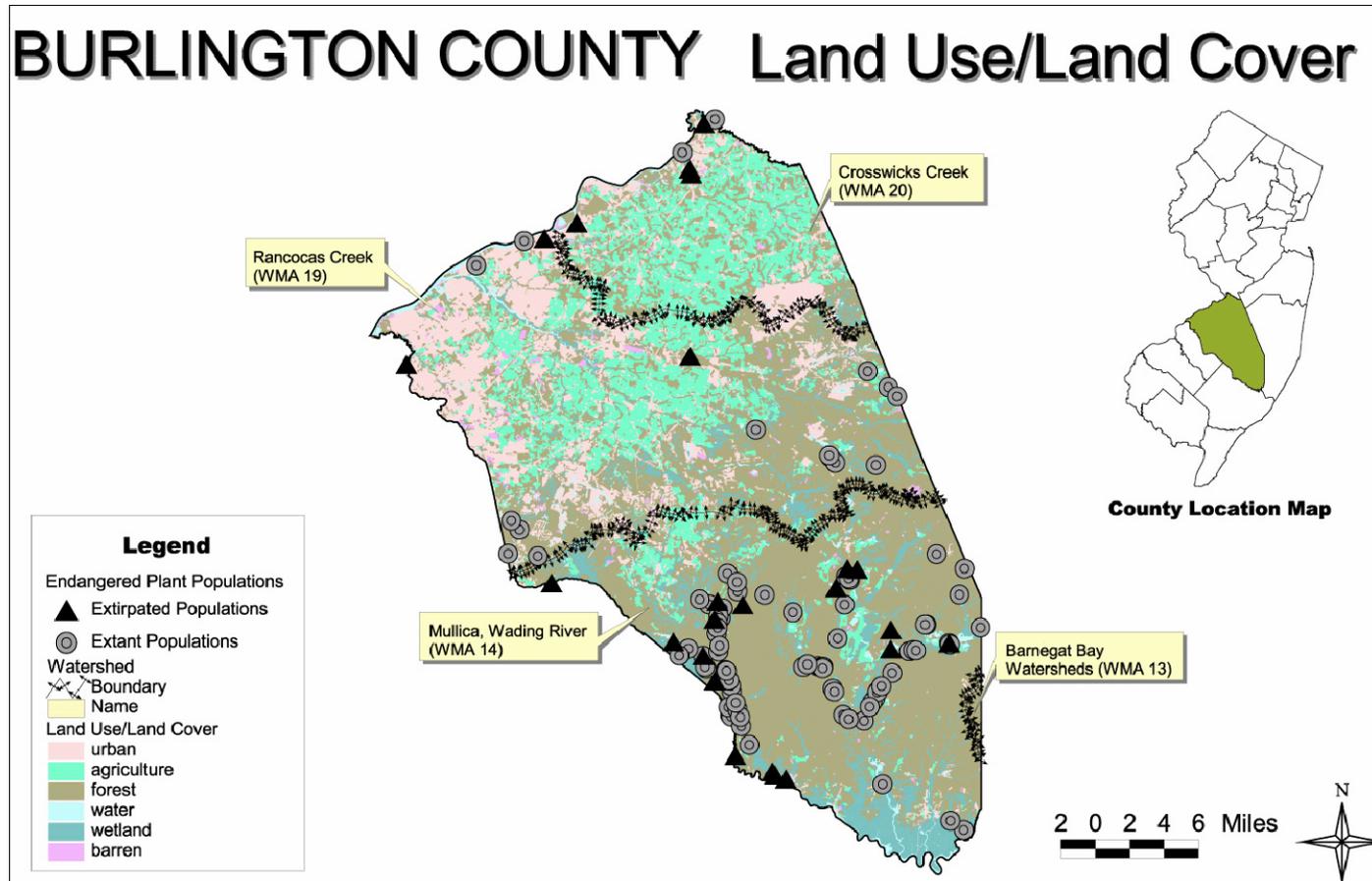
Table B3.1. Plant species populations in Bergen County.

| SPECIES | POPULATIONS |
|--|-------------------------|
| AESCHYNOMENE VIRGINICA | 1 extant |
| BIDENS BIDENTOIDES | 2 extant |
| BUCHNERA AMERICANA | 1 extirpated |
| CACALIA ATRIPLICIFOLIA | 1 extant |
| CALAMAGROSTIS PICKERINGII | 4 extant |
| DRABA REPTANS | 1 extirpated |
| EUPATORIUM RESINOSUM | 3 extant |
| HELONIAS BULLATA | 8 extant, 1 extirpated |
| HYPERICUM ADPRESSUM | 1 extant, 1 extirpated |
| JUNCUS CAESARIENSIS | 21 extant |
| KUHNIA EUPATORIODES | 2 extirpated |
| LINUM INTERCURSUM | 1 extant |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| NARTHECIUM AMERICANUM | 28 extant, 7 extirpated |
| NELUMBO LUTEA | 1 extirpated |
| NUPHAR MICROPHYLLUM | 1 extirpated |
| POLEMONIUM REPTANS | 1 extirpated |
| RHYNCHOSPORA KNIESKERNII | 8 extant |
| SCIRPUS LONGII | 5 extant |
| STYLISMA PICKERINGII var. PICKERINGII | 7 extant, 4 extirpated |
| TOFIELDIA RACEMOSA | 5 extant |
| UTRICULARIA RESUPINATA | 2 extant |
| UVULARIA PUBERULA var. NITIDA | 1 extant |
| VALERIANELLA RADIATA | 1 extirpated |
| XYRIS CAROLINIANA | 2 extant |
| XYRIS FIMBRIATA | 2 extant, 1 extirpated |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 3 extant, 1 extirpated |
| SENSITIVE SPECIES* | 1 extant, 4 extirpated |
| SENSITIVE SPECIES* | 1 extant |

* *Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.*

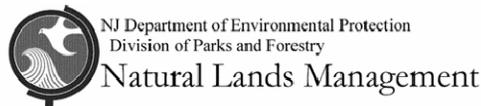
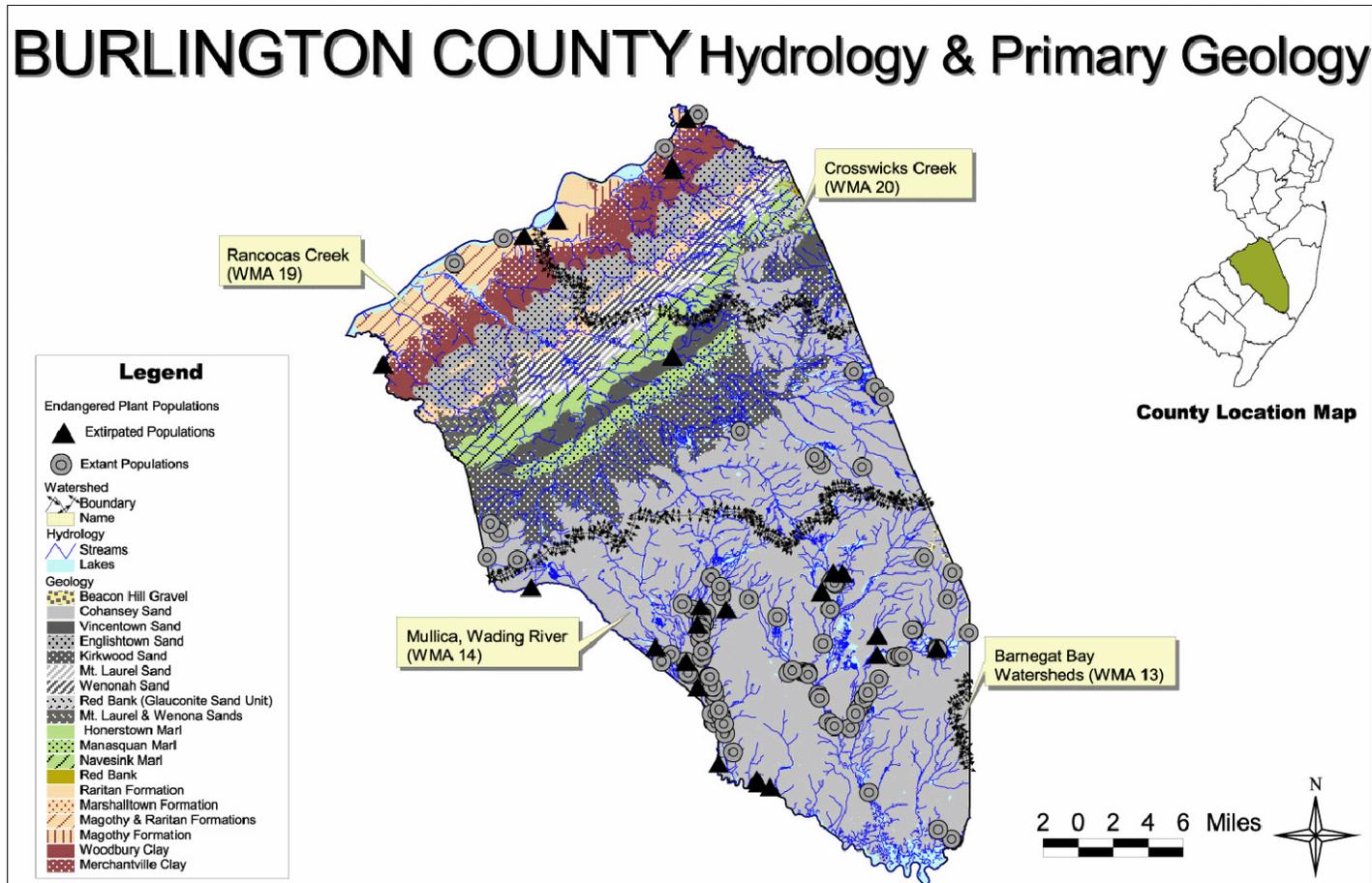
Table B3.2. Extant plant populations in Burlington County by land use.

| BURLINGTON COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------------|-------------------------------------|
| Urban | 1 |
| Agriculture | 0 |
| Forest | 63 |
| Water | 2 |
| Wetlands | 42 |
| Barren | 1 |
| Undetermined | 1 |
| Total number of populations | 110 |



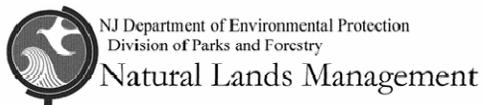
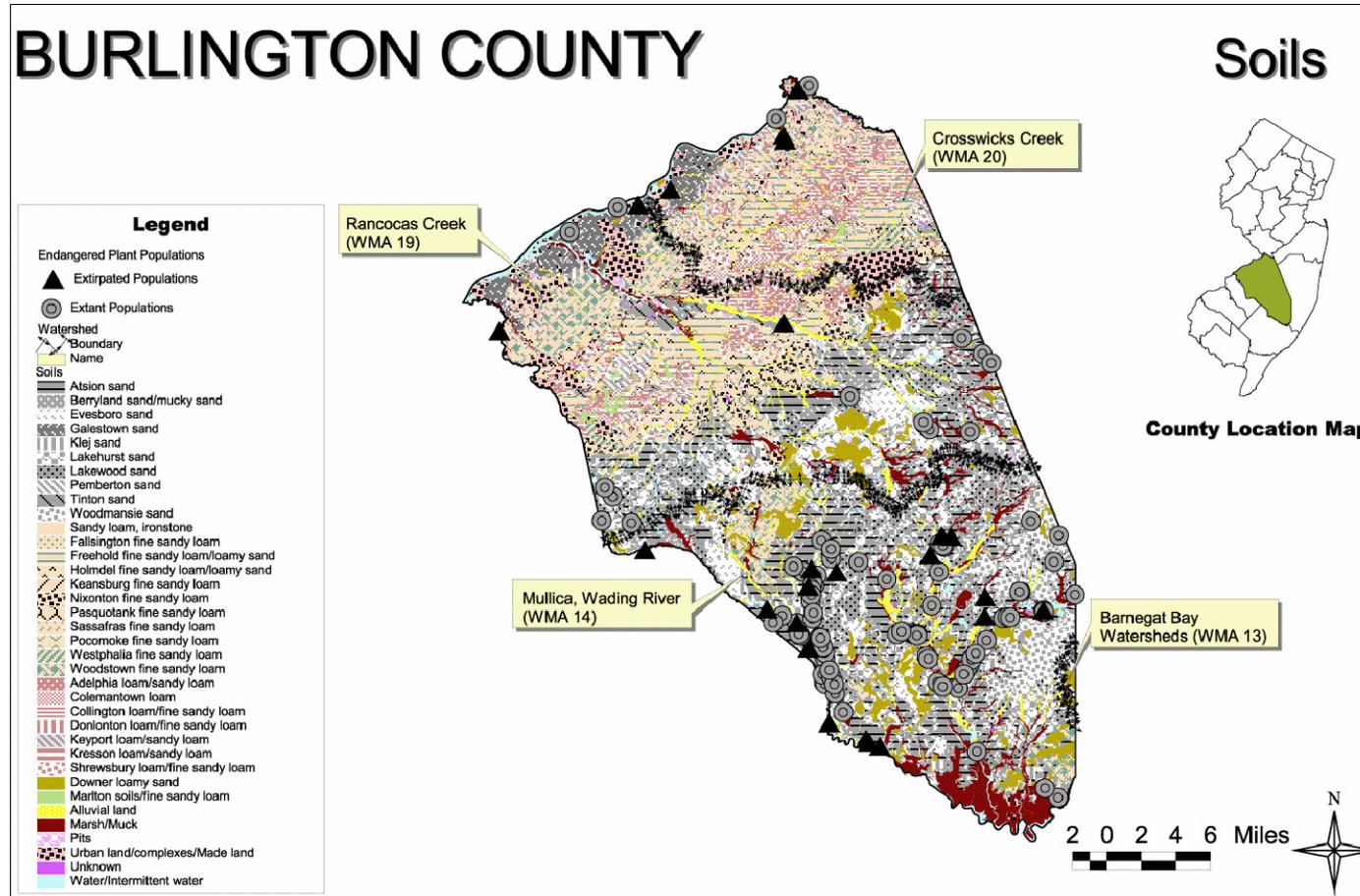
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B3.1. Extant and extirpated plant populations by land use/land cover in Burlington County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B3.2. Extant and extirpated plant populations by hydrology and primary geology in Burlington County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B3.3. Extant and extirpated plant populations by soil type in Burlington County.

There were 38 extant and extirpated species in Camden County, including 35 extant populations and 49 extirpated populations (Table B4.1). The majority of extant populations were found in forested and wetland areas (Table B4.2, Figure B4.1). The most common causes of extirpation were development and urbanization.

Portions of the Rancocas Creek WMA, Lower Delaware Tributaries WMA, Great Egg Harbor, Tuckahoe WMA, and Mullica, Wading River WMA are found within Camden County (Figure B4.2). It can be seen in Figure 21 that the majority of extant population in Camden County are found in an area underlain by the Cohansey Sand geologic formation, which extends into all four of the WMA's in the county.

Soil types found in Camden County include five types of sand, six loamy sands, one loam, and eight sandy loams (Figure B4.3). Other land types include muck/moderately wet land, alluvial land, and urban land complexes/made land. Though there is no pattern in extant population occurrence, the majority of extirpations occurred on the urban land complexes/made land of Camden County.

Endangered Plant Species Populations

Table B4.1. Plant species populations in Camden County.

| SPECIES | POPULATIONS |
|-----------------------------|-------------------------|
| AESCHYNOMENE VIRGINICA | 1 extirpated |
| ARISTIDA LANOSA | 1 extirpated |
| ASTER RADULA | 1 extirpated |
| BIDENS BIDENTOIDES | 1 extant, 1 extirpated |
| CACALIA MUEHLENBERGII | 1 extirpated |
| CERCIS CANADENSIS | 1 extirpated |
| CHENOPODIUM RUBRUM | 1 extirpated |
| CYPERUS RETROFRACTUS | 3 extirpated |
| DIODIA VIRGINIANA | 1 extirpated |
| DRABA REPTANS | 2 extirpated |
| ERYNGIUM YUCCIFOLIUM | 1 extirpated |
| EUPATORIUM RESINOSUM | 3 extant |
| HELONIAS BULLATA | 27 extant, 3 extirpated |
| HEMICARPHA MICRANTHA | 2 extirpated |
| JUNCUS CAESARIENSIS | 2 extirpated |
| KUHNIA EUPATORIOIDES | 3 extirpated |
| LIMOSELLA SUBULATA | 1 extirpated |
| LYTHRUM HYSSOPIFOLIA | 1 extirpated |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| MYRIOPHYLLUM TENELLUM | 1 extirpated |
| NELUMBO LUTEA | 1 extirpated |
| NUPHAR MICROPHYLLUM | 1 extirpated |
| ONOSMODIUM VIRGINIANUM | 5 extirpated |
| PLANTAGO PUSILLA | 1 extirpated |
| POLYGALA INCARNATA | 2 extirpated |
| PYCNANTHEMUM CLINOPODIOIDES | 1 extirpated |
| RHYNCHOSPORA GLOBULARIS | 2 extirpated |
| RHYNCHOSPORA KNIESKERNII | 1 extant |
| SAGITTARIA TERES | 1 extant |
| SCHEUCHZERIA PALUSTRIS | 1 extirpated |
| SCIRPUS LONGII | 2 extant |
| SCIRPUS MARITIMUS | 1 extirpated |
| STELLARIA PUBERA | 1 extirpated |
| VERBENA SIMPLEX | 1 extirpated |

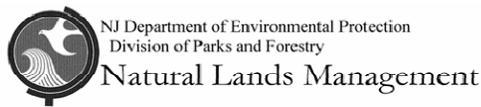
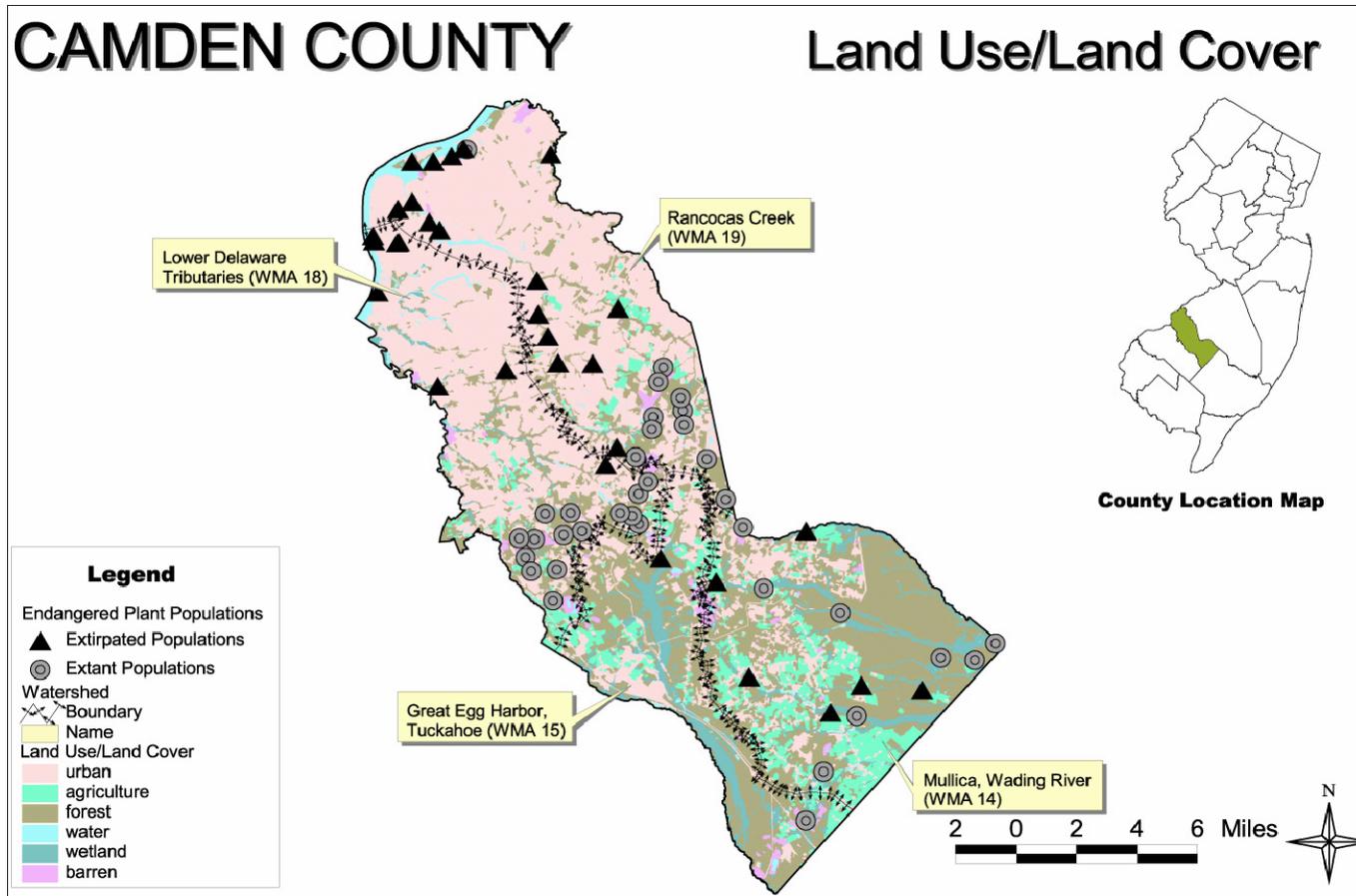
Endangered Plant Species Populations

| | |
|--------------------|--------------|
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

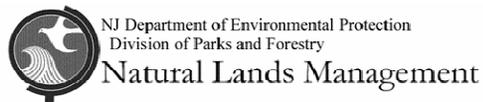
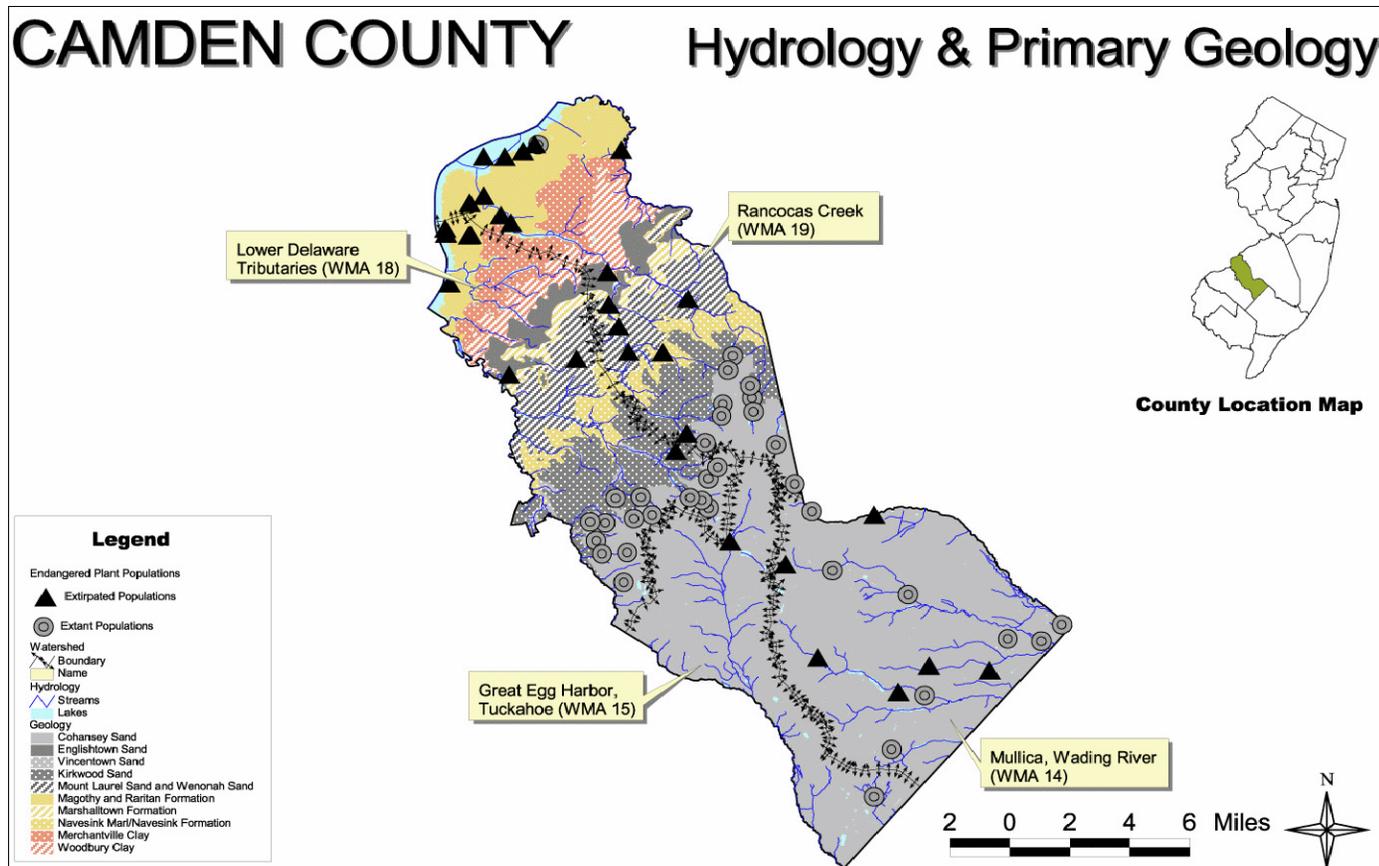
Table B4.2. Extant plant populations in Camden County by land use.

| CAMDEN COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 3 |
| Agriculture | 1 |
| Forest | 20 |
| Water | 2 |
| Wetlands | 9 |
| Barren | 0 |
| Total number of populations | 35 |



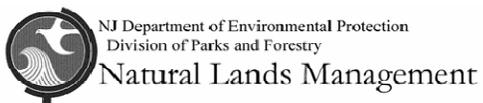
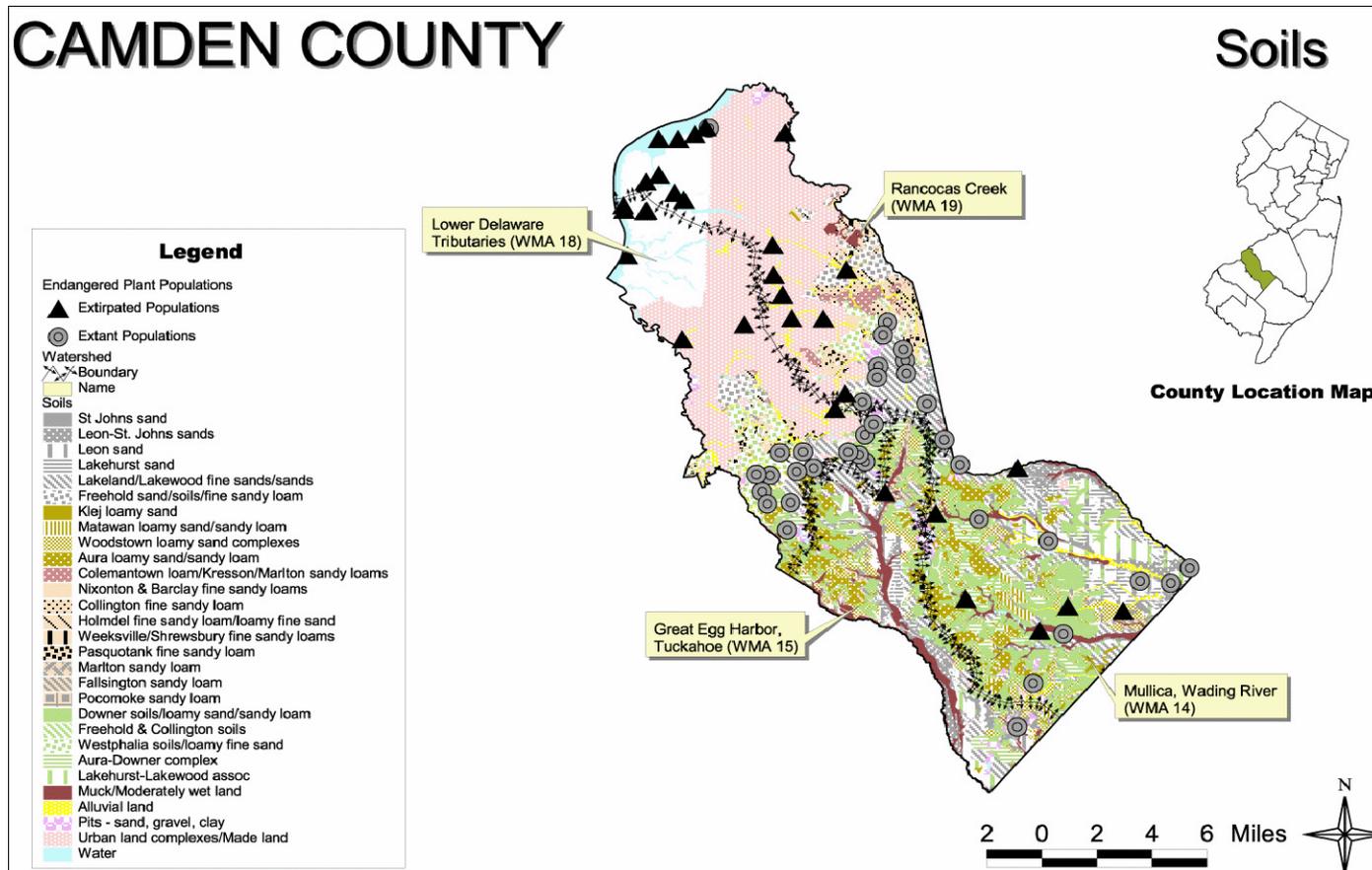
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B4.1. Extant and extirpated plant populations by land use/land cover in Camden County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B4.2. Extant and extirpated plant populations by hydrology and primary geology in Camden County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B4.3. Extant and extirpated plant populations by soil type in Camden County.

Cape May

There were 52 extant and extirpated species in Cape May County, including 71 extant populations and 33 extirpated populations (Table B5.1). Extant populations were found mainly in forested and wetland areas (Table B5.2, Figure B5.1). Common threats to extant populations included habitat disturbance and recreation. Common causes of extirpation included development, road maintenance, and canal construction.

Portions of the Great Egg Harbor, Tuckahoe WMA and Cape May WMA are found within Cape May County (Figure B5.2). The Cape May geologic formation is dominant in the county, and so the majority of extant population occurrences and population extirpations occurred on areas underlain by this formation.

Soils types found in Cape May County include three types of sand, three loamy sands, five sandy loams, and muck (Figure B5.3). Other land types include fill, coastal beach/urban land complex, and tidal marsh. As seen in Figure B5.1, there was a concentration of extant and extirpated populations on fill and coastal beach/urban land complex areas in the southern portion of the county.

Table B5.1. Plant species populations in Cape May County.

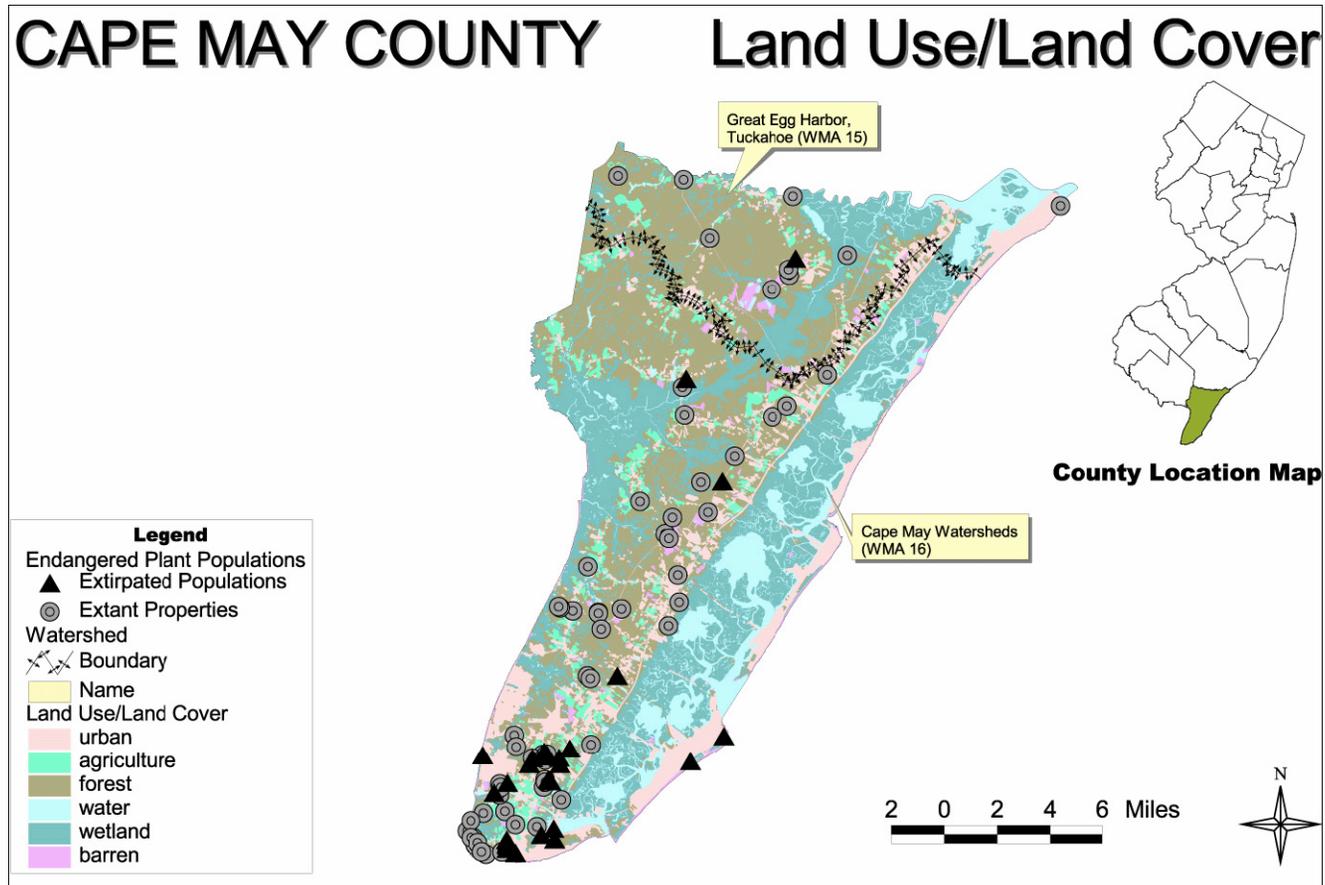
| SPECIES | POPULATIONS |
|---|------------------------|
| AESCHYNOMENE VIRGINICA | 1 extirpated |
| AMMANNIA LATIFOLIA | 2 extant |
| BOLTONIA ASTEROIDES var. GLASTIFOLIA | 2 extant |
| CLITORIA MARIANA | 1 extant |
| COELORACHIS RUGOSA | 1 extant |
| CYPERUS POLYSTACHYOS | 1 extant |
| DIODIA VIRGINIANA | 2 extant, 1 extirpated |
| ELEOCHARIS BRITTONII | 1 extant |
| ELEOCHARIS MELANOCARPA | 1 extant, 1 extirpated |
| ELEOCHARIS TORTILIS | 1 extant, 1 extirpated |
| EUPATORIUM CAPILLIFOLIUM | 5 extant, 1 extirpated |
| EUPATORIUM RESINOSUM | 2 extant |
| FRAXINUS PROFUNDA | 1 extant |
| GALIUM HISPIDULUM | 2 extant, 3 extirpated |
| GYMNOPOGON BREVIFOLIUS | 1 extant, 1 extirpated |
| HELONIAS BULLATA | 9 extant |
| HOTTONIA INFLATA | 2 extant |
| HYPERICUM ADPRESSUM | 3 extant, 2 extirpated |
| JUNCUS BRACHYCARPUS | 4 extirpated |
| JUNCUS CORIACEUS | 4 extant, 2 extirpated |
| LINUM INTERCURSUM | 1 extant |
| OENOTHERA HUMIFUSA | 2 extant |
| OPHIOGLOSSUM VULGATUM var. PYCNOSTICHUM | 1 extirpated |
| PANICUM ACICULARE | 1 extant, 1 extirpated |
| PHYLA LANCEOLATA | 1 extirpated |
| POLYGALA RAMOSA | 1 extirpated |
| POLYGONUM DENSIFLORUM | 1 extant |
| PRUNUS ANGUSTIFOLIA | 1 extant |
| RHEXIA ARISTOSA | 1 extant |
| RHEXIA INTERIOR | 5 extant |

| | |
|-------------------------|------------------------|
| RHODODENDRON ATLANTICUM | 1 extant |
| RHYNCHOSPORA FILIFOLIA | 1 extant |
| RHYNCHOSPORA GLOBULARIS | 1 extant, 1 extirpated |
| RUELLIA CAROLINIENSIS | 1 extirpated |
| SACCIOLEPIS STRIATA | 1 extant |
| SCLERIA VERTICILLATA | 1 extirpated |
| TRIADENUM WALTERI | 4 extant |
| UTRICULARIA RESUPINATA | 1 extant |
| VALERIANELLA RADIATA | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant, 2 extirpated |
| SENSITIVE SPECIES* | 1 extant, 2 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

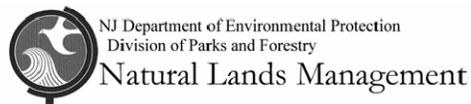
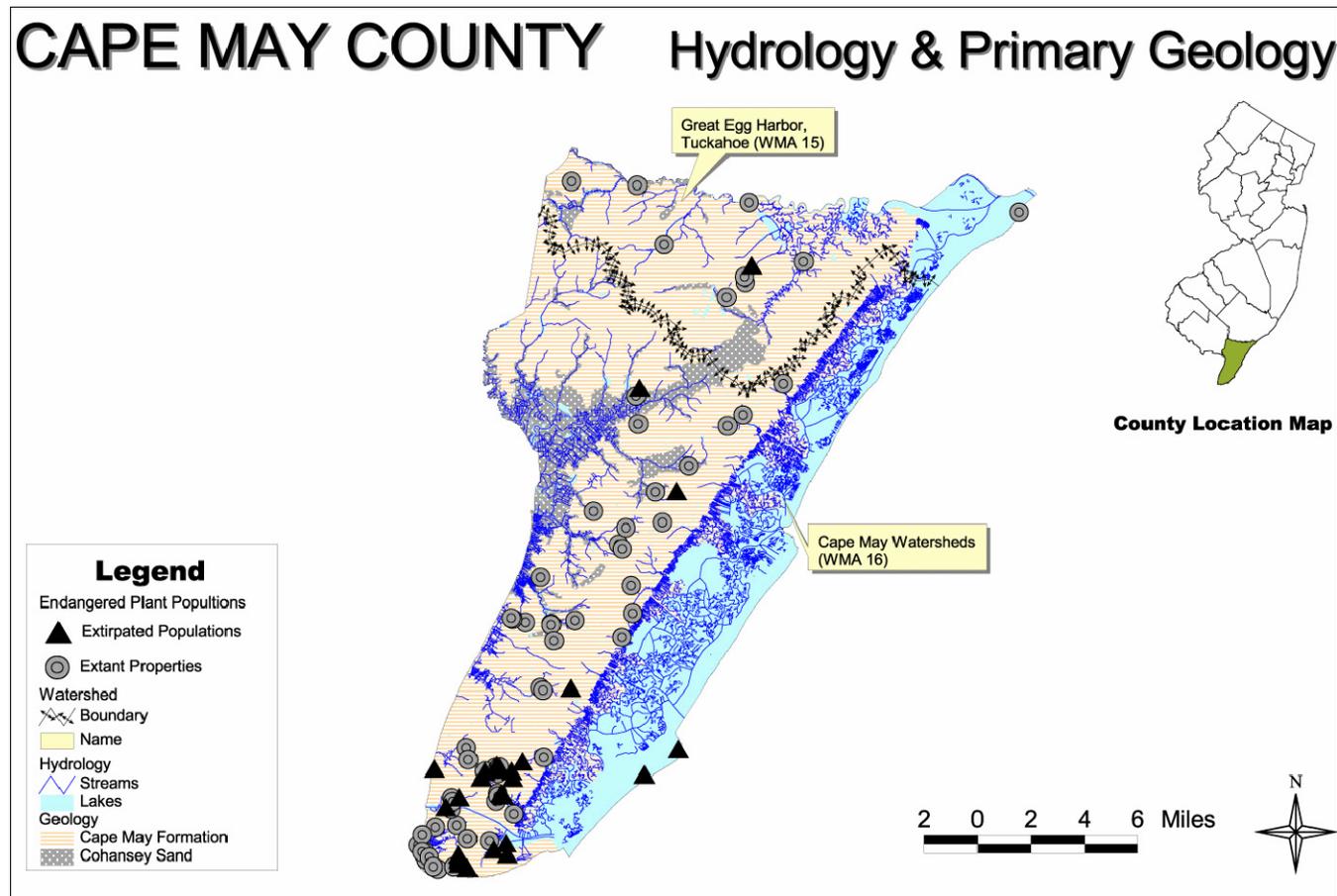
Table B5.2. Extant and extirpated plant populations in Cape May County by land use.

| CAPE MAY COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 8 |
| Agriculture | 0 |
| Forest | 26 |
| Water | 3 |
| Wetlands | 27 |
| Barren | 7 |
| Total number of populations | 71 |



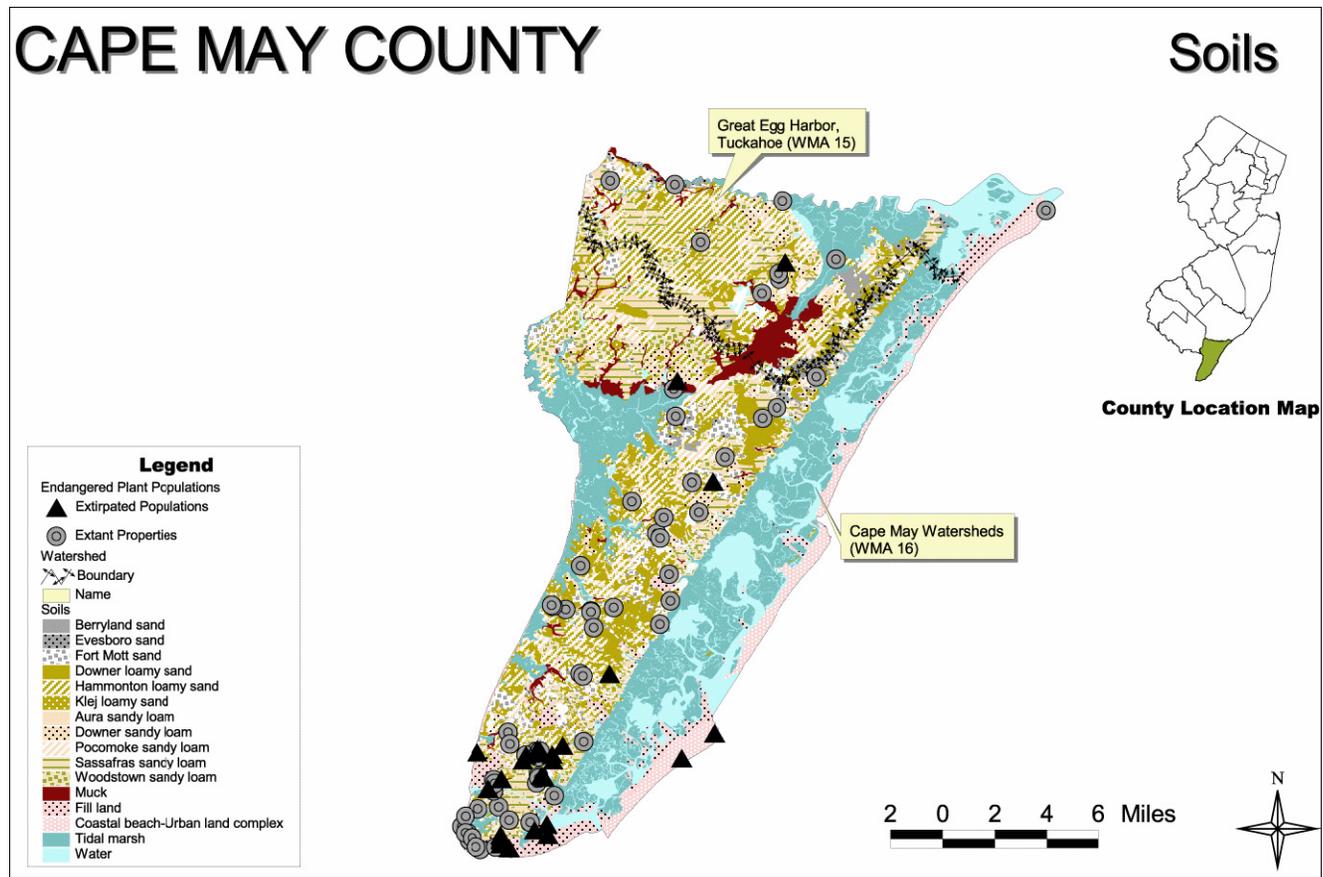
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B5.1. Extant and extirpated plant populations by land use/land cover in Cape May County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B5.2. Extant and extirpated plant populations by hydrology and primary geology in Cape May County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B5.3. Extant and extirpated plant populations by soil type in Cape May County.

Cumberland County

There were 11 extant and extirpated species in Cumberland County, including 22 extant populations and five extirpated populations (Table B6.1). The majority of extant populations were found on forested land (Table B6.2, Figure B6.1). Causes of extirpation and threats to extant populations were varied.

Portions of the Maurice, Salem, Cohansey WMA, Great Egg Harbor, Tuckahoe WMA, and Cape May WMA are found within Cumberland County (Figure B6.2). The majority of extant and extirpated populations in Cumberland County were found in areas underlain by the county-dominant Cohansey Sand geologic formation.

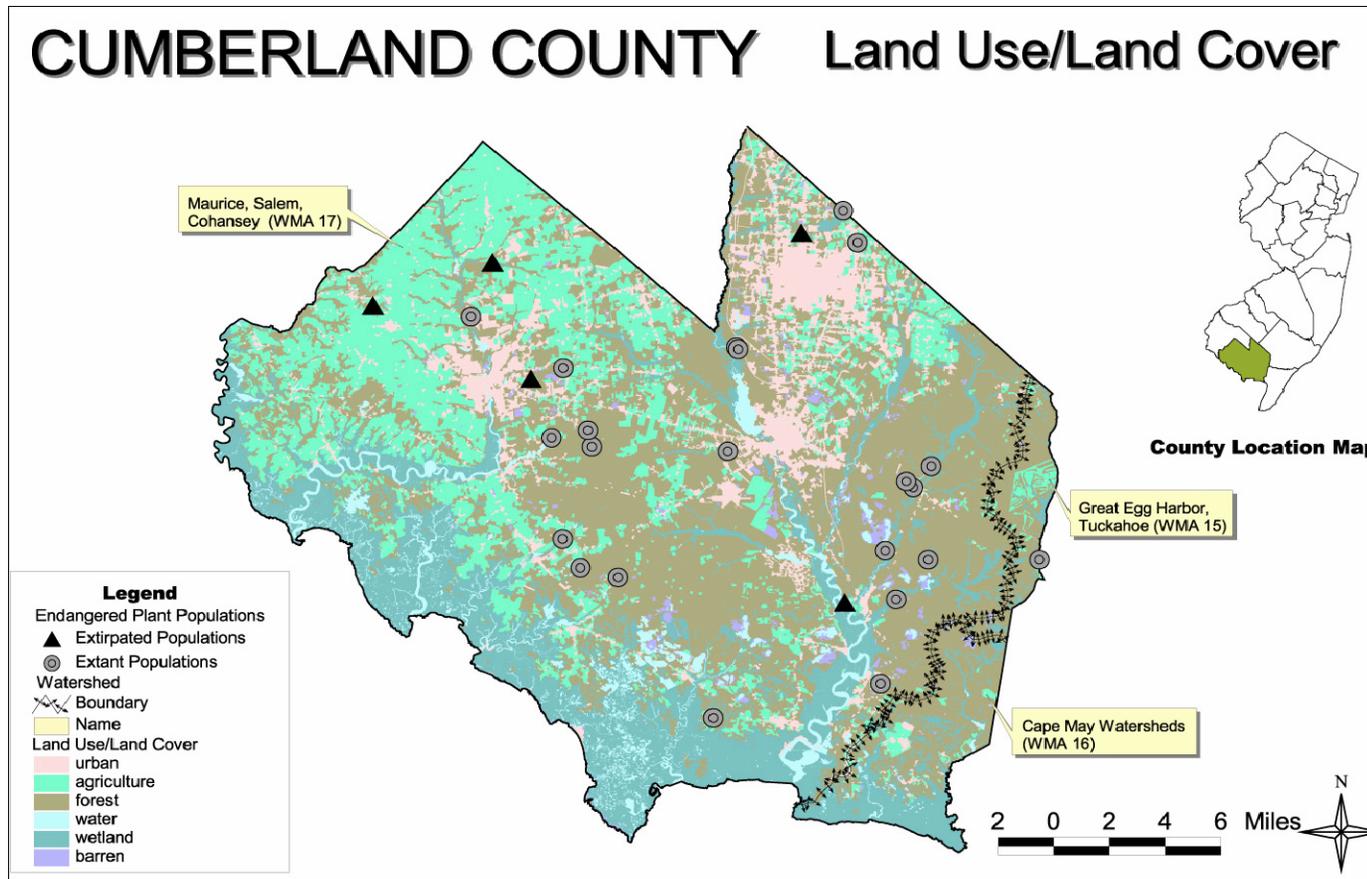
Soils information was not available for Cumberland County

Table B6.1. Plant species populations in Cumberland County.

| SPECIES | POPULATIONS |
|--------------------------|-------------------------|
| AESCHYNOMENE VIRGINICA | 1 extant, 1 extirpated |
| CLITORIA MARIANA | 1 extant |
| ELEOCHARIS EQUISETOIDES | 1 extirpated |
| ELEOCHARIS MELANOCARPA | 1 extant |
| EUPATORIUM CAPILLIFOLIUM | 1 extant |
| EUPATORIUM RESINOSUM | 4 extant |
| GENTIANA VILLOSA | 1 extirpated |
| HELONIAS BULLATA | 11 extant, 2 extirpated |
| JUNCUS CAESARIENSIS | 1 extant |
| ONOSMODIUM VIRGINIANUM | 1 extant |
| QUERCUS NIGRA | 1 extant |

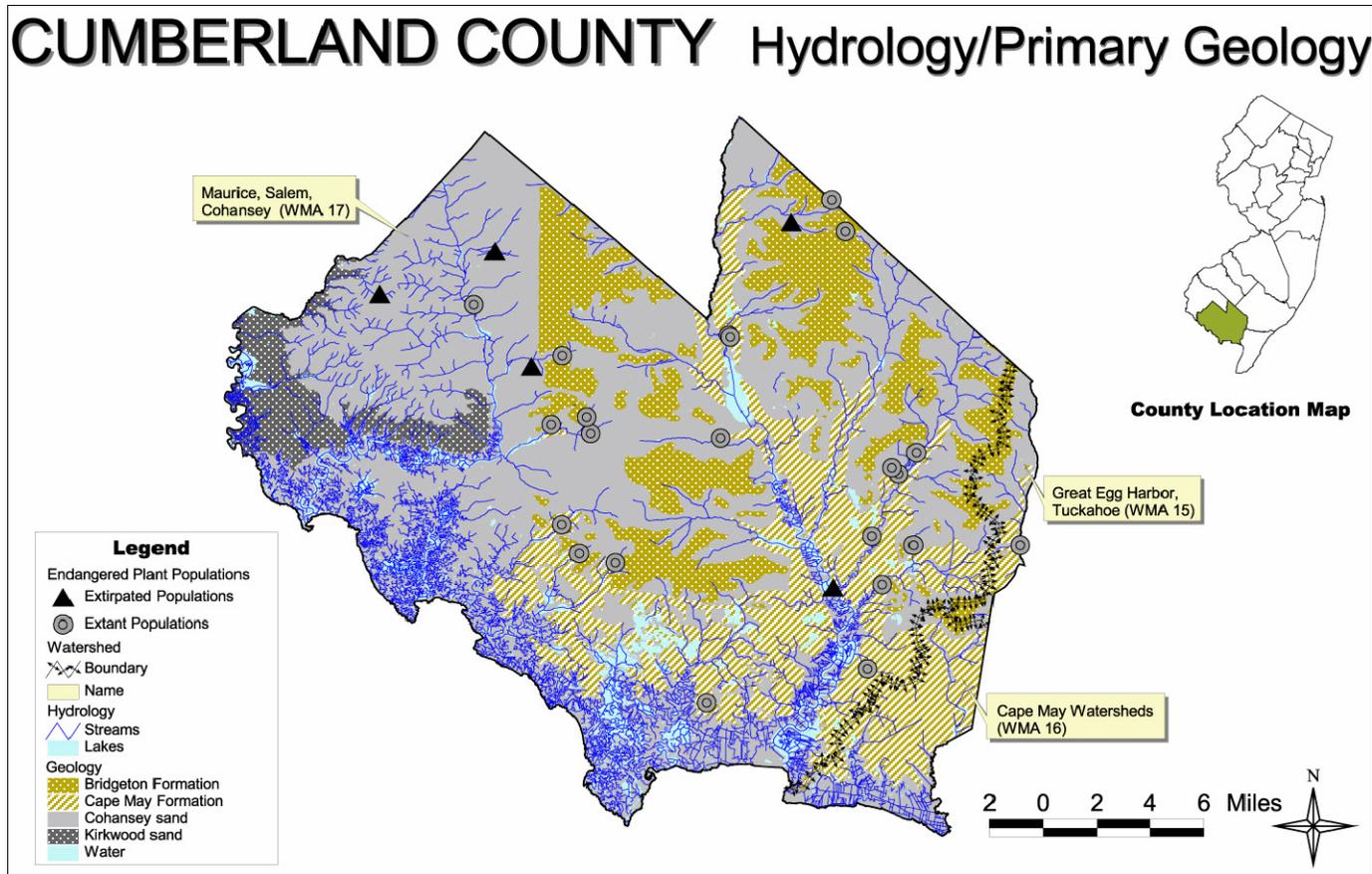
Table B6.2. Extant plant populations in Cumberland County by land use.

| CUMBERLAND COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------------|-------------------------------------|
| Urban | 1 |
| Agriculture | 0 |
| Forest | 17 |
| Water | 1 |
| Wetlands | 2 |
| Barren | 0 |
| Undetermined | 1 |
| Total number of populations | 22 |



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B6.1. Extant and extirpated plant populations by land use/land cover in Cumberland County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B6.2. Extant and extirpated plant populations by hydrology and primary geology in Cumberland County.

Essex County

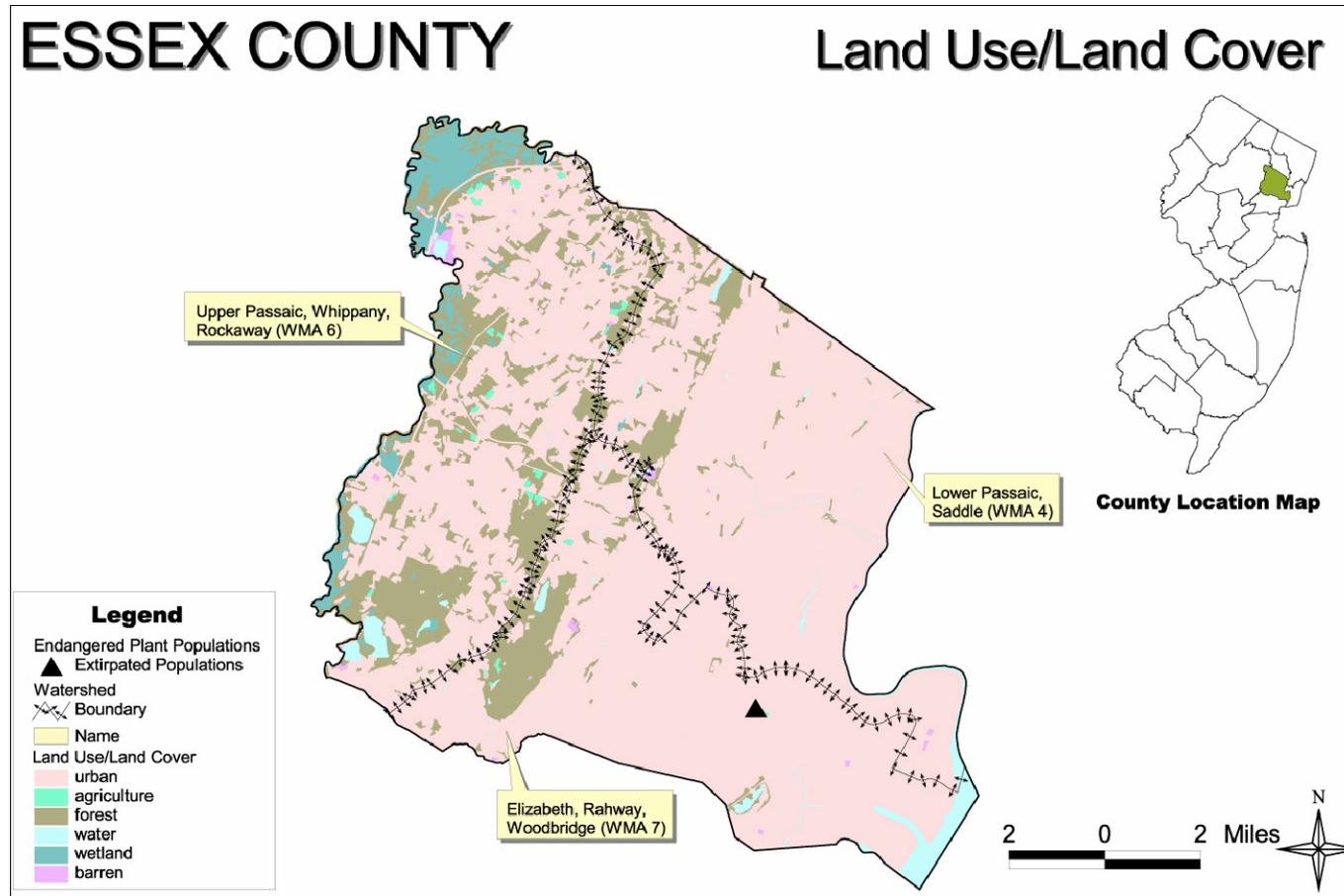
Only one extirpated population of one species, *Sanicula trifoliata* or large-fruited black snakeroot, was recorded in Essex County (Table B7.1, Figure B7.1). Development and urbanization were cited as the causes of extirpation.

Portions of the Upper Passaic, Whippany, Rockaway WMA, Lower Passaic, Saddle WMA, and Elizabeth, Rahway, Woodbridge WMA are located in Essex County (Figure B7.2). The population extirpation in Essex County occurred in the Elizabeth, Rahway, Woodbridge WMA, which is underlain by the Brunswick geologic formation.

No soils information was available for Essex County.

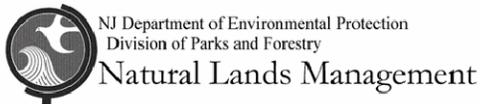
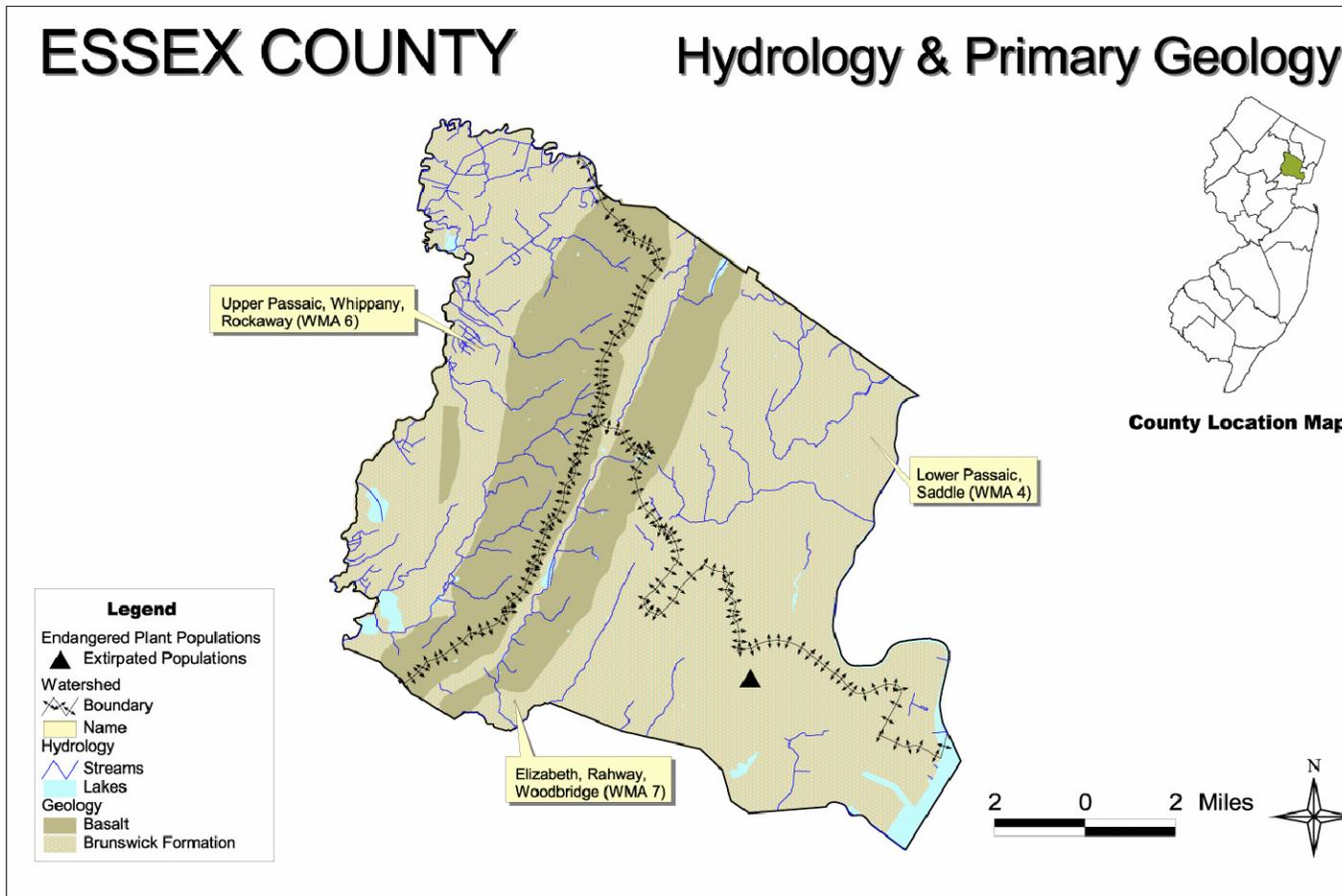
Table B7.1. Plant species populations in Essex County.

| SPECIES | POPULATIONS |
|---------------------|--------------------|
| SANICULA TRIFOLIATA | 1 extirpated |



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B7.1. Extant and extirpated plant species by land use/land cover in Essex County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B7.2. Extant and extirpated plant populations by hydrology and primary geology in Essex County.

Endangered Plant Species Populations Gloucester County

Appendix B8 Gloucester

There were 18 extant and extirpated species in Gloucester County, including 22 extant populations and ten extirpated populations (Table B8.1). Most extant populations were found on wetland and forested land (Table B8.2, Figure B8.1). Common threats to extant populations included habitat disturbance, right of ways, pollution, and siltation. Common causes of extirpation included development, agriculture, and industry.

Portions of the Lower Delaware Tributaries WMA, Maurice, Salem, Cohansey WMA, and Great Egg Harbor, Tuckahoe WMA are found in Gloucester County (Figure B8.2). All population extirpations in this county occurred in the Lower Delaware Tributaries WMA. The majority of extant populations were found in the dominant Cohansey Sand geologic formation, which extends into all three WMAs in this county.

Soil types in Gloucester County include three types of sand, four loamy sands, three loams, and eleven sandy loams (Figure B8.3). Other land types include alluvial land, made land/pits, and muck/fresh water marsh/tidal marsh. There were no patterns in plant population occurrence and soil type in Gloucester County.

Endangered Plant Species Populations

Table B8.1. Plant species populations in Gloucester County.

| SPECIES | POPULATIONS |
|-------------------------|-------------------------|
| APLECTRUM HYEMALE | 1 extant |
| ASIMINA TRILOBA | 1 extant |
| BOUTELOUA CURTIPENDULA | 1 extirpated |
| CAREX LIMOSA | 1 extirpated |
| CAREX POLYMORPHA | 1 extirpated |
| CASTANEA PUMILA | 1 extant |
| DRABA REPTANS | 1 extirpated |
| ELEOCHARIS EQUISETOIDES | 1 extirpated |
| ERIOPHORUM GRACILE | 1 extirpated |
| EUPATORIUM RESINOSUM | 2 extant |
| HELONIAS BULLATA | 12 extant, 1 extirpated |
| LUZULA ACUMINATA | 2 extant |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| PRUNUS ANGUSTIFOLIA | 1 extant |
| SCHEUCHZERIA PALUSTRIS | 1 extirpated |
| VERNONIA GLAUCA | 1 extant |
| SENSITIVE SPECIES | 1 extirpated |
| SENSITIVE SPECIES | 1 extant |

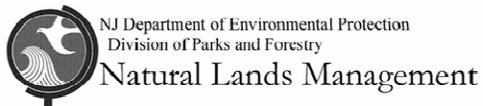
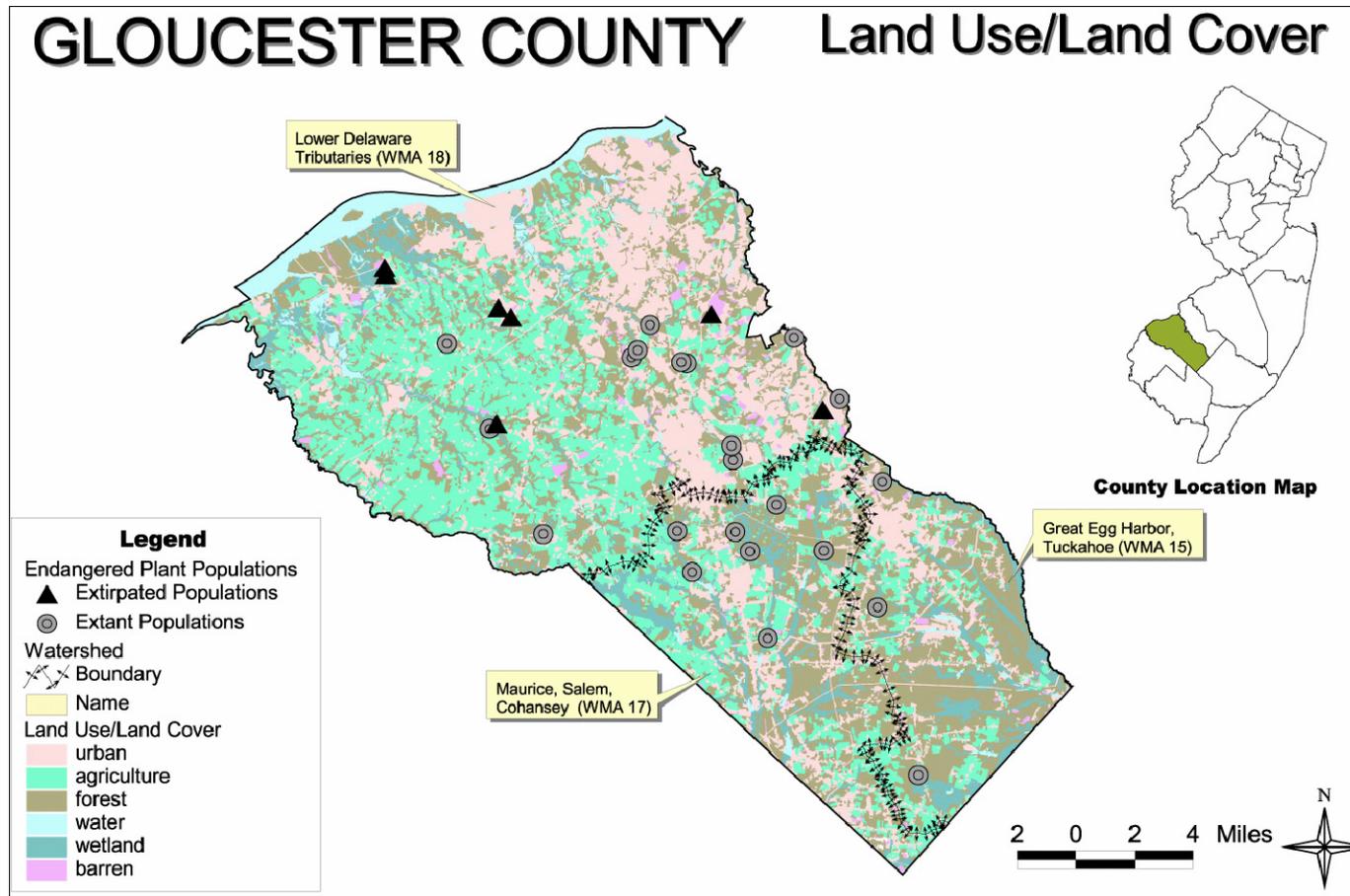
* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Endangered Plant Species Populations

Table B8.2. Extant plant populations in Gloucester County by land use.

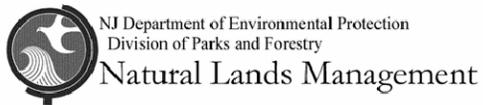
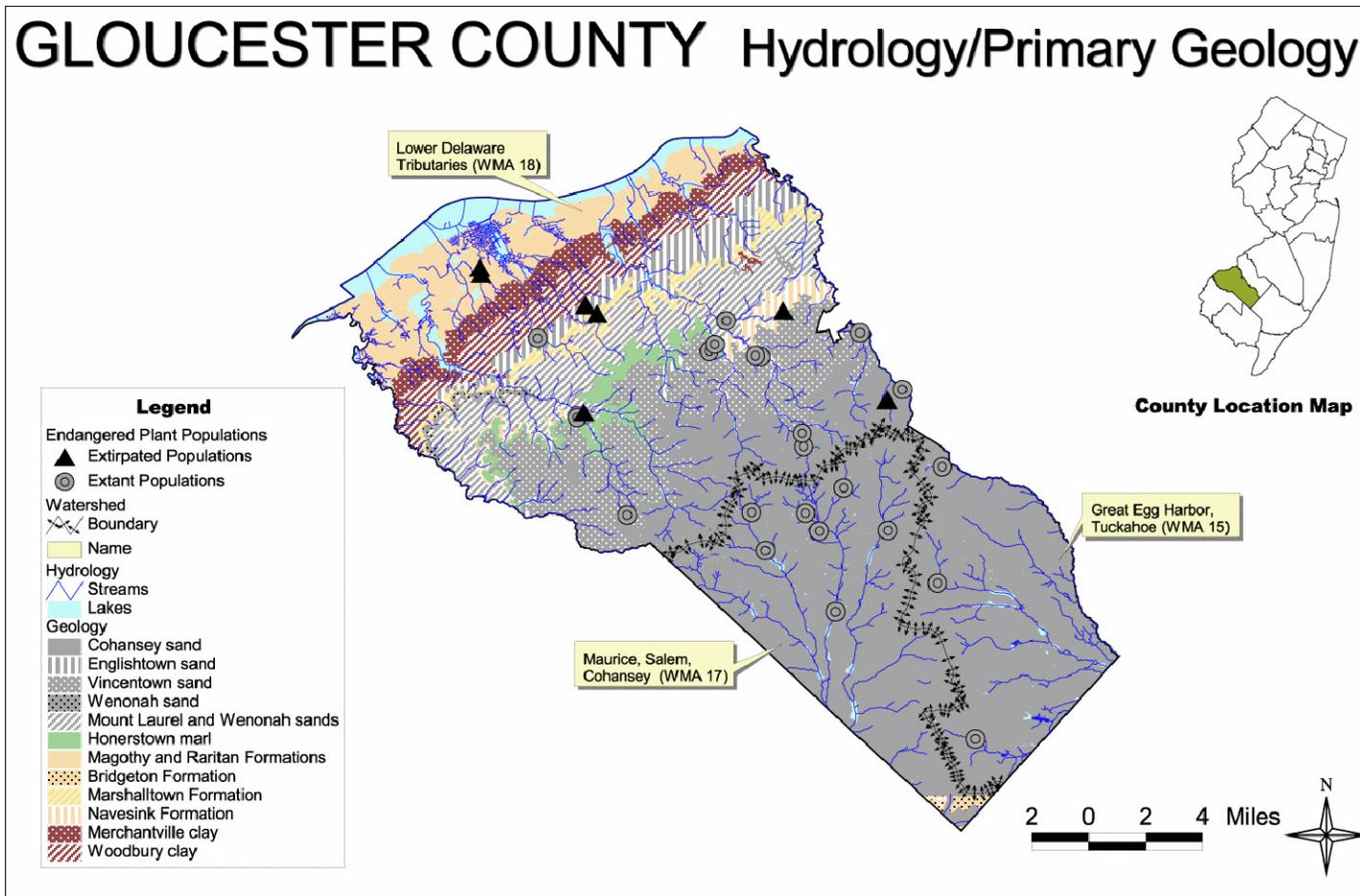
Appendix B8 Gloucester

| GLOUCESTER COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------------|-------------------------------------|
| Urban | 3 |
| Agriculture | 0 |
| Forest | 7 |
| Water | 0 |
| Wetlands | 11 |
| Barren | 1 |
| Total number of populations | 22 |



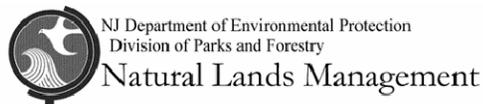
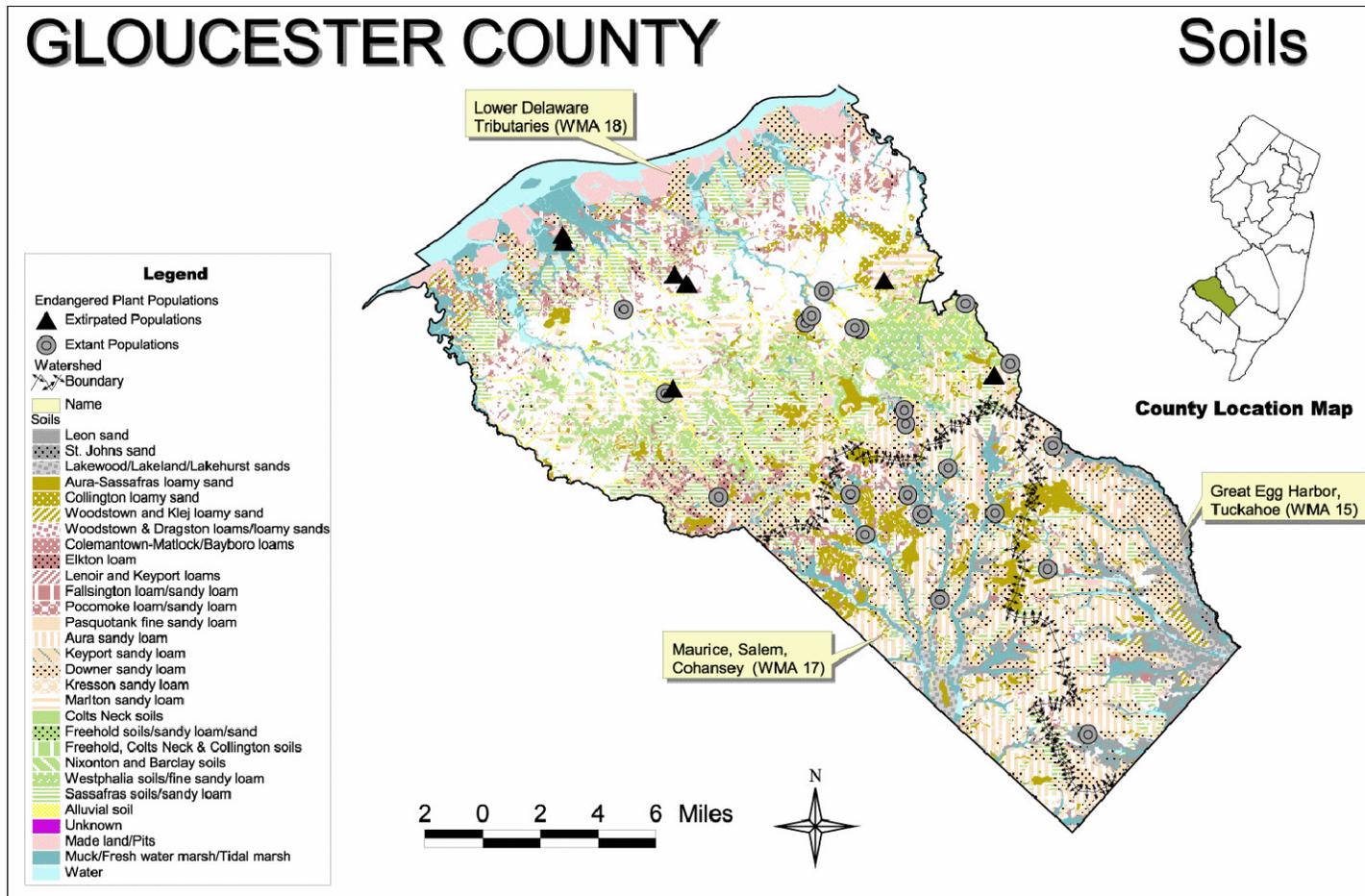
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B8.1. Extant and extirpated plant populations by land use/land cover in Gloucester County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B8.2. Extant and extirpated plant populations by hydrology and primary geology in Gloucester County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B8.3. Extant and extirpated plant populations by soil type in Gloucester County.

Endangered Plant Species Populations Hudson County

There were 15 extant and extirpated species were in Hudson County, including 16 extirpated populations (Table B9.1, Figure B9.1). Common causes of extirpation included land clearing, development, urbanization, and mining, including rock quarries.

Portions of the Lower Passaic, Saddle WMA, Hackensack, Pascack WMA, and Elizabeth, Rahway, Woodbridge WMA are found in Hudson County (Figure B9.2). All of the population extirpations that occurred in Hudson County occurred in the Hackensack, Pascack WMA. Within this WMA, the majority of extirpations occurred in areas that are underlain by the Stockton geologic formation.

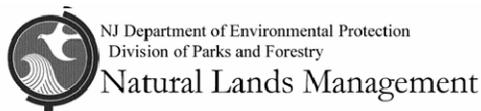
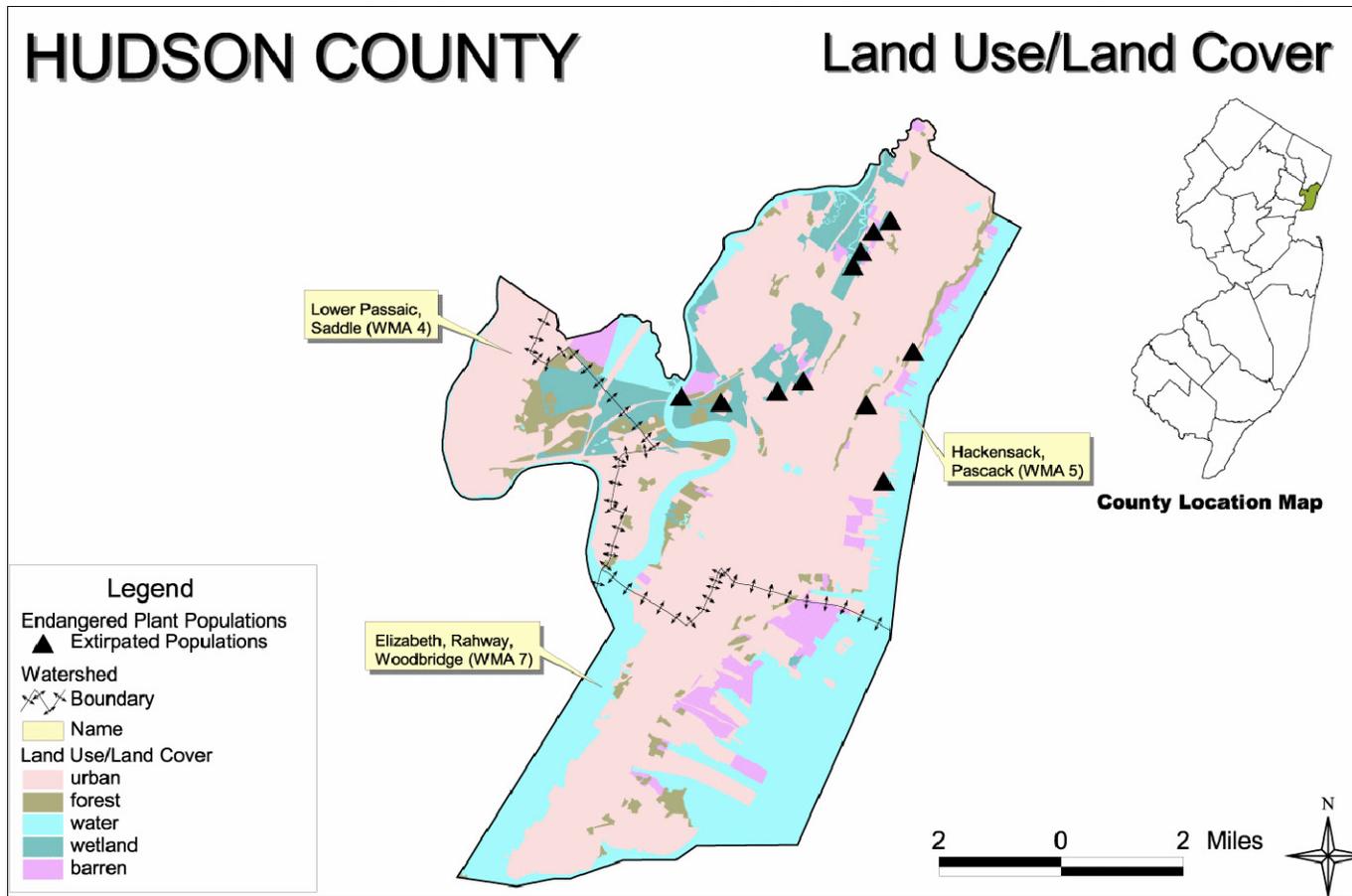
Soils information was not available for Hudson County.

Endangered Plant Species Populations

Table B9.1. Plant species populations in Hudson County.

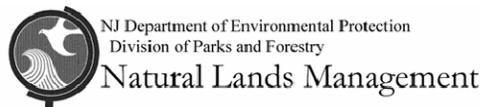
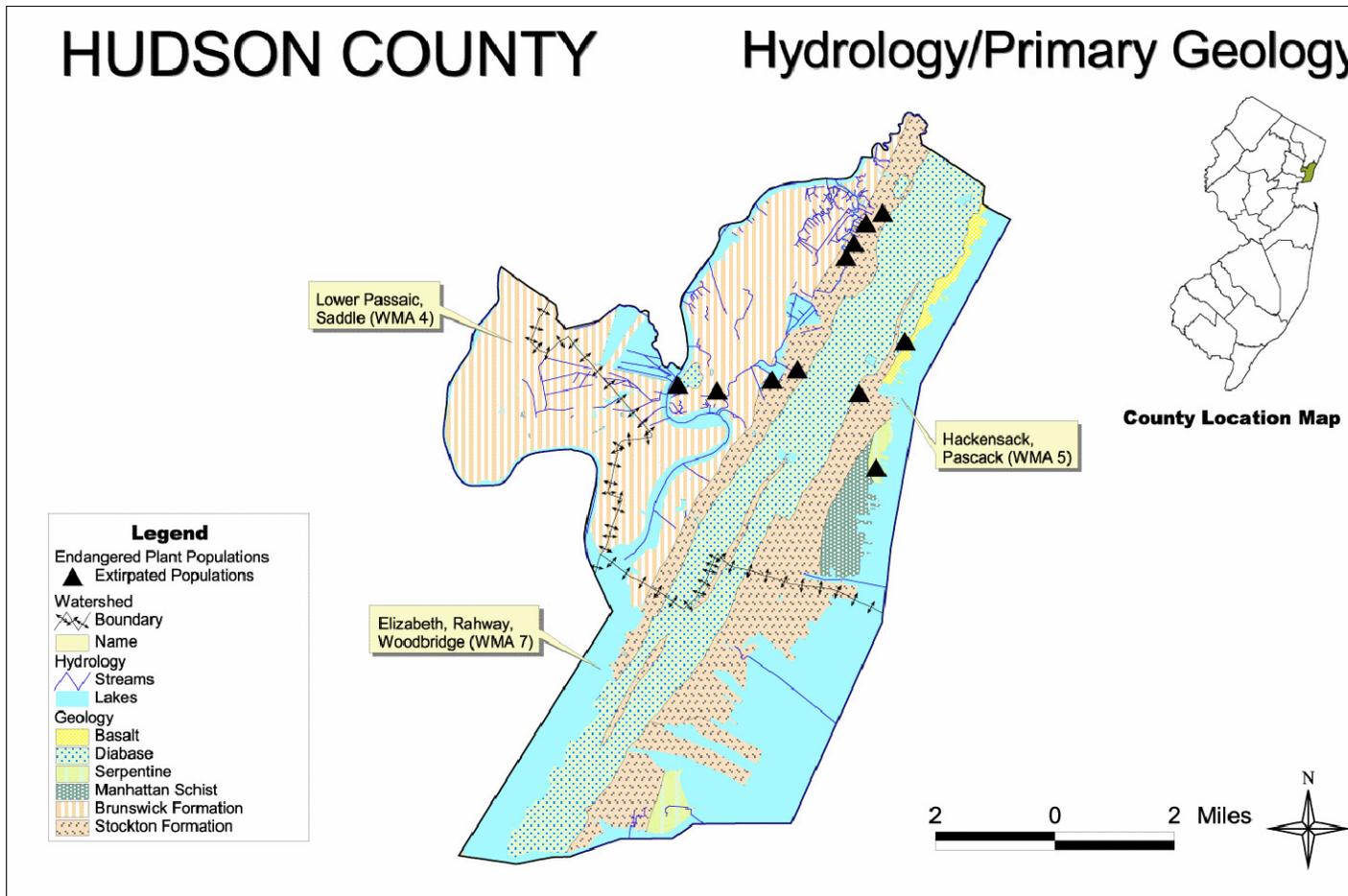
| SPECIES | POPULATIONS |
|-------------------------|--------------|
| CHENOPODIUM RUBRUM | 1 extirpated |
| CLITORIA MARIANA | 1 extirpated |
| GAULTHERIA HISPIDULA | 1 extirpated |
| HIERACIUM KALMII | 1 extirpated |
| HOTTONIA INFLATA | 1 extirpated |
| HYPERICUM MAJUS | 1 extirpated |
| LINNAEA BOREALIS | 1 extirpated |
| LYTHRUM HYSSOPIFOLIA | 1 extirpated |
| MUHLENBERGIA CAPILLARIS | 1 extirpated |
| ONOSMODIUM VIRGINIANUM | 1 extirpated |
| POLYMNIA UVEDALIA | 1 extirpated |
| PRENANTHES RACEMOSA | 2 extirpated |
| SCIRPUS MARITIMUS | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B9.1. Extant and extirpated plant populations by land use/land cover in Hudson County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B9.2. Extant and extirpated plant populations by hydrology and primary geology in Hudson County.

Endangered Plant Species Populations Hunterdon County

Appendix B10 Hunterdon

There were 22 extant and extirpated species in Hunterdon County, including 22 extant populations and four extirpated populations (Table B10.1). Extant populations were found mainly on forested land (Table B10.2, Figure B10.1). Common threats to extant populations were succession and roadways. Causes for extirpations included railroads, succession, mining, and quarry.

Portions of the Upper Delaware River, Central Delaware Tributaries, Millstone River, and the North and South Branch Raritan WMAs are found in Hunterdon County (Figure B10.2). As seen in Figure 36, there was a concentration of extant and extirpated populations along the Delaware River in the Central Delaware Tributaries WMA. This area is underlain by the Brunswick/Lockatong/Stockton geologic formations.

A range of loam soil types is found in Hunterdon County, but there was no clear pattern in population occurrence and soil type in this county (Figure B10.3).

Endangered Plant Species Populations
 Table B10.1. Plant species populations in Hunterdon County.

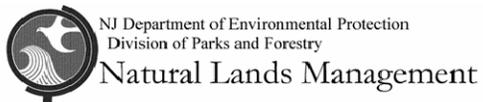
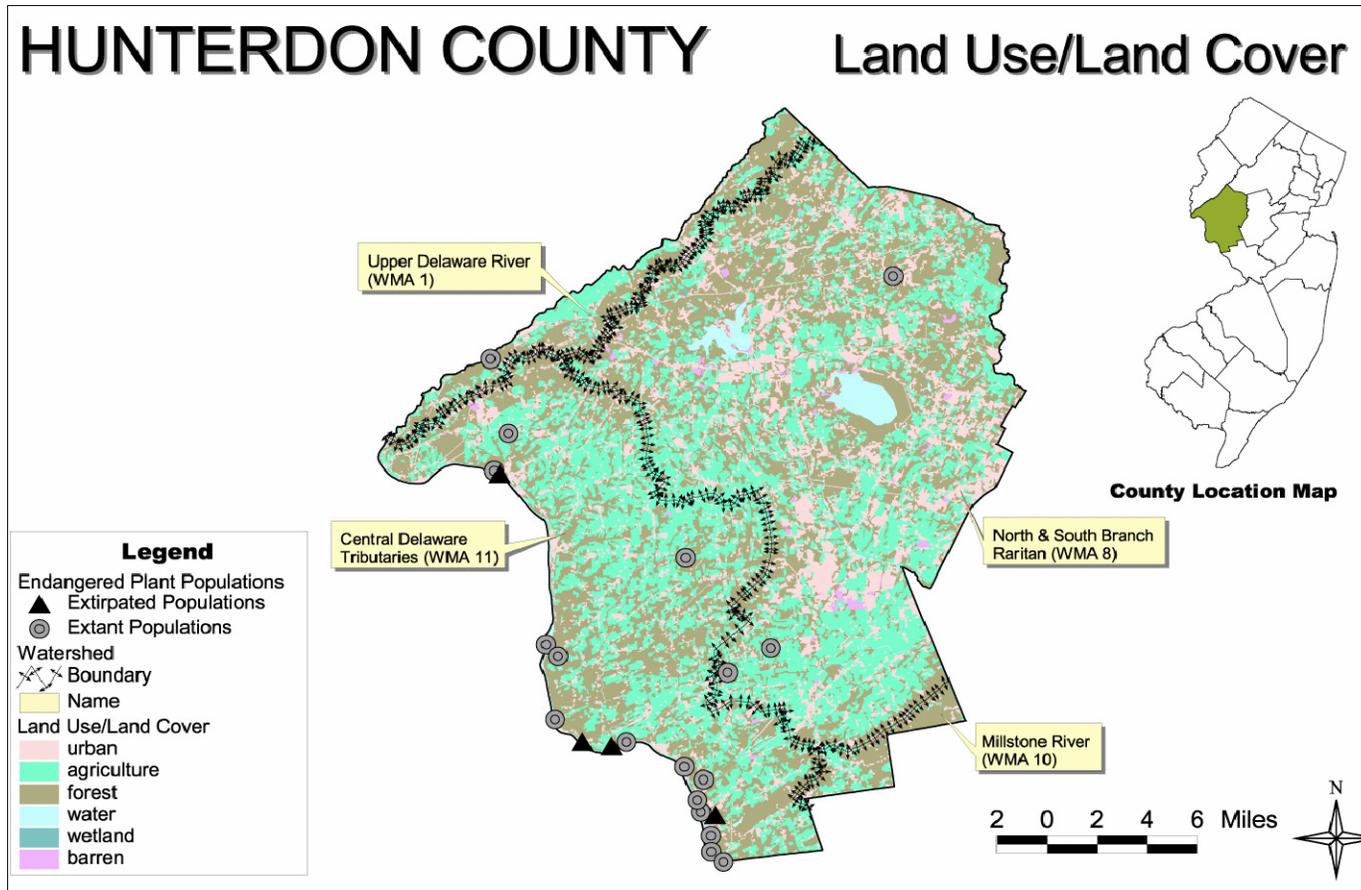
| SPECIES | POPULATIONS |
|------------------------|--------------------|
| ASIMINA TRILOBA | 1 extant |
| ASTER PRAEALTUS | 1 extant |
| CAREX BUSHII | 2 extant |
| CUSCUTA CEPHALANTHI | 1 extant |
| ELLISIA NYCTELEA | 1 extant |
| HYBANTHUS CONCOLOR | 2 extant |
| LATHYRUS VENOSUS | 1 extirpated |
| MONARDA CLINOPODIA | 1 extant |
| ONOSMODIUM VIRGINIANUM | 1 extirpated |
| PENSTEMON LAEVIGATUS | 1 extant |
| PTELEA TRIFOLIATA | 1 extant |
| RIBES MISSOURIENSE | 1 extant |
| RUDBECKIA FULGIDA | 1 extant |
| VIOLA CANADENSIS | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 2 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Endangered Plant Species Populations

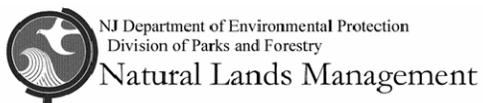
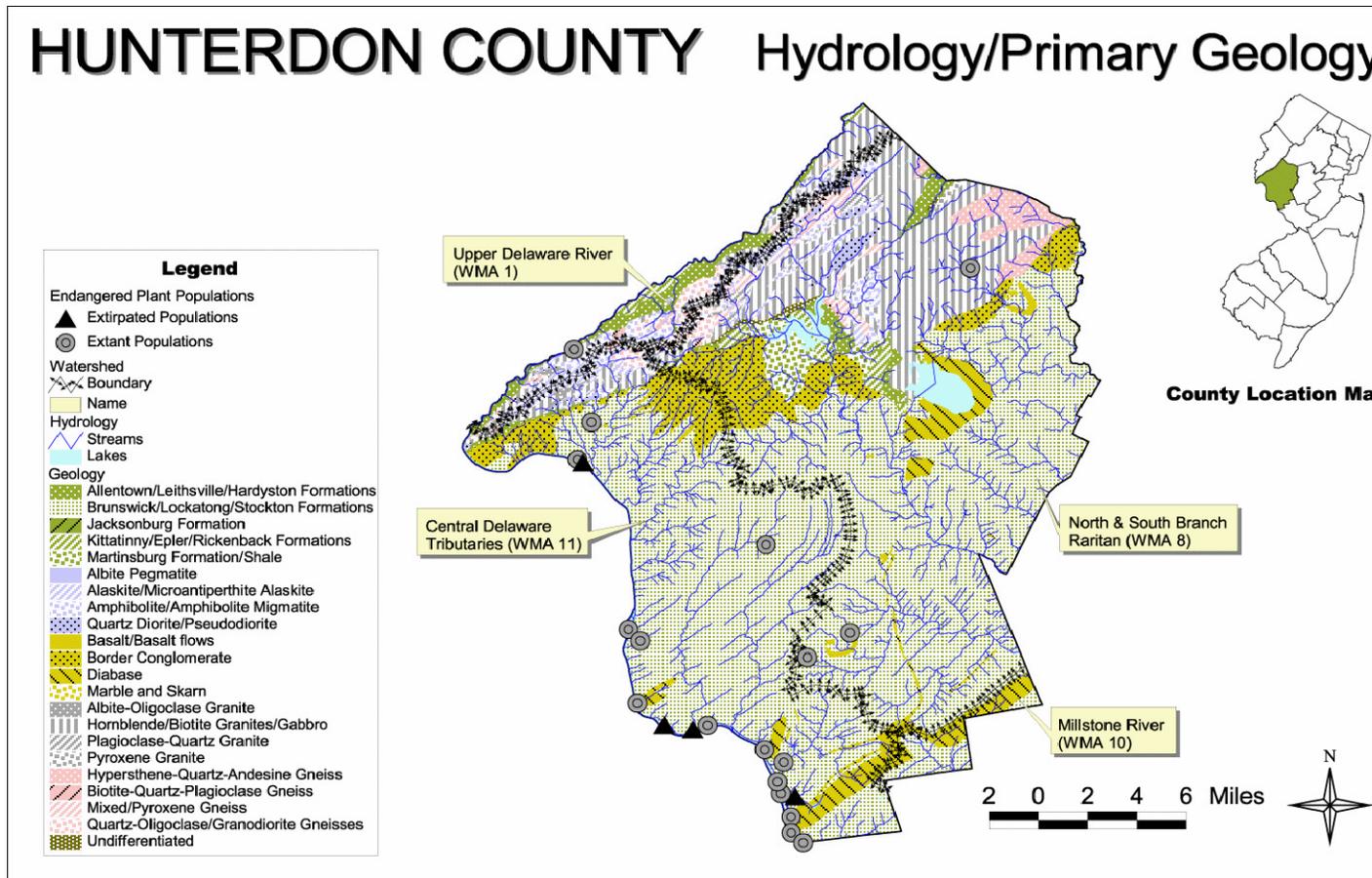
Table B10.2. Extant plant populations in Hunterdon County by land use.

| HUNTERDON COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|----------------------------------|-------------------------------------|
| Urban | 1 |
| Agriculture | 1 |
| Forest | 19 |
| Water | 0 |
| Wetlands | 0 |
| Barren | 0 |
| Undetermined | 1 |
| Total number of populations | 22 |



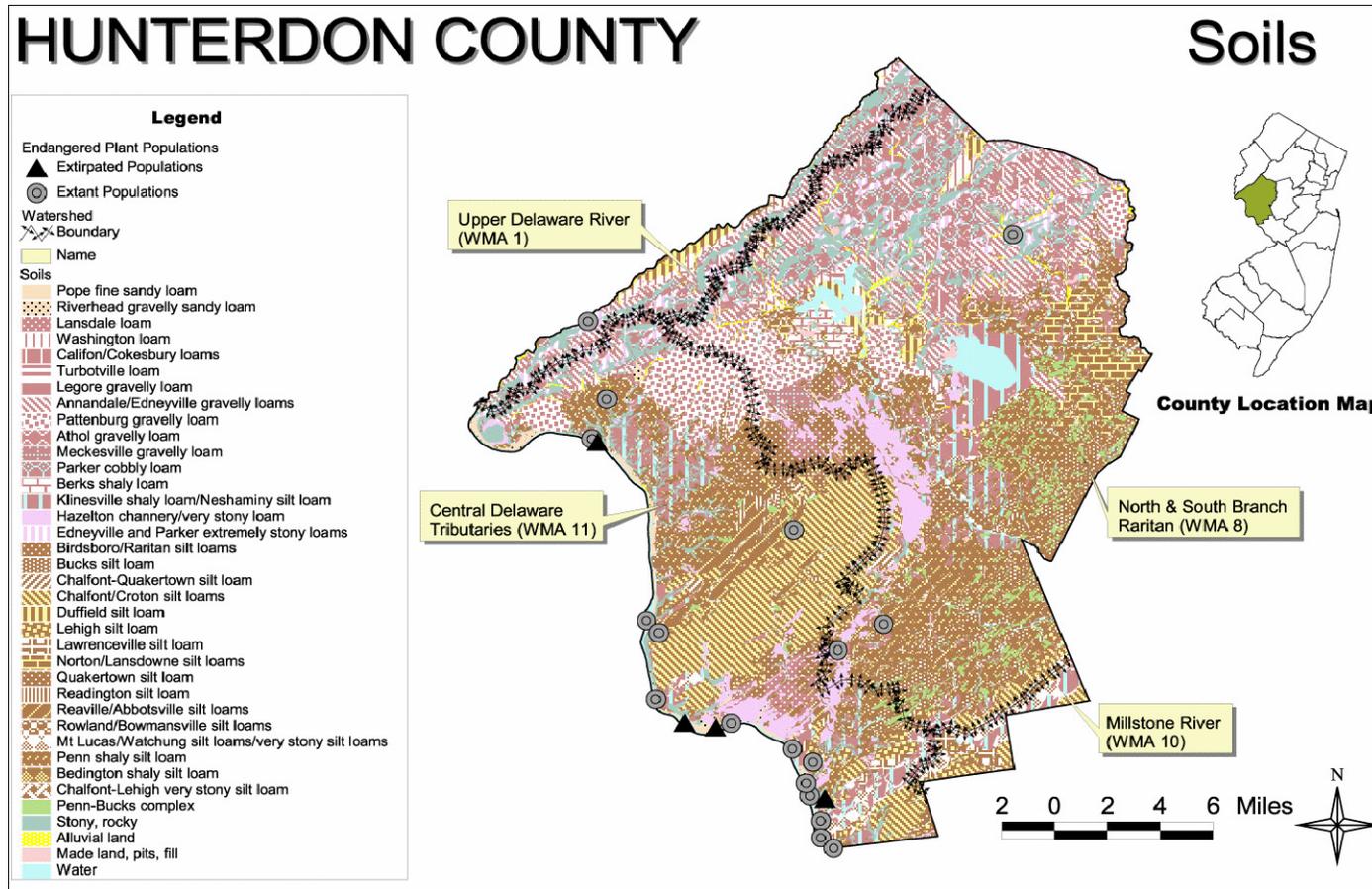
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B10.1. Extant and extirpated plant populations by land use/land cover in Hunterdon County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B10.2. Extant and extirpated plant populations by hydrology and primary geology in Hunterdon County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B10.3. Extant and extirpated plant populations by soil type in Hunterdon County.

Endangered Plant Species Populations
Mercer County

There were 15 extant and extirpated species in Mercer County, including 10 extant populations and eight extirpated populations (Table B11.1). Extant populations were located on forested, urban, and agricultural land (Table B11.2, Figure B11.1). Common threats to extant populations included recreation, habitat disturbance, and mining, including rock quarries. Common causes of extirpation were development and urbanization.

Portions of the Millstone River, Central Delaware Tributaries, and Crosswicks Creek WMAs are found in Mercer County (Figure B11.2). Again, there was a concentration of extant and extirpated plant populations along the Delaware River in the Central Delaware Tributaries WMA.

There were no trends in plant population occurrence and soil type in Mercer County (Figure B11.3).

Table B11.1. Plant species populations in Mercer County.

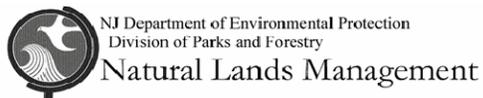
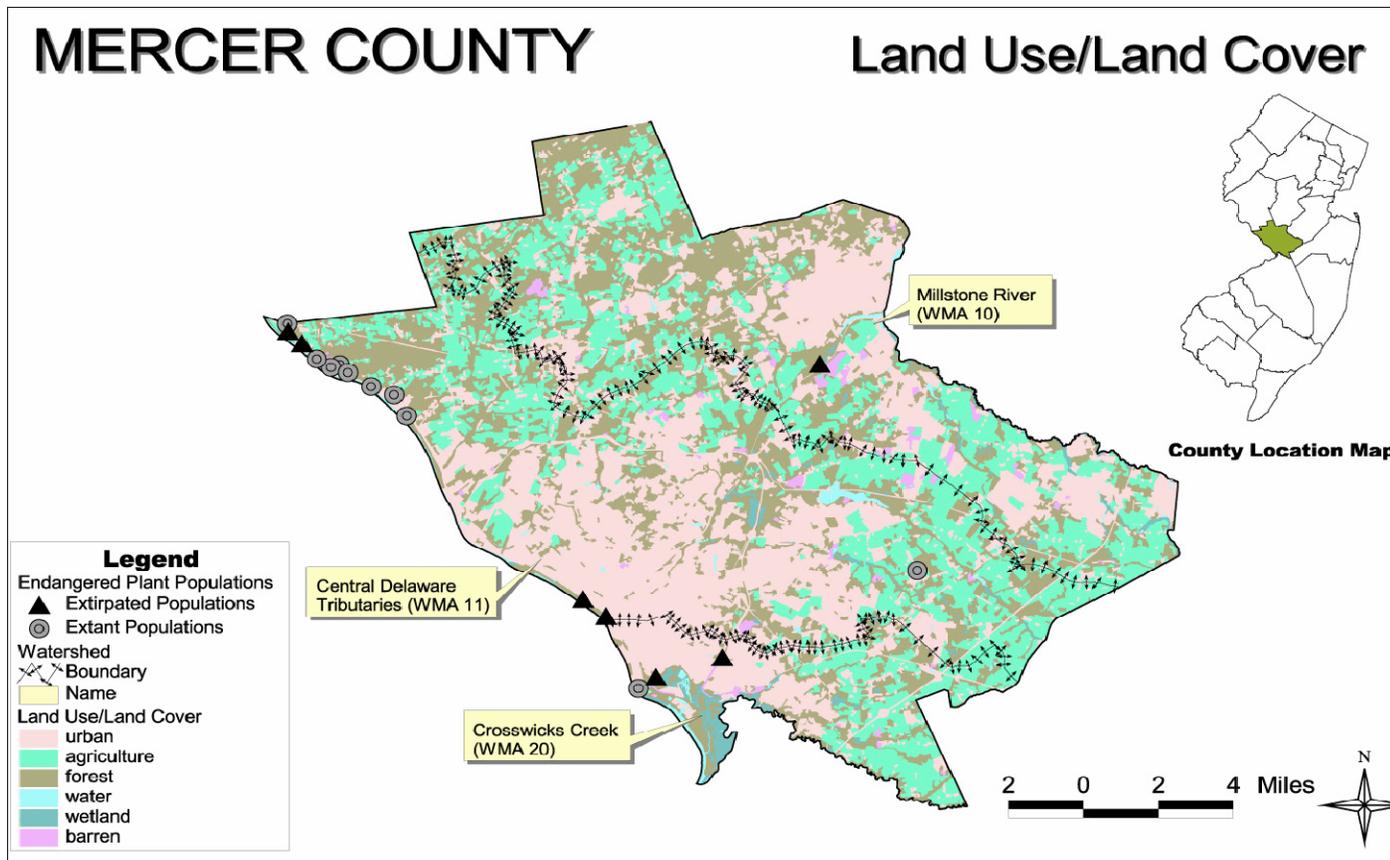
| SPECIES | POPULATIONS |
|-------------------------|------------------------|
| BIDENS BIDENTOIDES | 1 extant |
| CACALIA SUAVEOLENS | 1 extirpated |
| CALYSTEGIA SPITHAMAEA | 1 extirpated |
| CERCIS CANADENSIS | 1 extant |
| CUSCUTA CEPHALANTHI | 2 extant |
| ELLISIA NYCTELEA | 1 extant, 1 extirpated |
| ERIOPHORUM GRACILE | 1 extirpated |
| HYBANTHUS CONCOLOR | 1 extant |
| LIMOSELLA SUBULATA | 1 extirpated |
| PENSTEMON LAEVIGATUS | 1 extant |
| VERBENA SIMPLEX | 1 extirpated |
| ZIGADENUS LEIMANTHOIDES | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant, 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |

* *Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.*

Endangered Plant Species Populations

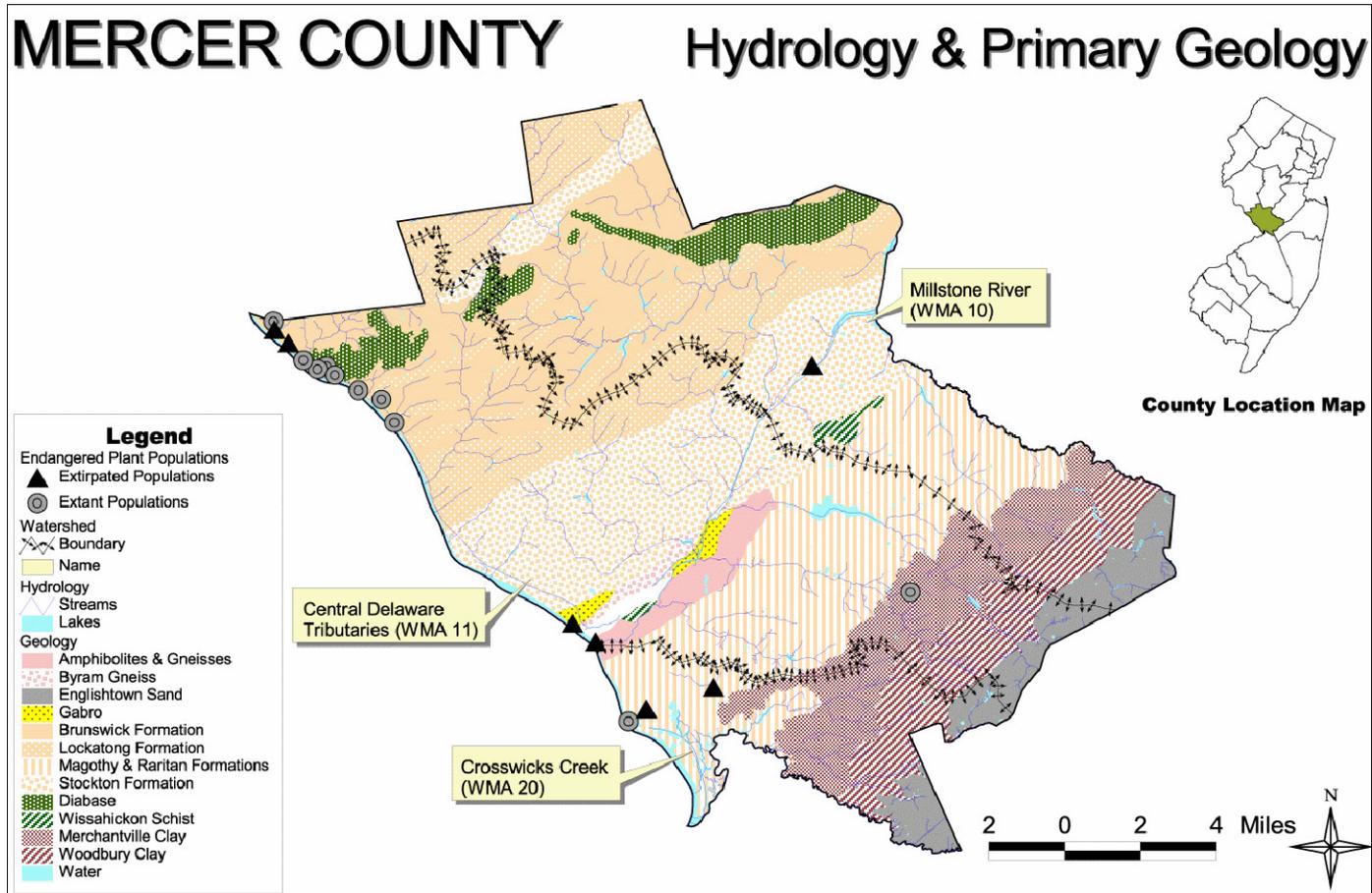
Table B11.2. Extant plant populations in Mercer County by land use.

| MERCER COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-------------------------------|-------------------------------------|
| Urban | 2 |
| Agriculture | 1 |
| Forest | 7 |
| Water | 0 |
| Wetlands | 0 |
| Barren | 0 |
| Total number of populations | 10 |



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B11.1. Extant and extirpated plant populations by land use/land cover in Mercer County.



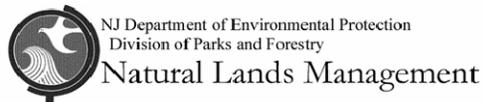
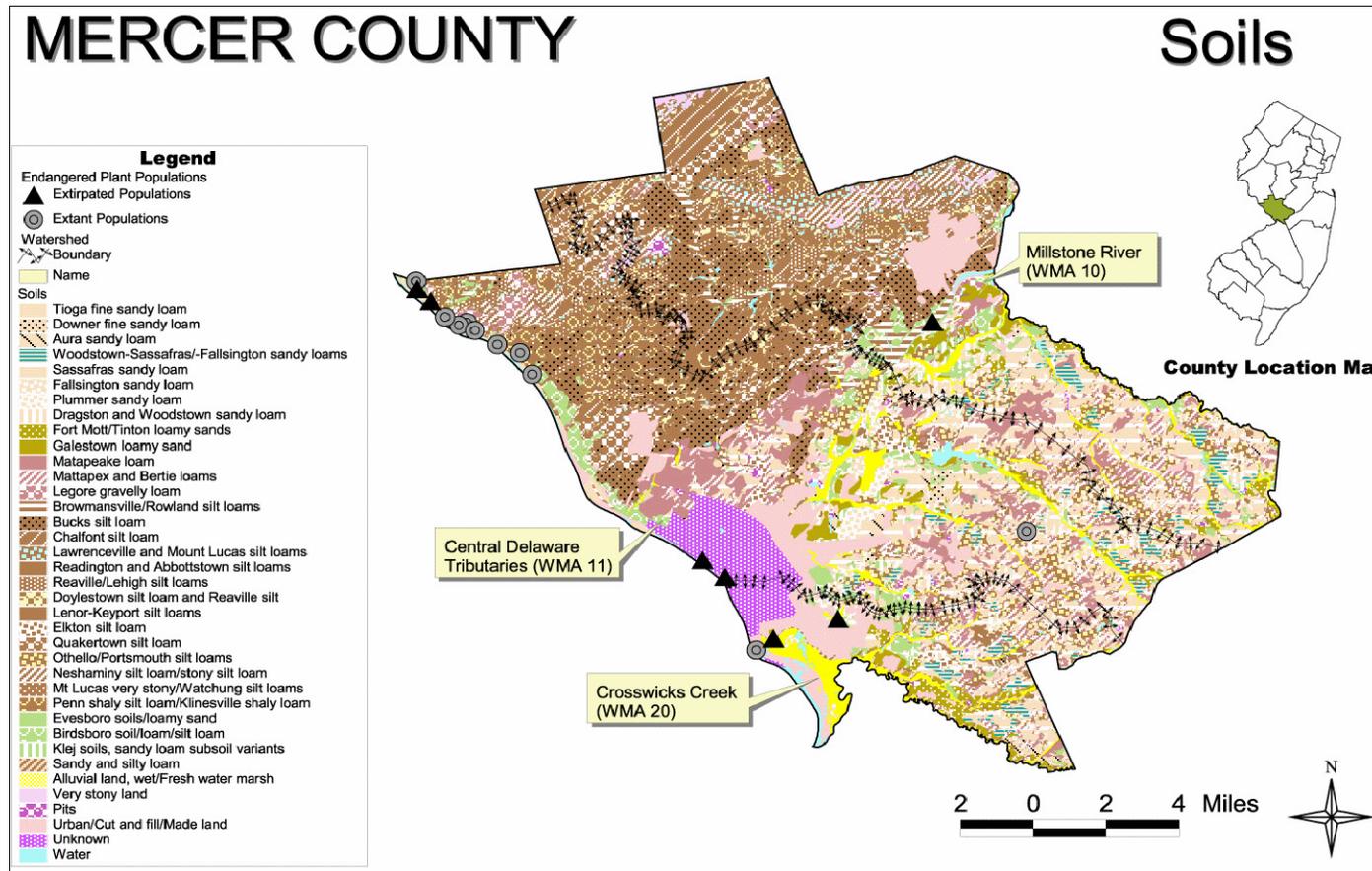
NJ Department of Environmental Protection
Division of Parks and Forestry

Natural Lands Management



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B11.2. Extant and extirpated plant populations by hydrology and primary geology in Mercer County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B11.3. Extant and extirpated plant populations by soil type in Mercer County.

Middlesex County

There were 22 extant and extirpated species in Middlesex County, including seven extant populations and 19 extirpated populations (Table B12.1). Extant populations were found on forested, agricultural, wetland and urban land (Table B12.2, Figure B12.1). Road construction was a common threat to extant populations. Common causes of extirpation included development, urbanization, and industry.

Portions of the Lower Raritan, South River, Lawrence Brook WMA, the Millstone River, Monmouth Watersheds WMA, and the Elizabeth, Rahway, Woodbridge WMA are found in Middlesex County (Figure B12.2). Most extant and extirpated plant populations were found in the Lower Raritan, South River, Lawrence Brook WMA, which occupies the majority of Middlesex County. This WMA is underlain mostly by the Brunswick, as well as the Magothy and Raritan geologic formations.

Although there are a variety of soil types found in Middlesex County, the majority of population extirpations in this county occurred on areas classified as urban land complexes/urban land (Figure B12.3).

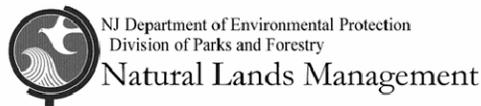
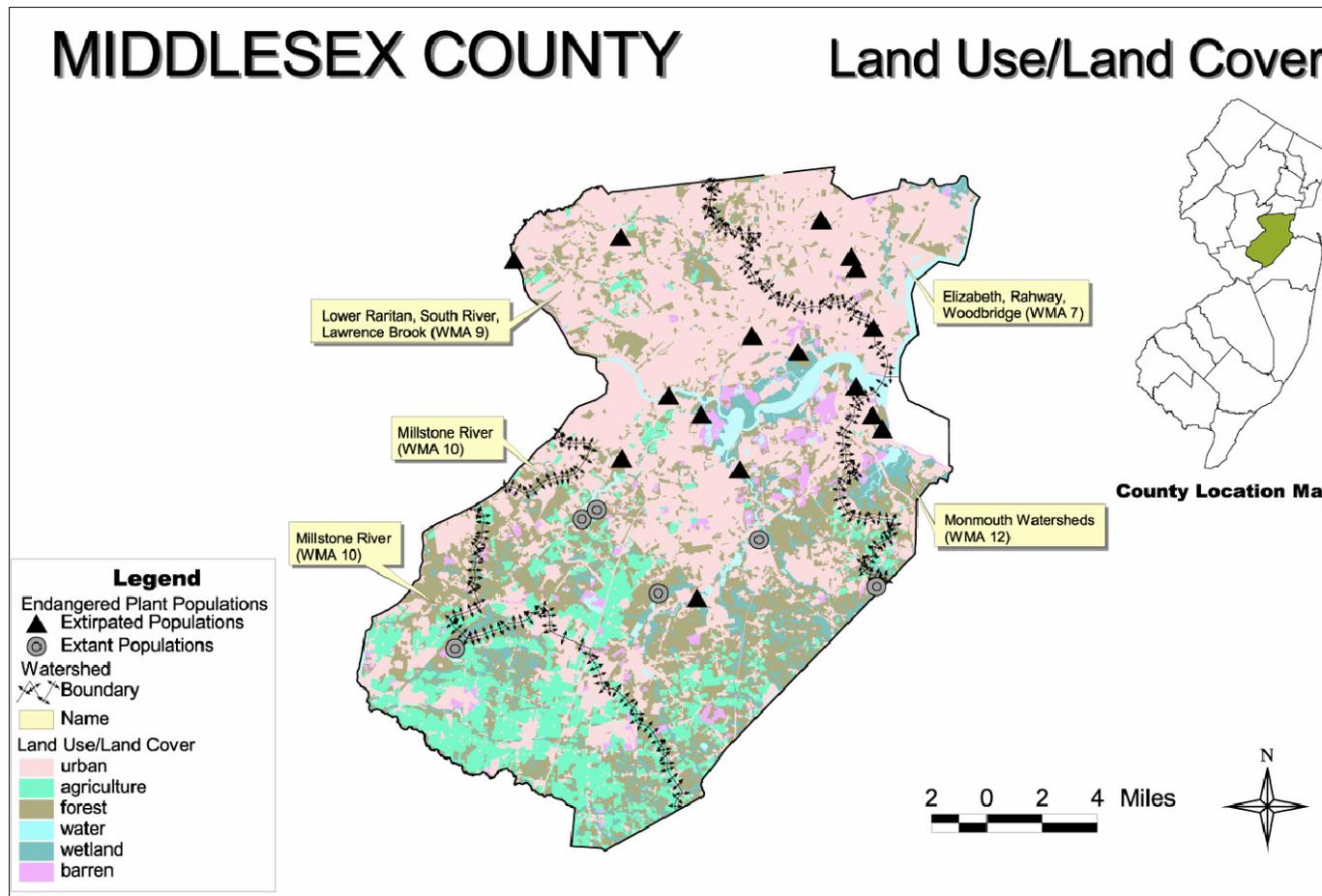
Table B12.1. Plant species populations in Middlesex County.

| SPECIES | POPULATIONS |
|---------------------------|------------------------|
| AGALINIS AURICULATA | 1 extirpated |
| ASTER RADULA | 1 extant, 1 extirpated |
| CAREX POLYMORPHA | 2 extirpated |
| CRATAEGUS CALPODENDRON | 1 extirpated |
| DRABA REPTANS | 1 extirpated |
| HELONIAS BULLATA | 1 extant, 3 extirpated |
| HOTTONIA INFLATA | 1 extirpated |
| HYDROCOTYLE RANUNCULOIDES | 1 extant |
| LATHYRUS OCHROLEUCUS | 1 extirpated |
| MELANTHIUM VIRGINICUM | 1 extirpated |
| MYRIOPHYLLUM TENELLUM | 1 extant |
| POLYGONUM GLAUCUM | 2 extirpated |
| SAGITTARIA AUSTRALIS | 1 extant |
| VERBENA SIMPLEX | 1 extirpated |
| ZIGADENUS LEIMANTHOIDES | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

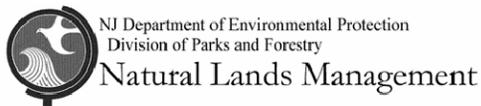
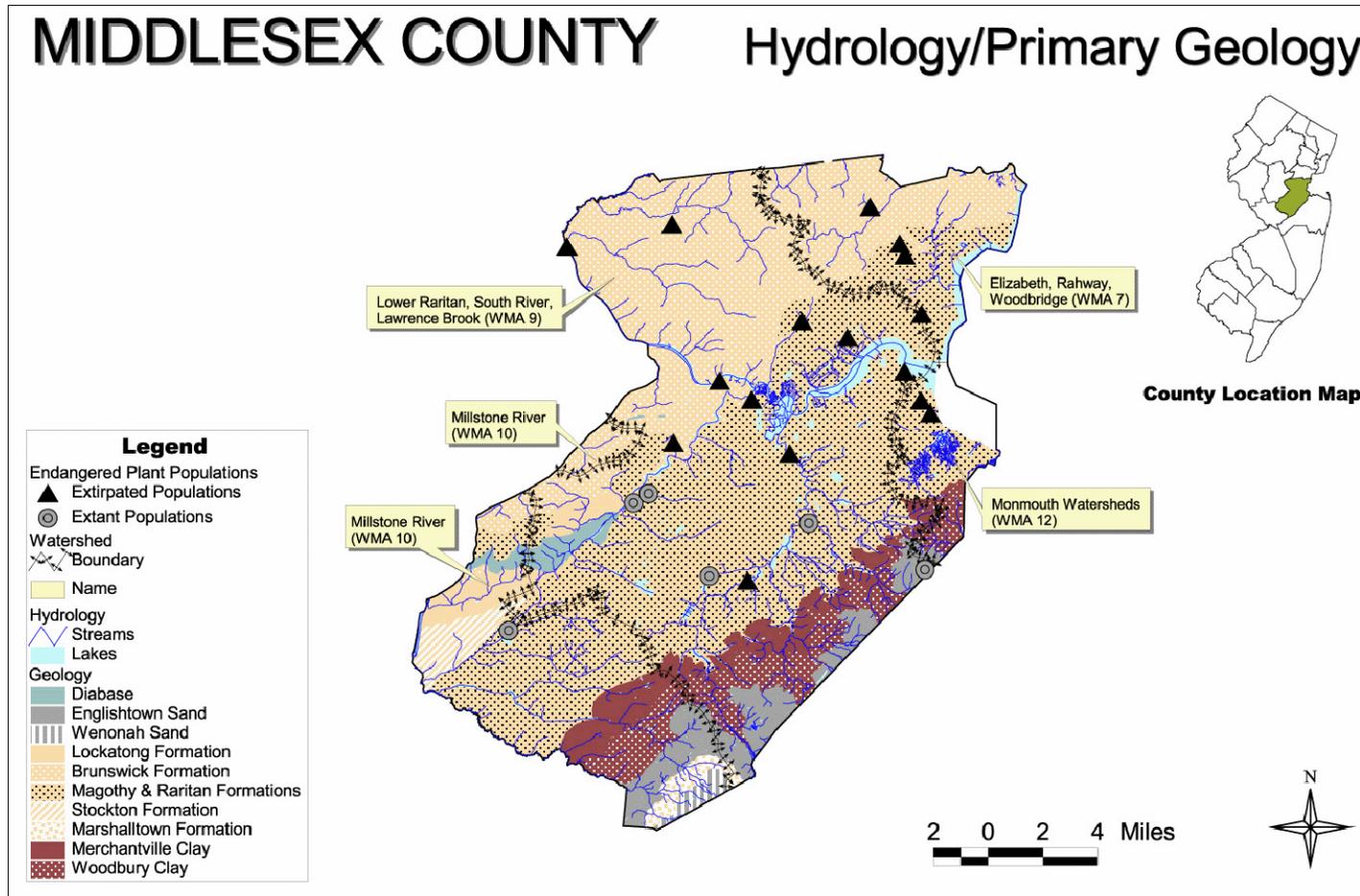
Table B12.2. Extant plant populations in Middlesex County by land use.

| MIDDLESEX COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 1 |
| Agriculture | 2 |
| Forest | 3 |
| Water | 0 |
| Wetlands | 1 |
| Barren | 0 |
| Total number of populations | 7 |



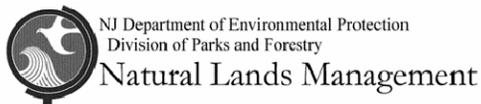
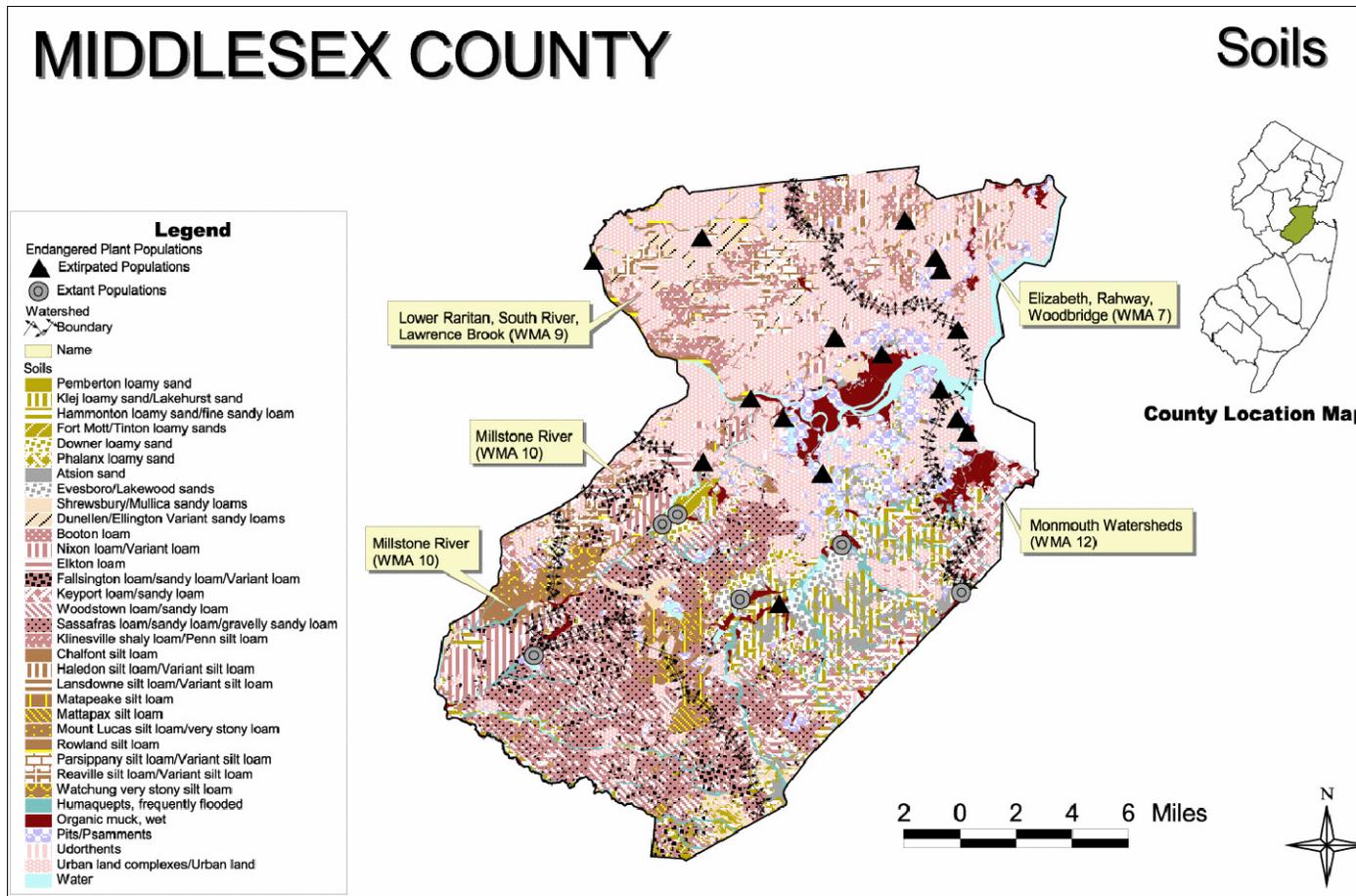
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B12.1. Extant and extirpated plant populations by land use/land cover in Middlesex County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B12.2. Extant and extirpated plant populations by hydrology and primary geology in Middlesex County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B12.3. Extant and extirpated plant populations by soil type in Middlesex County.

Endangered Plant Species Populations Monmouth County

Appendix B13 Monmouth

There were 15 extant and extirpated species in Monmouth County, including 27 extant populations and 13 extirpated populations (Table B13.1). Extant populations were found mainly on wetland, forested, and urban land (Table B13.2, Figure B13.1). Common threats to extant populations included right of ways and development. Development was also the most common cause of extirpation.

Portions of the Lower Raritan, South River, Lawrence Brook WMA, the Millstone River WMA, the Central Delaware Tributaries WMA, the Barnegat Bay WMA, the Crosswicks Creek WMA, and the Monmouth Watersheds WMA are found in Monmouth County (Figure B13.2). A concentration of extirpated populations was found in the Monmouth Watersheds WMA along the coast. The soils in this region are classified as urban complexes (Figure B13.3). A concentration of extant populations was found in a central portion of the same WMA that is underlain by the Vincentown Sand geologic formation (Figure B13.2). This area is dominated by Atison, Evesboro, Lakehurst, and Lakewood sands and by Udorthents (Figure B13.3).

Endangered Plant Species Populations

Table B13.1. Plant species populations in Monmouth County.

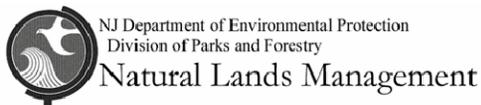
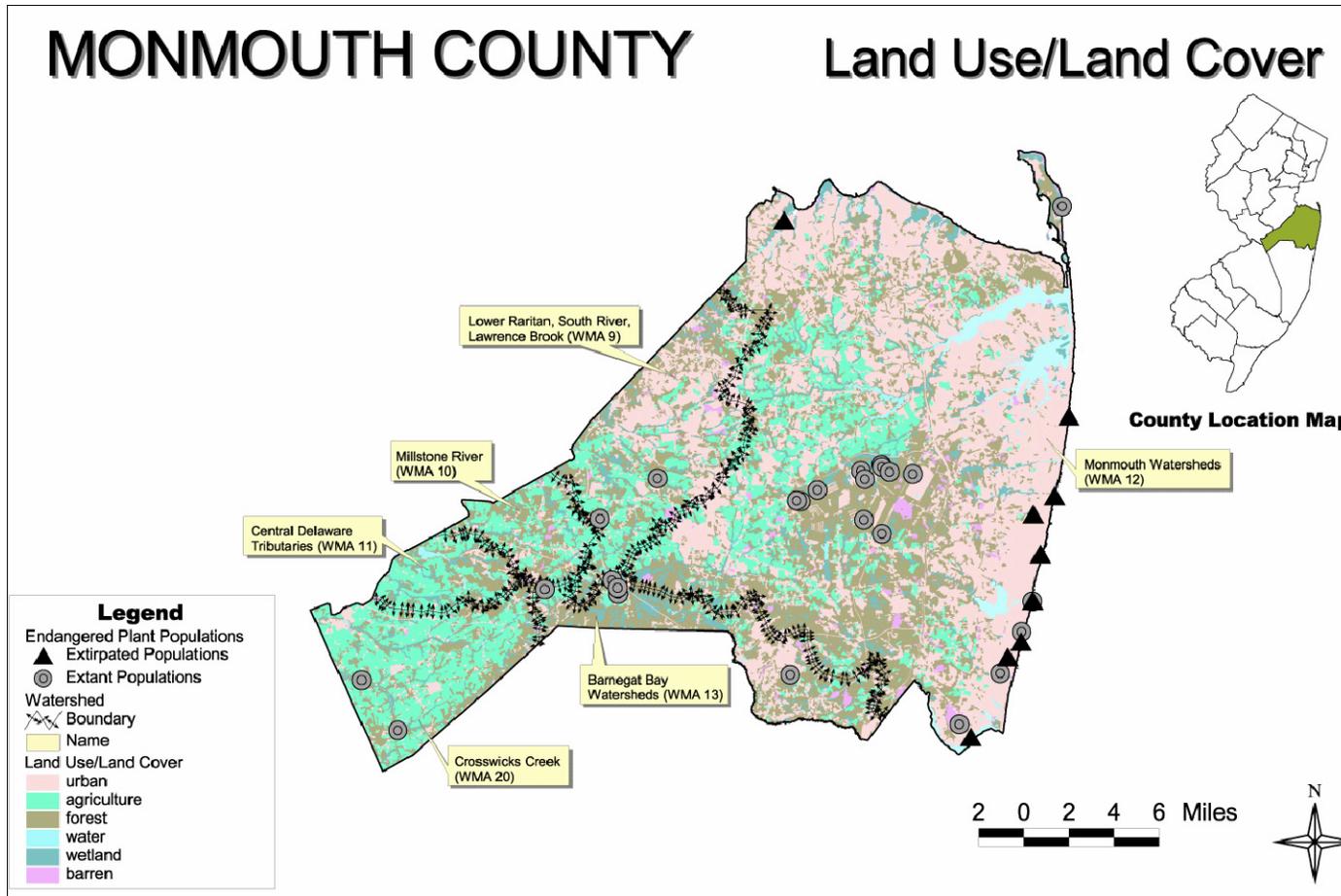
| SPECIES | POPULATIONS |
|-------------------------------------|------------------------|
| AMARANTHUS PUMILUS | 1 extirpated |
| CALAMAGROSTIS PICKERINGII | 1 extant |
| FRAXINUS PROFUNDA | 1 extant |
| GLAUX MARITIMA | 1 extirpated |
| HELONIAS BULLATA | 9 extant |
| JUNCUS CAESARIENSIS | 7 extant |
| LIATRIS SCARIOSA var. NOVAE-ANGLIAE | 1 extirpated |
| LIMOSELLA SUBULATA | 2 extant, 2 extirpated |
| LUZULA ACUMINATA | 1 extant |
| MYRIOPHYLLUM TENELLUM | 1 extirpated |
| POLYGONUM GLAUCUM | 2 extant, 2 extirpated |
| RANUNCULUS CYMBALARIA | 3 extirpated |
| RHYNCHOSPORA KNIESKERNII | 3 extant |
| SAGITTARIA AUSTRALIS | 1 extant |
| SCIRPUS MARITIMUS | 2 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Endangered Plant Species Populations

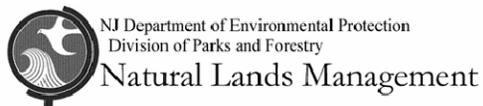
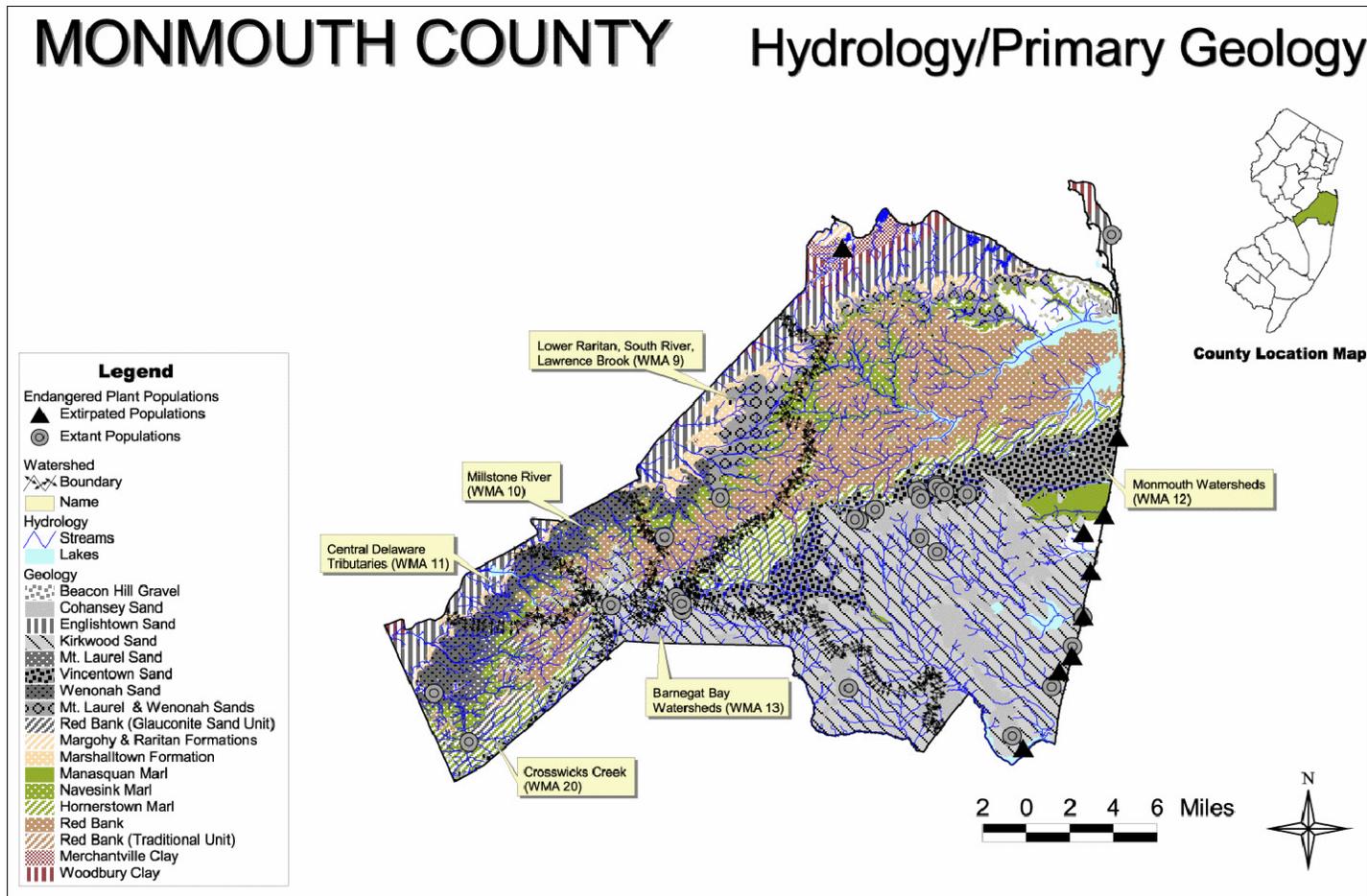
Table B13.2. Extant plant populations in Monmouth County by land use.

| MONMOUTH COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|---------------------------------|-------------------------------------|
| Urban | 9 |
| Agriculture | 0 |
| Forest | 8 |
| Water | 0 |
| Wetlands | 8 |
| Barren | 2 |
| Total number of populations | 27 |



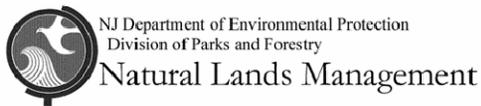
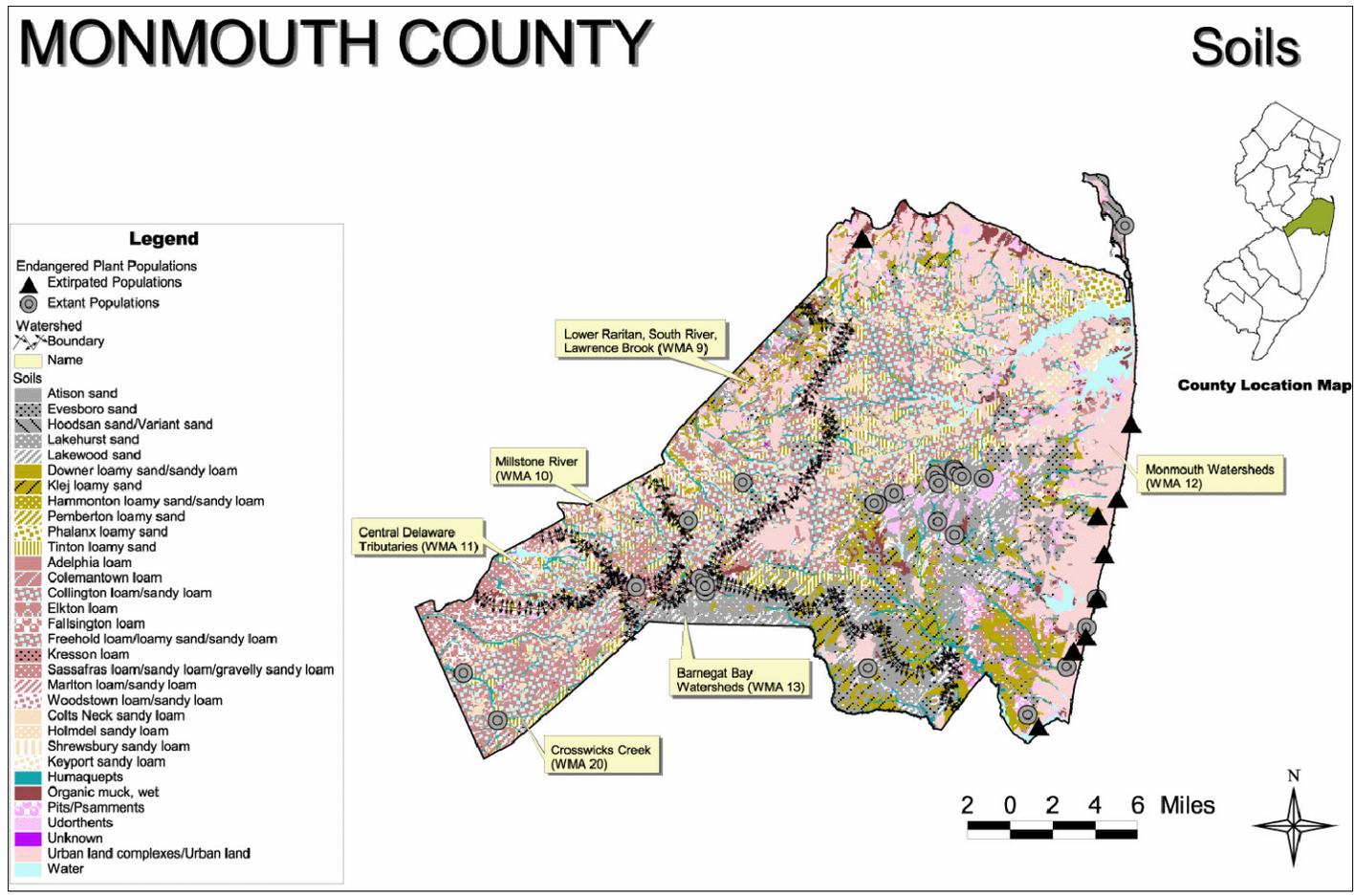
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B13.1. Extant and extirpated plant populations by land use/land cover in Monmouth County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B13.2. Extant and extirpated plant populations by hydrology and primary geology in Monmouth County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B13.3. Extant and extirpated plant populations by soil type in Monmouth County.

Endangered Plant Species Populations
Morris County

There were 24 extant and extirpated species in Morris County, including 25 extant populations and six extirpated populations (Table B14.1). Extant populations were recorded mainly on wetland, forested, and urban land (Table B14.2, Figure B14.1). Development was the most common cause of extirpation, and common threats to extant populations were recreation, succession, and right of ways.

Portions of the Upper Delaware River WMA, the Pompton, Pequannock, Wanaque, Ramapo WMA, the North and South Branch Raritan WMA, and the Upper Passaic, Whippany, Rockaway WMA are found within Morris County (Figure B14.2).

Soil types in Morris County include a variety of loams, loamy sands, gravelly loams, stony loams, sandy loams, gravelly sandy loams, stony sandy loams, silt loams, shaly silt loams, and mucks (Figure B14.3). There are also areas of rock outcrop complexes, urban land, alluvial land, and water. There were a relatively large number of extant plant populations in areas with muck and water.

Table B14.1. Plant species populations in Morris County.

| SPECIES | POPULATIONS |
|--------------------------|------------------------|
| ANDROMEDA GLAUCOPHYLLA | 1 extirpated |
| ASPLENIUM BRADLEYI | 1 extant |
| ASTER RADULA | 1 extant |
| CAREX LEPTONERVA | 1 extant |
| CAREX POLYMORPHA | 2 extant |
| CAREX SICCATATA | 1 extant |
| CUSCUTA CEPHALANTHI | 1 extant |
| EQUISETUM VARIEGATUM | 2 extant |
| HELONIAS BULLATA | 2 extant |
| HOTTONIA INFLATA | 2 extant |
| ILEX MONTANA | 1 extant |
| LEDUM GROENLANDICUM | 1 extirpated |
| MELANTHIUM VIRGINICUM | 1 extant, 1 extirpated |
| POTAMOGETON OBTUSIFOLIUS | 1 extant |
| POTAMOGETON ROBBINSII | 1 extant |
| SMILACINA TRIFOLIA | 1 extant |
| SPARGANIUM MINIMUM | 2 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |

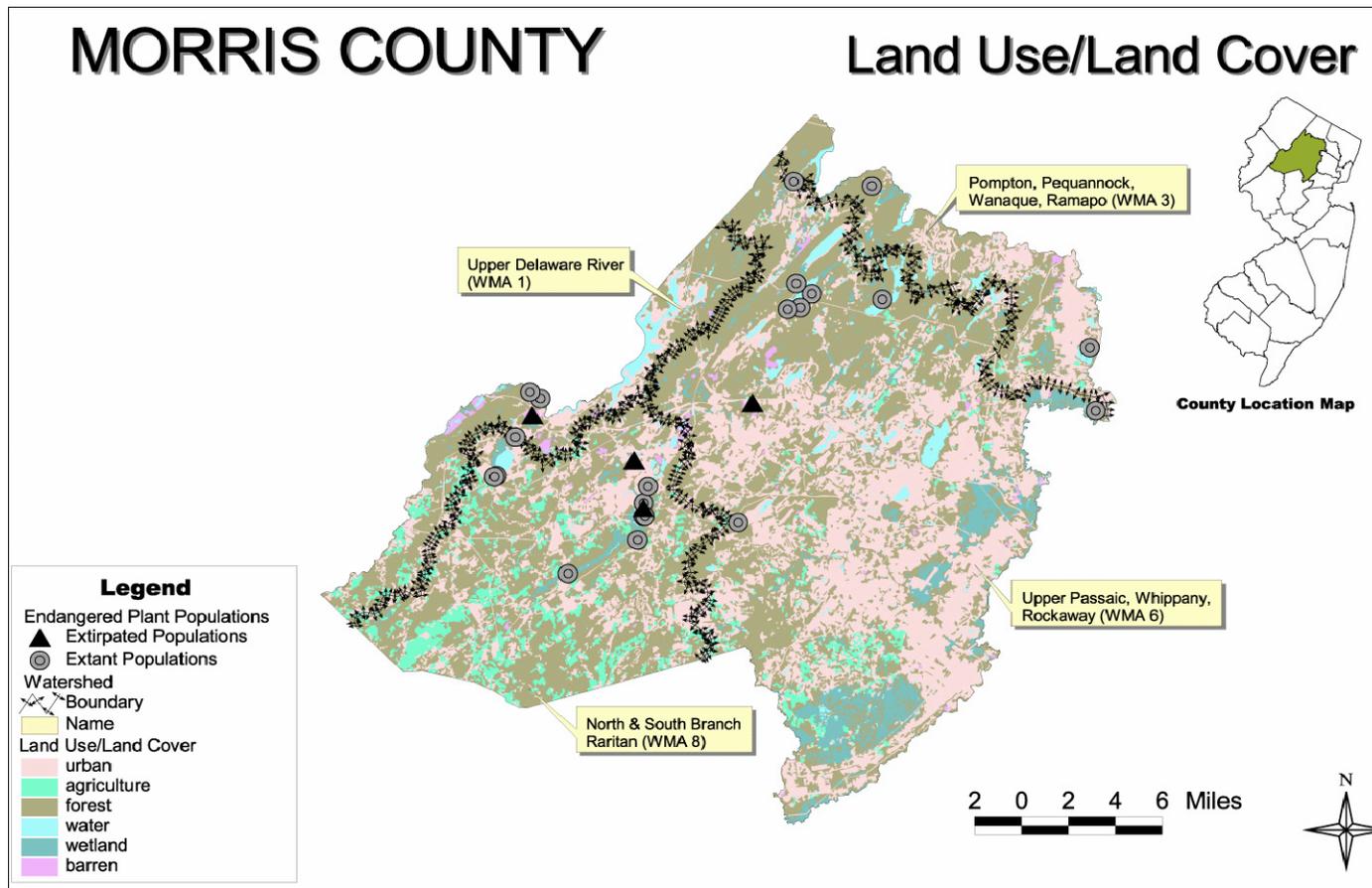
Endangered Plant Species Populations

| | |
|--------------------|--------------|
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 2 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

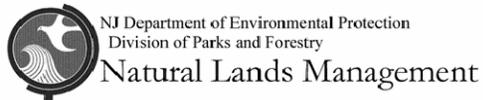
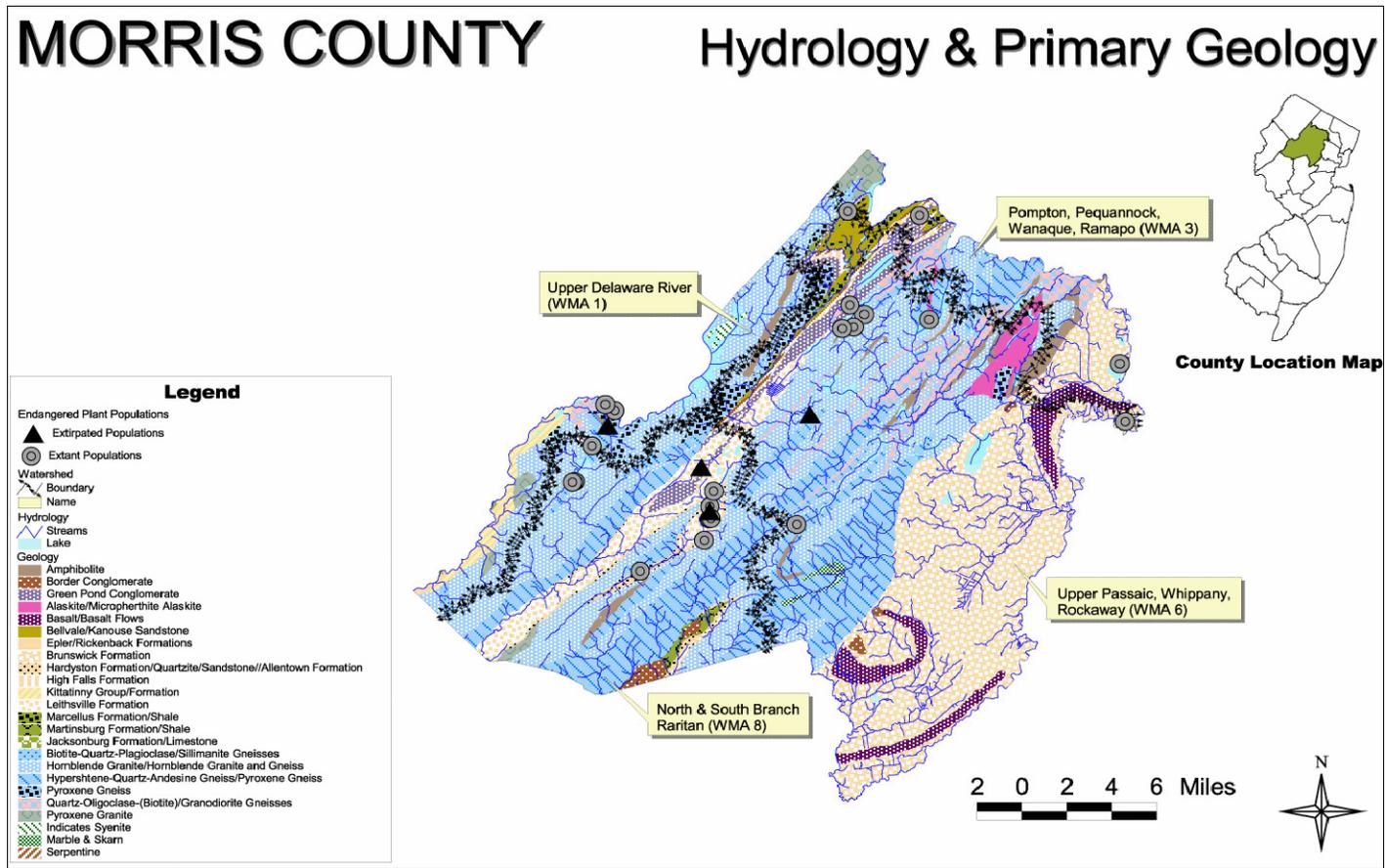
Table B14.2. Extant plant populations in Morris County by land use.

| MORRIS COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 4 |
| Agriculture | 0 |
| Forest | 14 |
| Water | 2 |
| Wetlands | 5 |
| Barren | 0 |
| Total number of populations | 25 |



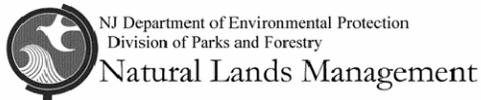
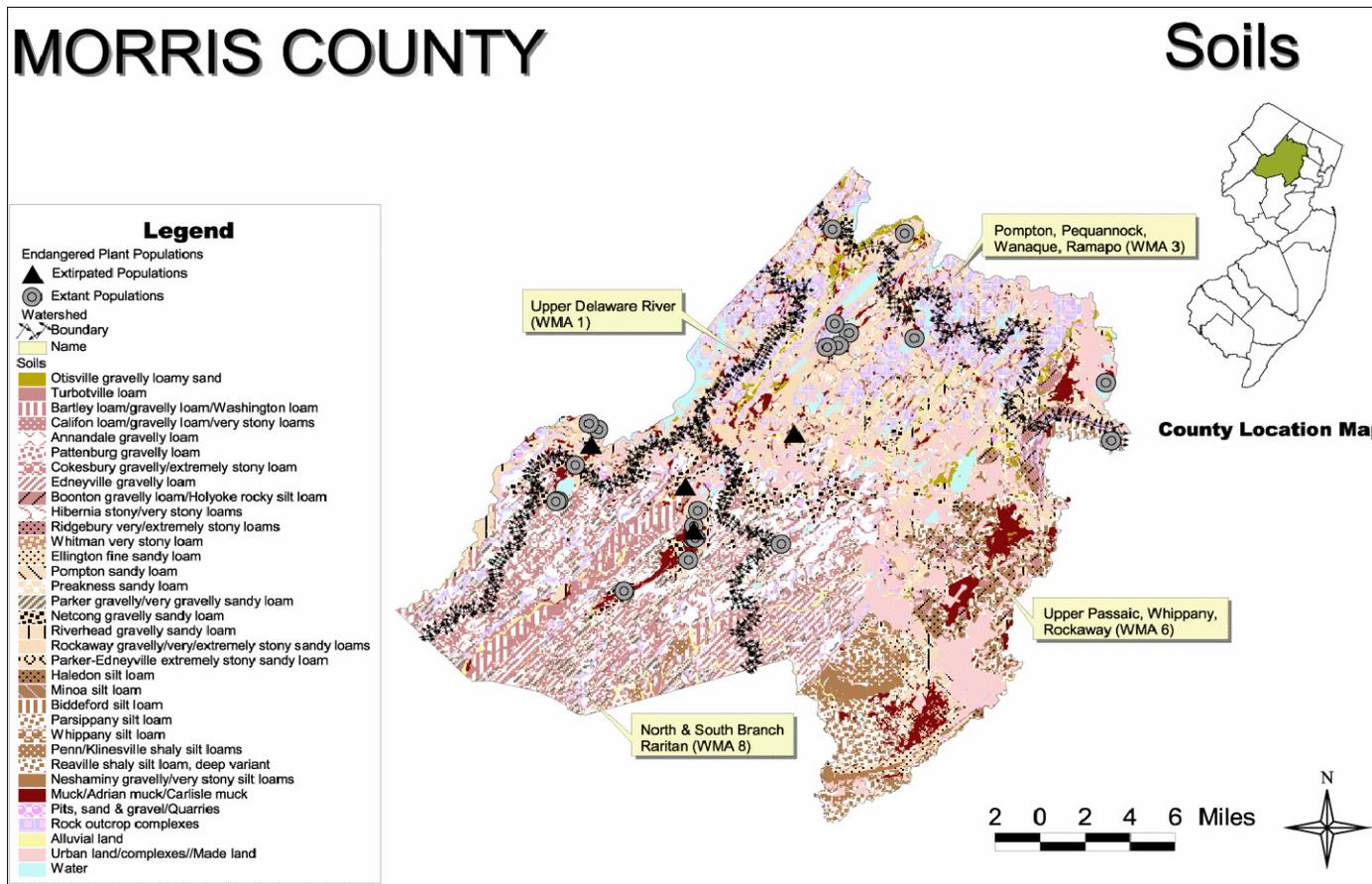
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B14.1. Extant and extirpated plant populations by land use/land cover in Morris County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B14.2. Extant and extirpated plant populations by hydrology and primary geology in Morris County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B14.3. Extant and extirpated plant populations by soil type in Morris County.

Ocean County

There were 23 extant and extirpated species in Ocean County, including 71 extant populations and 13 extirpated populations (Table B15.1).

Extant populations were found mainly in forested and wetland areas (Table B15.2, Figure B15.1). Common threats to extant populations included recreation, succession, and roadways.

Development was the most common cause of extirpation.

Portions of the Crosswicks Creek WMA, the Monmouth Watersheds WMA, the Rancocas Creek WMA, the Barnegat Bay WMA, and the Mullica, Wading River WMA are found in Ocean County (Figure B15.2). This county is underlain mostly by the Cohansey Sand geologic formation. There were a relatively large number of extant populations found in the Barnegat Bay WMA in Ocean County.

Ocean County is dominated by sand soil types, such as Lakewood sand, Lakehurst sand, Woodmansie sand, and Downer sandy loam/gravelly sandy loam (Figure B15.3). Thus, the majority of the extant populations in Ocean County are found on these soil types.

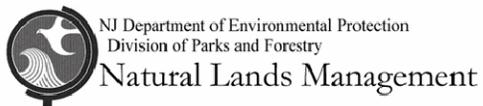
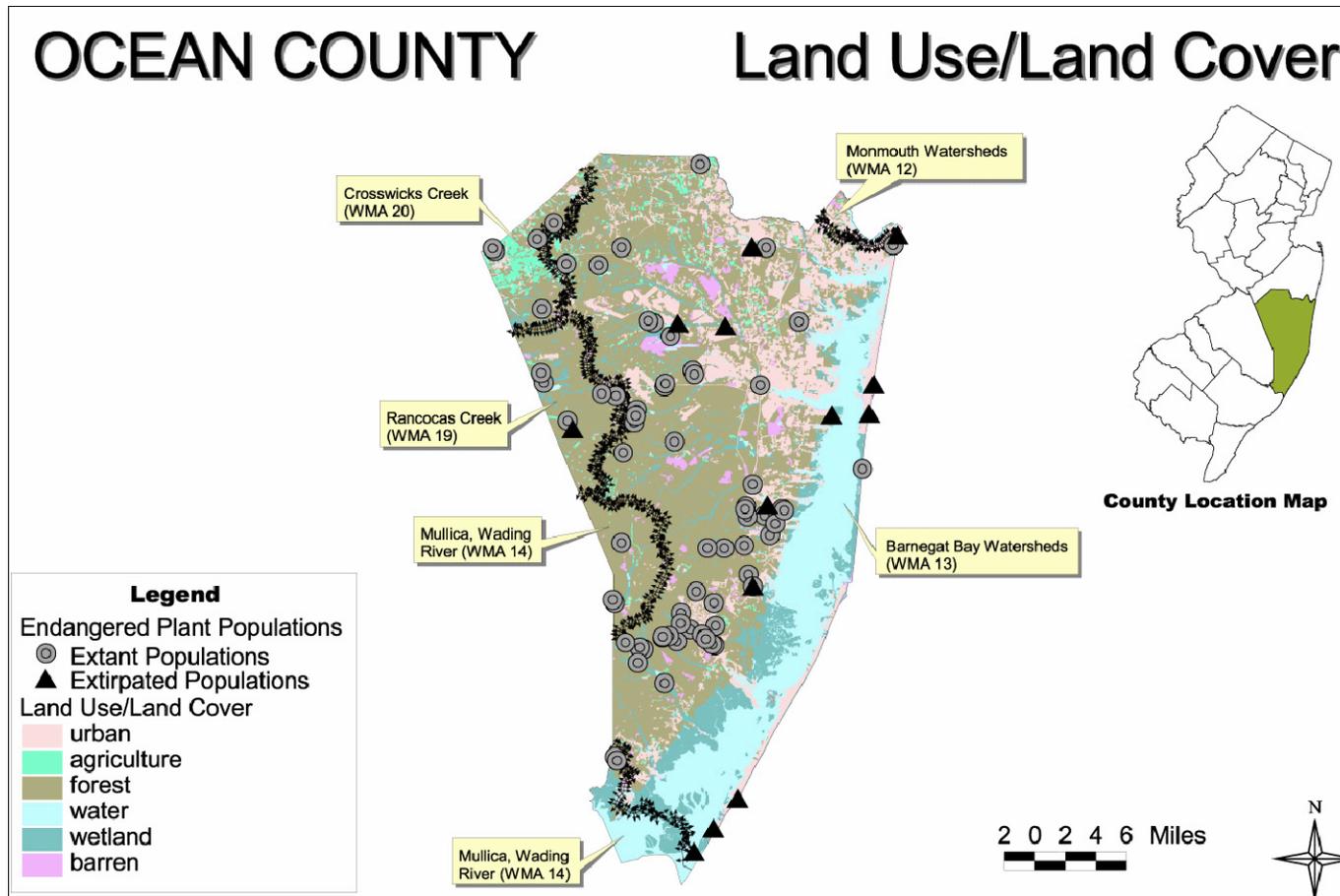
Table B15.1. Plant species populations in Ocean County.

| SPECIES | POPULATIONS |
|---------------------------------------|-------------------------|
| AMARANTHUS PUMILUS | 1 extirpated |
| COREMA CONRADII | 2 extant |
| ELEOCHARIS TORTILIS | 1 extirpated |
| EUPATORIUM RESINOSUM | 7 extant |
| FRAXINUS PROFUNDA | 1 extant |
| HEDYOTIS LONGIFOLIA | 1 extirpated |
| HELONIAS BULLATA | 20 extant, 1 extirpated |
| JUNCUS CAESARIENSIS | 6 extant |
| LIMOSELLA SUBULATA | 1 extirpated |
| LUDWIGIA BREVIPES | 1 extirpated |
| LUZULA ACUMINATA | 1 extant |
| MYRIOPHYLLUM TENELLUM | 1 extant |
| NARTHECIUM AMERICANUM | 9 extant, 3 extirpated |
| PLANTAGO PUSILLA | 1 extirpated |
| POLYGONUM GLAUCUM | 1 extant |
| RHODODENDRON ATLANTICUM | 1 extant |
| RHYNCHOSPORA KNIESKERNII | 15 extant |
| SCIRPUS LONGII | 1 extant |
| SCIRPUS MARITIMUS | 2 extirpated |
| STYLISMA PICKERINGII var. PICKERINGII | 4 extant |
| UTRICULARIA BIFLORA | 1 extant |
| ZIGADENUS LEIMANTHOIDES | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

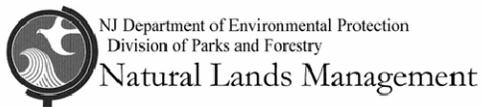
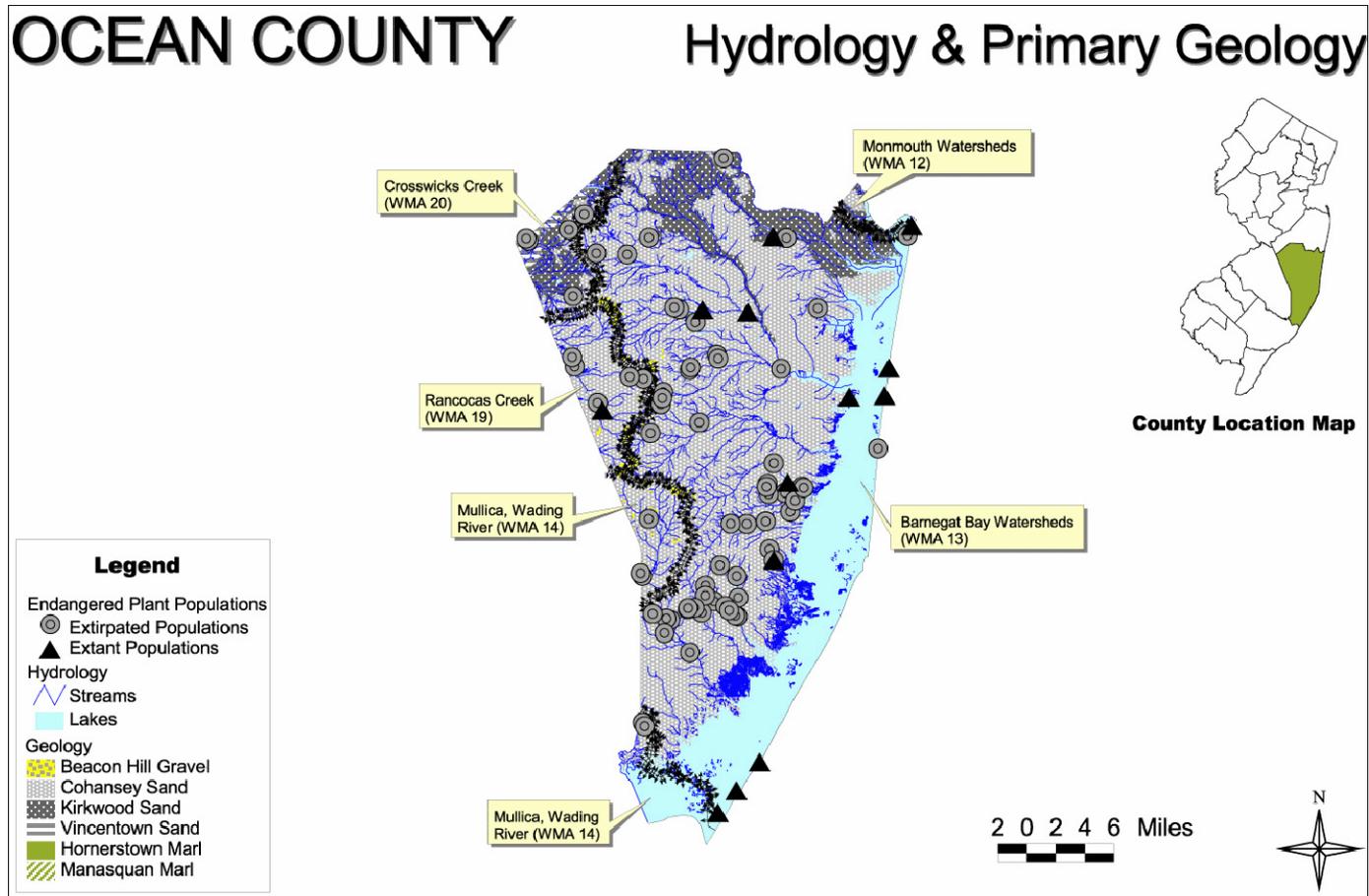
Table B15.2. Extant plant populations in Ocean County by land use.

| OCEAN COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 4 |
| Agriculture | 1 |
| Forest | 34 |
| Water | 2 |
| Wetlands | 27 |
| Barren | 2 |
| Undetermined | 1 |
| Total number of populations | 71 |



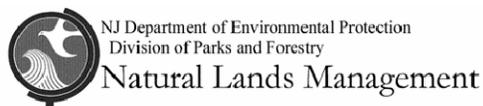
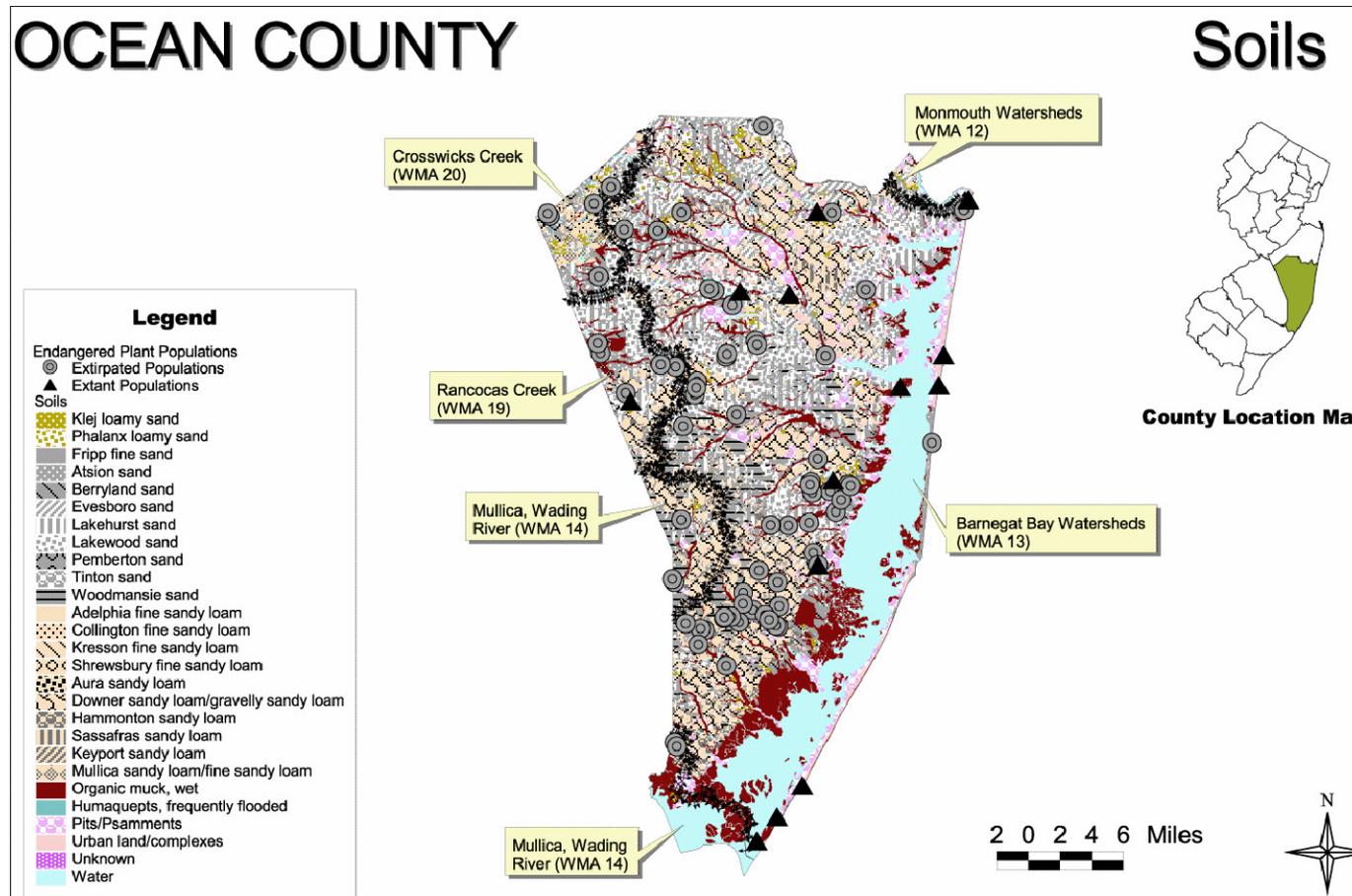
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B15.1. Extant and extirpated plant populations by land use/land cover in Ocean County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B15.2. Extant and extirpated plant populations by hydrology and primary geology in Ocean County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B15.3. Extant and extirpated plant populations by soil type in Ocean County.

Passaic County

There were 19 extant and extirpated species in Passaic County, including 17 extant populations and four extirpated populations (Table B16.1). Extant populations were found in forested, water, and wetland areas (Table B16.2, Figure B16.1). Common threats to extant populations were succession and recreation. Causes for extirpations included development, urbanization, damming, dumping, and pollution.

Portions of the Walkill, Pochuck, Papakating WMA, the Pompton, Pequannock, Wanaque, Ramapo WMA, and the Lower Passaic, Saddle WMA are found in Passaic County (Figure B16.2). A concentration of extant and extirpated endangered plant populations was found on the Basalt/Basalt Flows geologic formation in the southern portion of the county.

Soil types in Passaic County include three types of sandy loam, two types of stony sandy loam, four stony loams, four silt loams, and one gravelly silt loam (Figure B16.3). However, the county is dominated by rock outcrop and urban land complexes. There were no clear patterns in plant population occurrence and soil types in Passaic County.

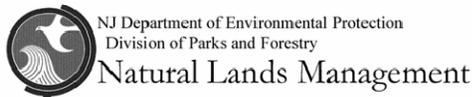
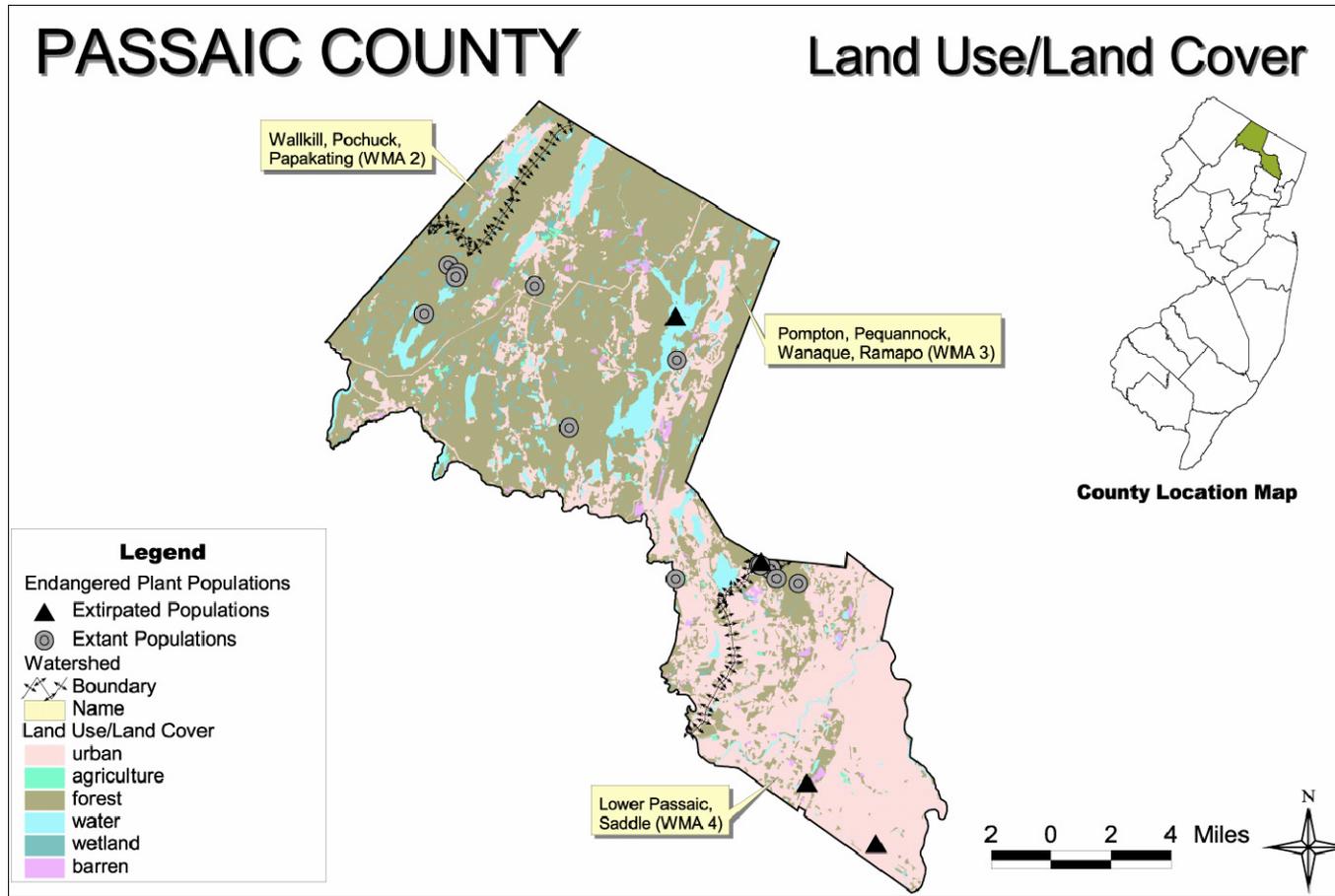
Table B16.1. Plant species populations in Passaic County.

| SPECIES | POPULATIONS |
|-----------------------------|------------------------|
| ANDROMEDA GLAUCOPHYLLA | 1 extant |
| CAREX BRUNNESCENS | 1 extant |
| CAREX DEWEYANA | 1 extirpated |
| EQUISETUM VARIEGATUM | 1 extant |
| GAULTHERIA HISPIDULA | 1 extant |
| HEMICARPHA MICRANTHA | 1 extant |
| ILEX MONTANA | 1 extant |
| LECHEA TENUIFOLIA | 1 extant, 1 extirpated |
| MUHLENBERGIA CAPILLARIS | 1 extant |
| PYCNANTHEMUM CLINOPODIOIDES | 1 extant |
| PYCNANTHEMUM TORREI | 1 extant |
| SANICULA TRIFOLIATA | 1 extant |
| SCUTELLARIA LEONARDII | 2 extant |
| STELLARIA BOREALIS | 1 extant |
| VERBENA SIMPLEX | 1 extant |
| VIOLA SEPTENTRIONALIS | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

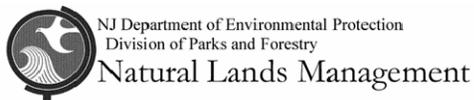
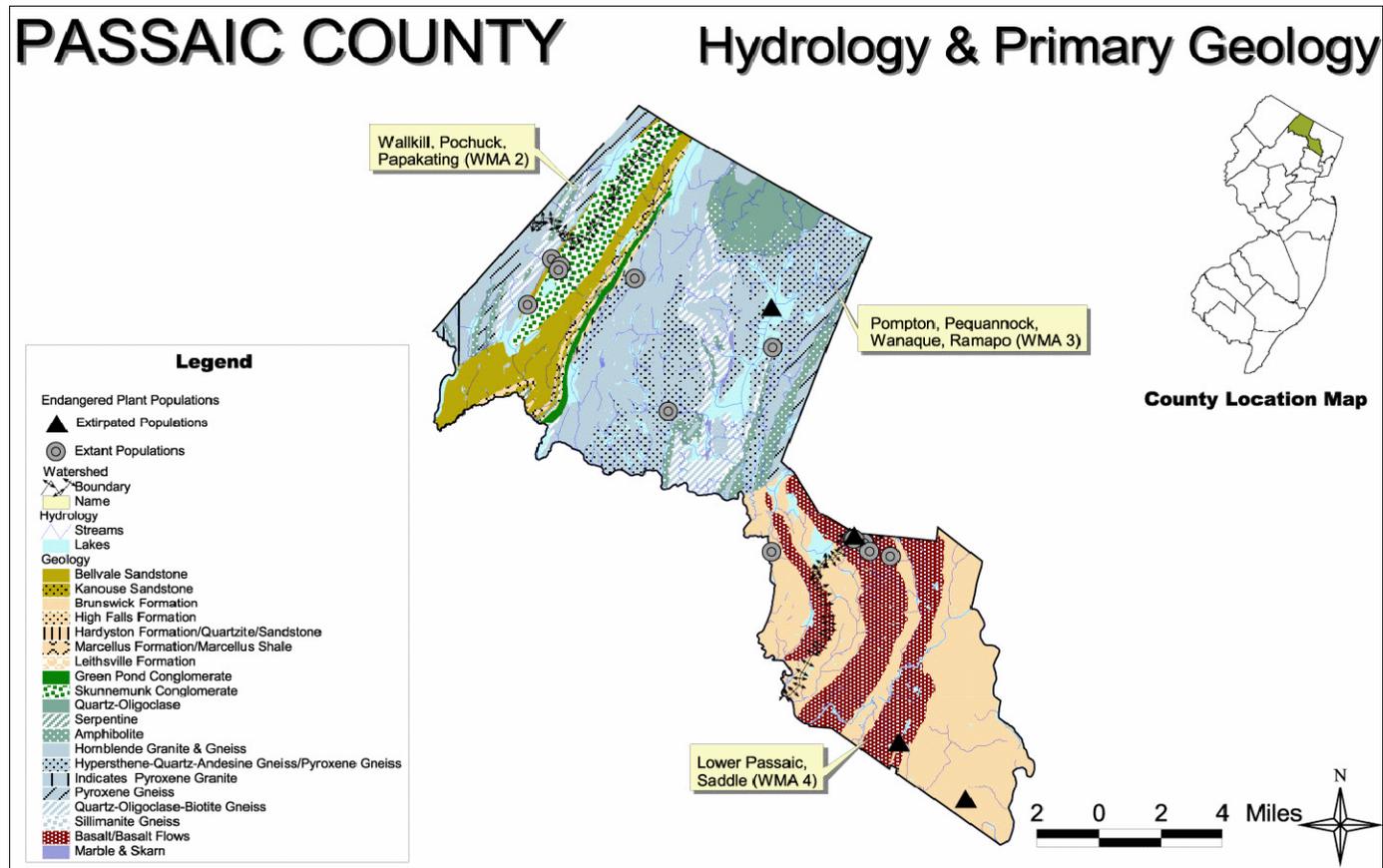
Table B16.2. Extant plant populations in Passaic County by land

| PASSAIC COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|--------------------------------|-------------------------------------|
| Urban | 0 |
| Agriculture | 0 |
| Forest | 11 |
| Water | 1 |
| Wetlands | 5 |
| Barren | 0 |
| Total number of populations | 17 |



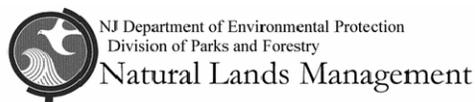
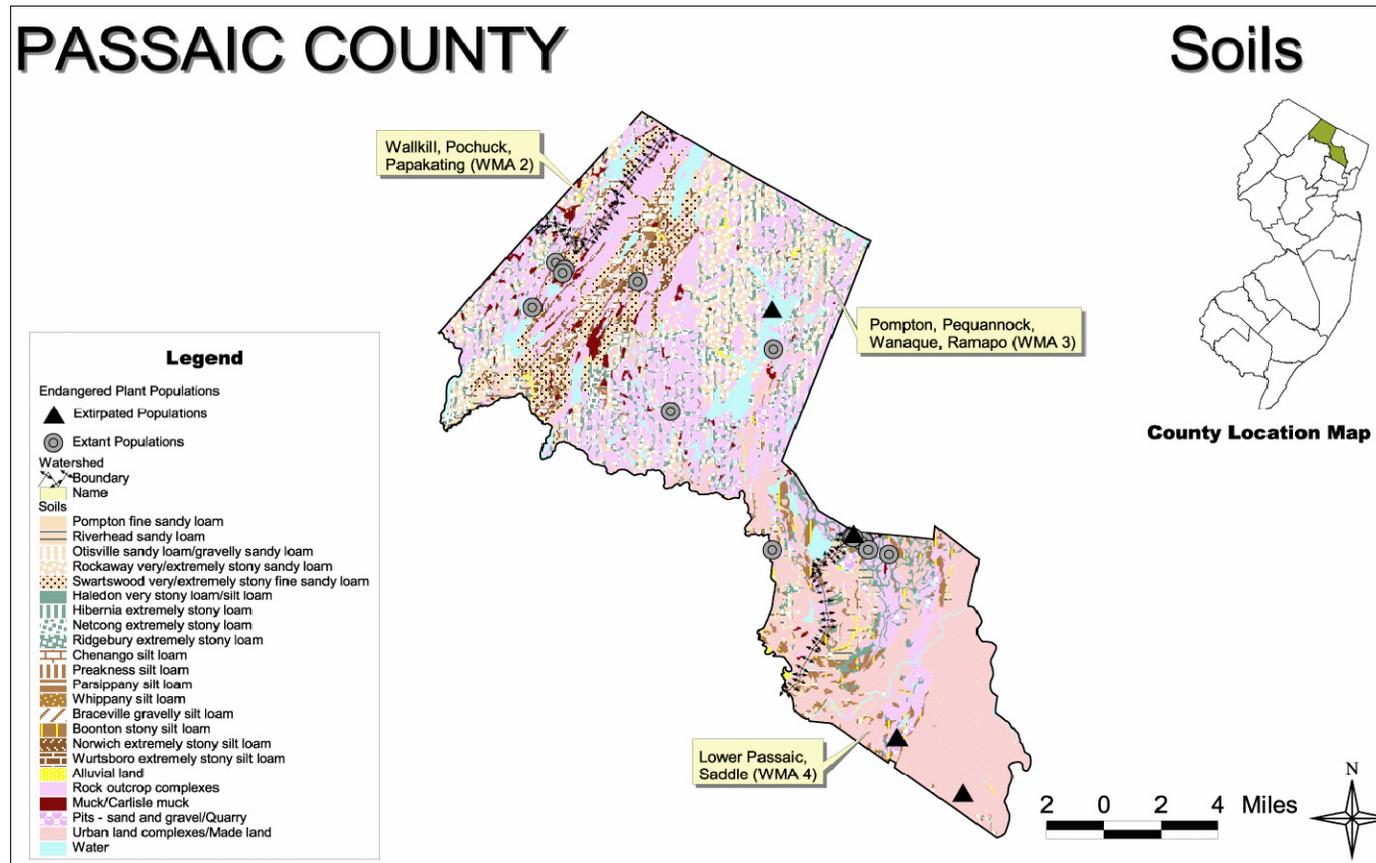
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B16.1. Extant and extirpated plant populations by land use/land cover in Passaic County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B16.2. Extant and extirpated plant populations by hydrology and primary geology in Passaic County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B16.3. Extant and extirpated plant populations by soil type in Passaic County.

Endangered Plant Species Populations Salem County

There were 12 extant and extirpated species Salem County, including 24 extant populations and three extirpated populations (Table B17.1). Extant populations were found mainly on forested and wetland sites (Table B17.2, Figure B17.1). Habitat disturbance was the most common threat to extant populations. Causes of extirpation included succession, pollution, and siltation.

Portions of the Lower Delaware Tributaries and the Maurice, Salem, Cohansey WMAs are found in Salem County (Figure B17.2). The majority of extant and extirpated populations in this county are found in areas underlain by the Cohansey sand and Kirkwood sand geologic formations.

Soil types of Salem County include three types of sand, five types of loamy sand, four types of sandy loams, one type of loam, four silt loams, udorthents, mucks, fluvaquents, and urban complexes (Figure B17.3). There were no clear patterns in plant population occurrence and soil type.

Endangered Plant Species Populations

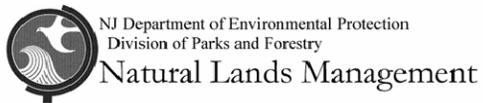
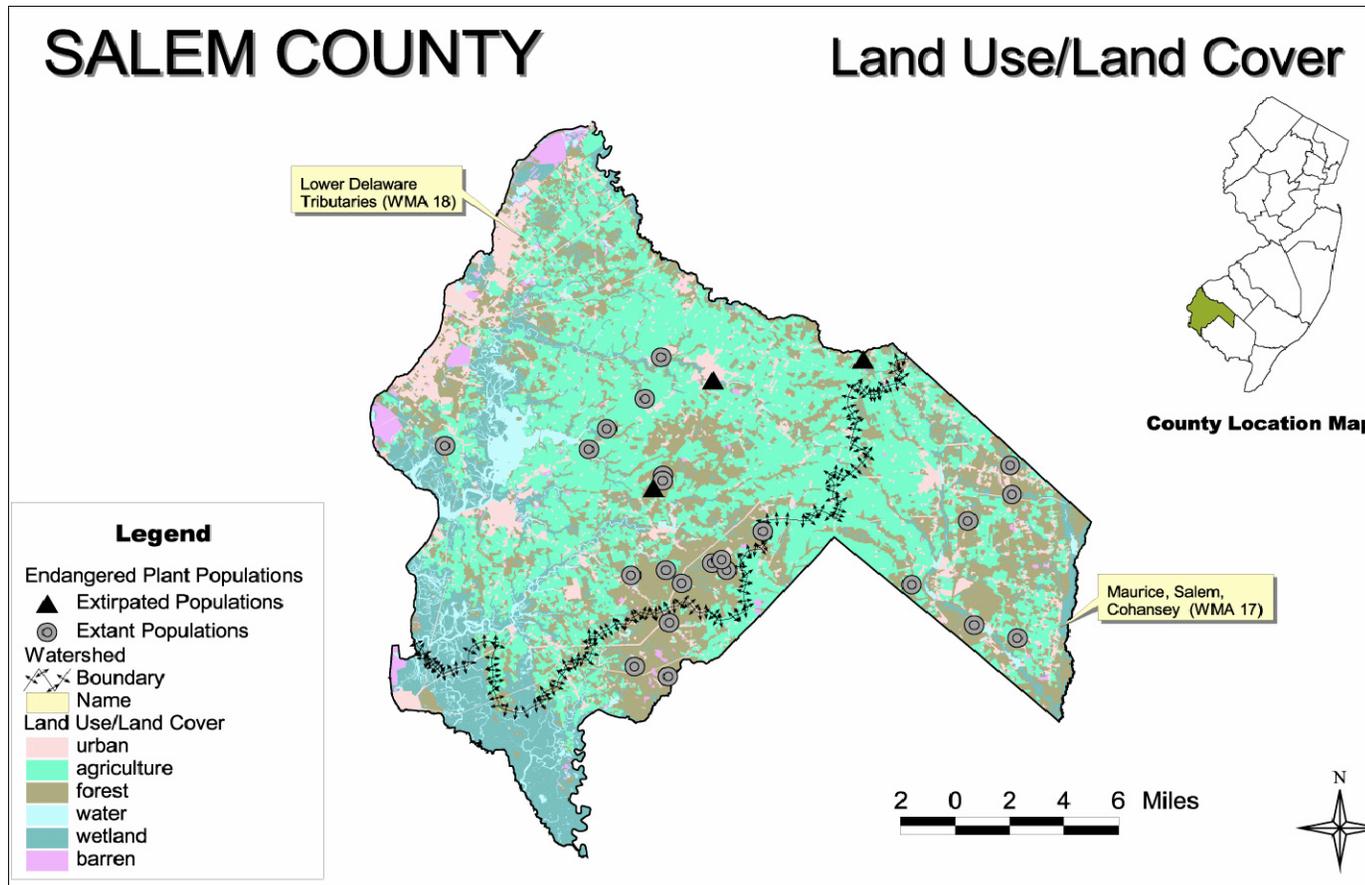
Table B17.1. Plant species populations in Salem County.

| SPECIES | POPULATIONS |
|---------------------------|-------------------------|
| CASTANEA PUMILA | 1 extant |
| HELONIAS BULLATA | 12 extant, 1 extirpated |
| HOTTONIA INFLATA | 1 extant |
| HYDROCOTYLE RANUNCULOIDES | 1 extant |
| HYPERICUM ADPRESSUM | 2 extant |
| LUZULA ACUMINATA | 1 extant |
| NELUMBO LUTEA | 1 extant, 1 extirpated |
| POLEMONIUM REPTANS | 2 extant |
| QUERCUS LYRATA | 1 extant |
| RHODODENDRON ATLANTICUM | 1 extant |
| WOLFFIELLA FLORIDANA | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

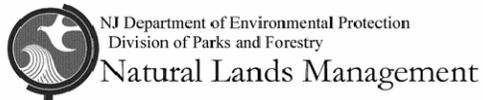
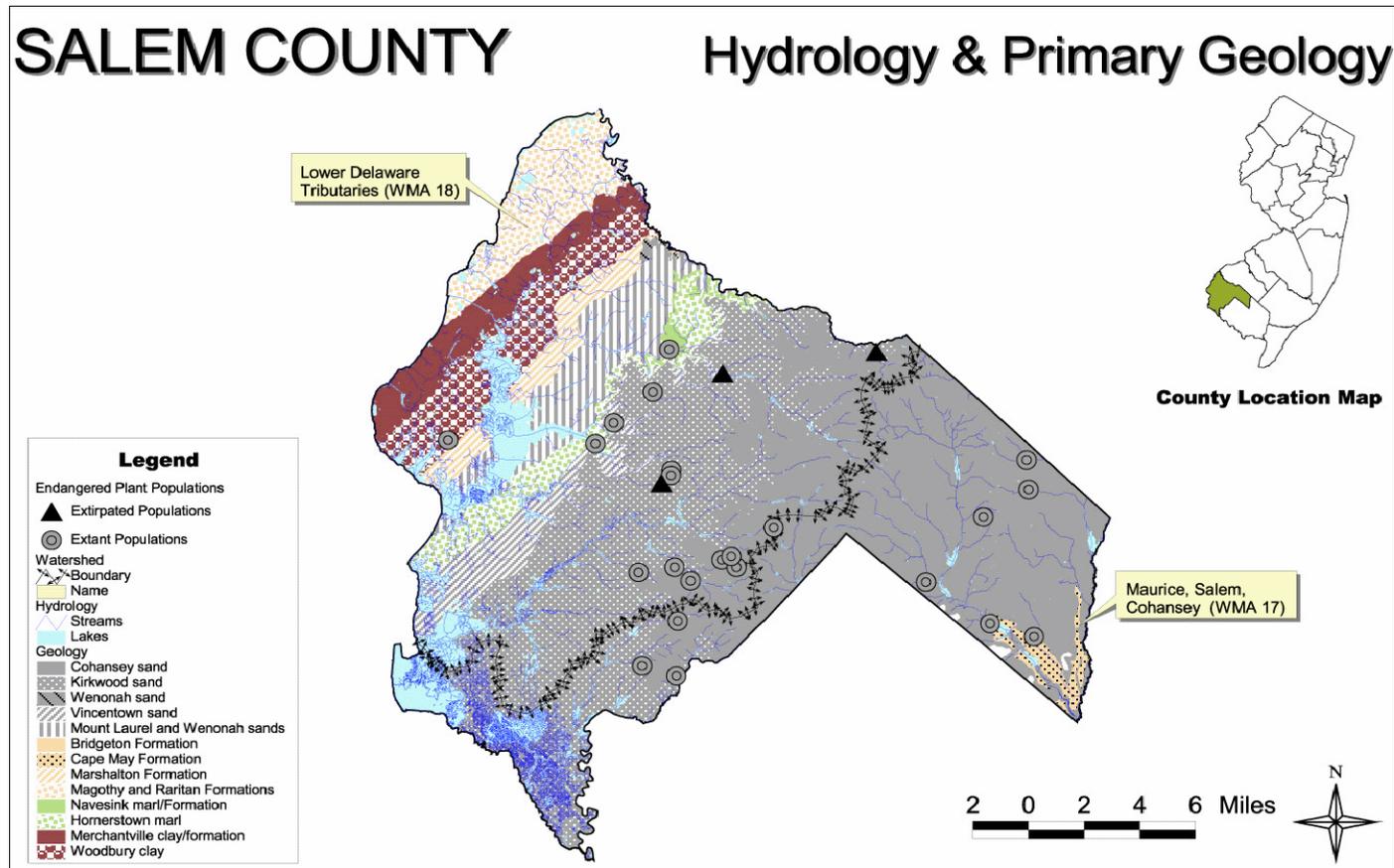
Table B17.2. Extant plant populations in Salem County by land use.

| SALAM COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 1 |
| Agriculture | 0 |
| Forest | 13 |
| Water | 2 |
| Wetlands | 7 |
| Barren | 1 |
| Total number of populations | 24 |



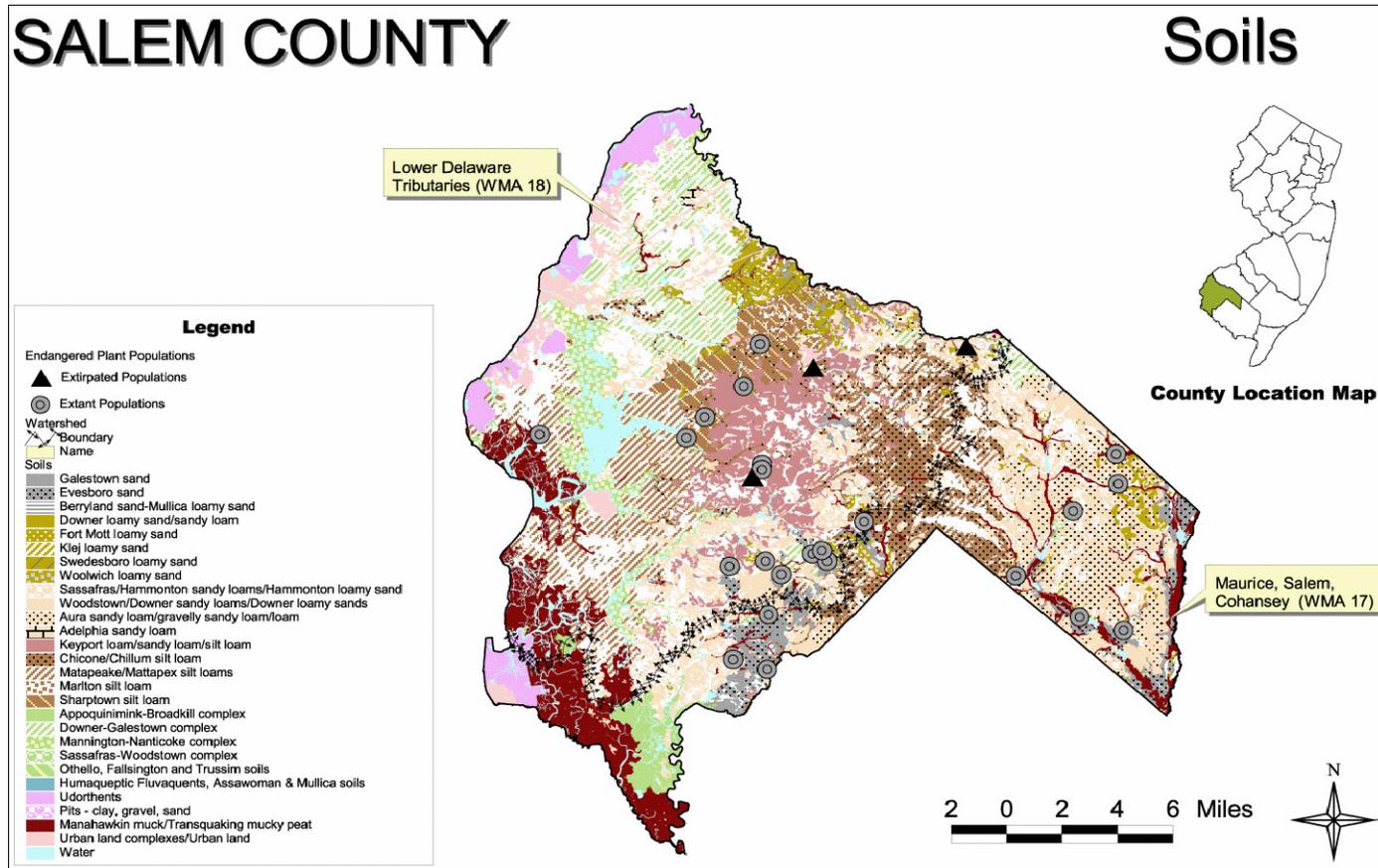
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B17.1. Extant and extirpated plant populations by land use/land cover in Salem County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B17.2. Extant and extirpated plant populations by hydrology and primary geology in Salem County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B17.3. Extant and extirpated plant populations by soil type in Salem County.

Somerset County

There were eight extant and extirpated species in Somerset County, including seven extant populations and one extirpated population (Table B18.1). Extant populations were found mainly on forested land (Table B18.2, Figure B18.1). Threats to extant populations included roadways, roadway maintenance, development, succession, ditch construction, right of ways, and habitat disturbance. The cause of the population extirpation in this county was uncertain.

Portions of the Upper Passaic, Whippany, Rockaway WMA, the North and South Branch Raritan WMA, the Lower Raritan, South River, Lawrence Brook WMA, and the Millstone River WMA are found in Somerset County (Figure B18.2). In this county, a relatively high number of extant plant populations were found on Mount Lucas-Neshaminy-Watchung very stony silt loam soils (Figure B18.3) that are underlain by a basalt geologic formation (Figure B18.2). The remainder of the county is dominated by silt loams and stony silt loams (Figure B18.3).

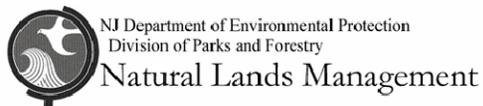
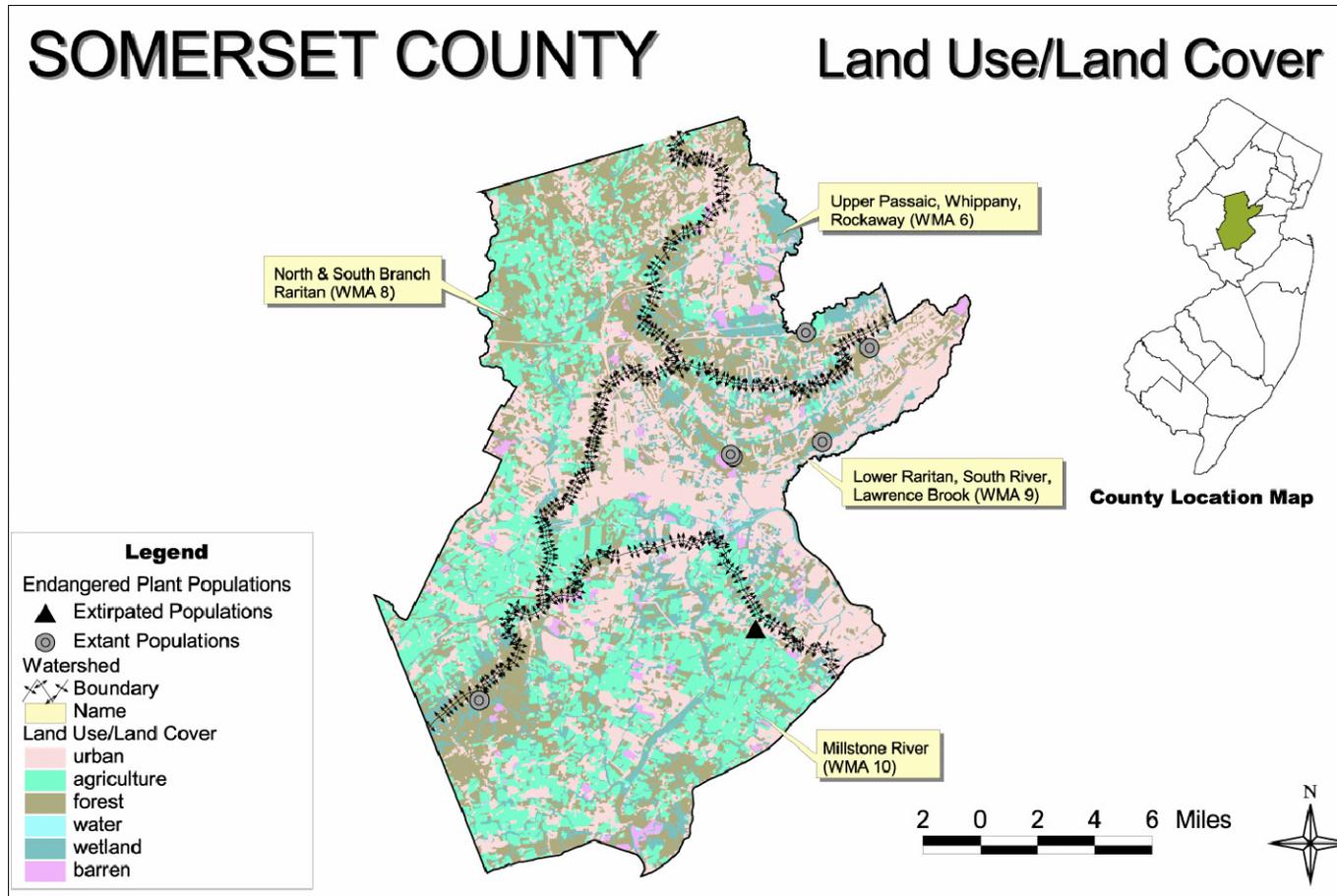
Table B18.1. Plant species populations in Somerset County.

| SPECIES | POPULATIONS |
|-------------------------|--------------------|
| ASTER PRAEALTUS | 1 extant |
| BOUTELOUA CURTIPENDULA | 1 extant |
| CALYSTEGIA SPITHAMAEA | 1 extirpated |
| CERCIS CANADENSIS | 1 extant |
| SANICULA TRIFOLIATA | 1 extant |
| SCUTELLARIA LEONARDII | 1 extant |
| TRIOSTEUM ANGUSTIFOLIUM | 1 extant |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

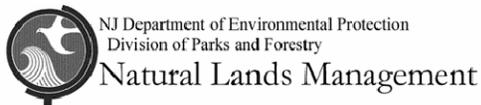
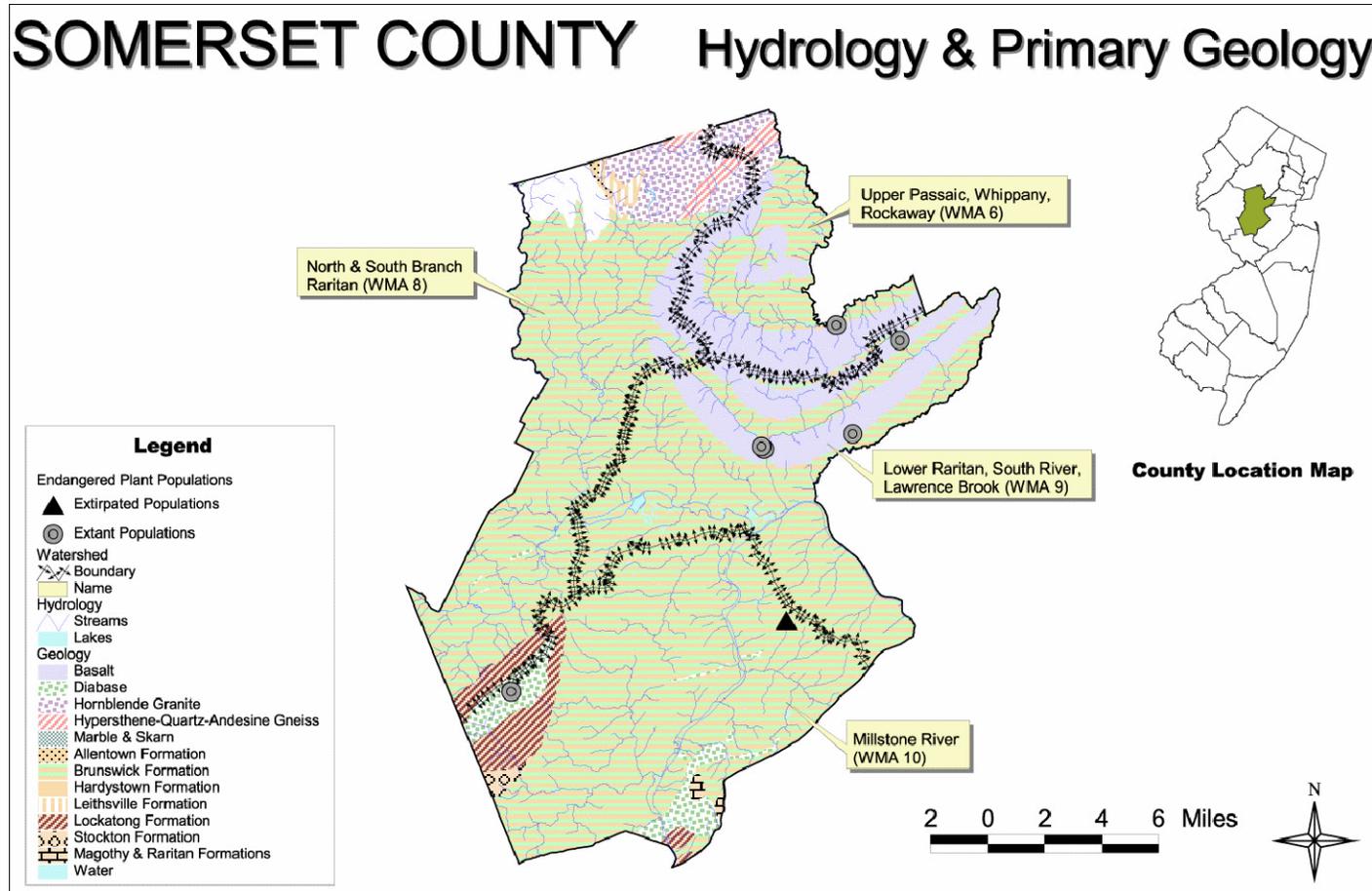
Table B18.2. Extant plant populations in Somerset County by land use.

| SOMERSET COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|---------------------------------|-------------------------------------|
| Urban | 1 |
| Agriculture | 0 |
| Forest | 4 |
| Water | 1 |
| Wetlands | 1 |
| Barren | 0 |
| Total number of populations | 7 |



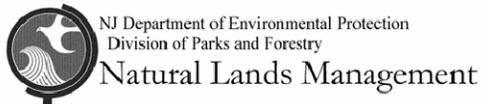
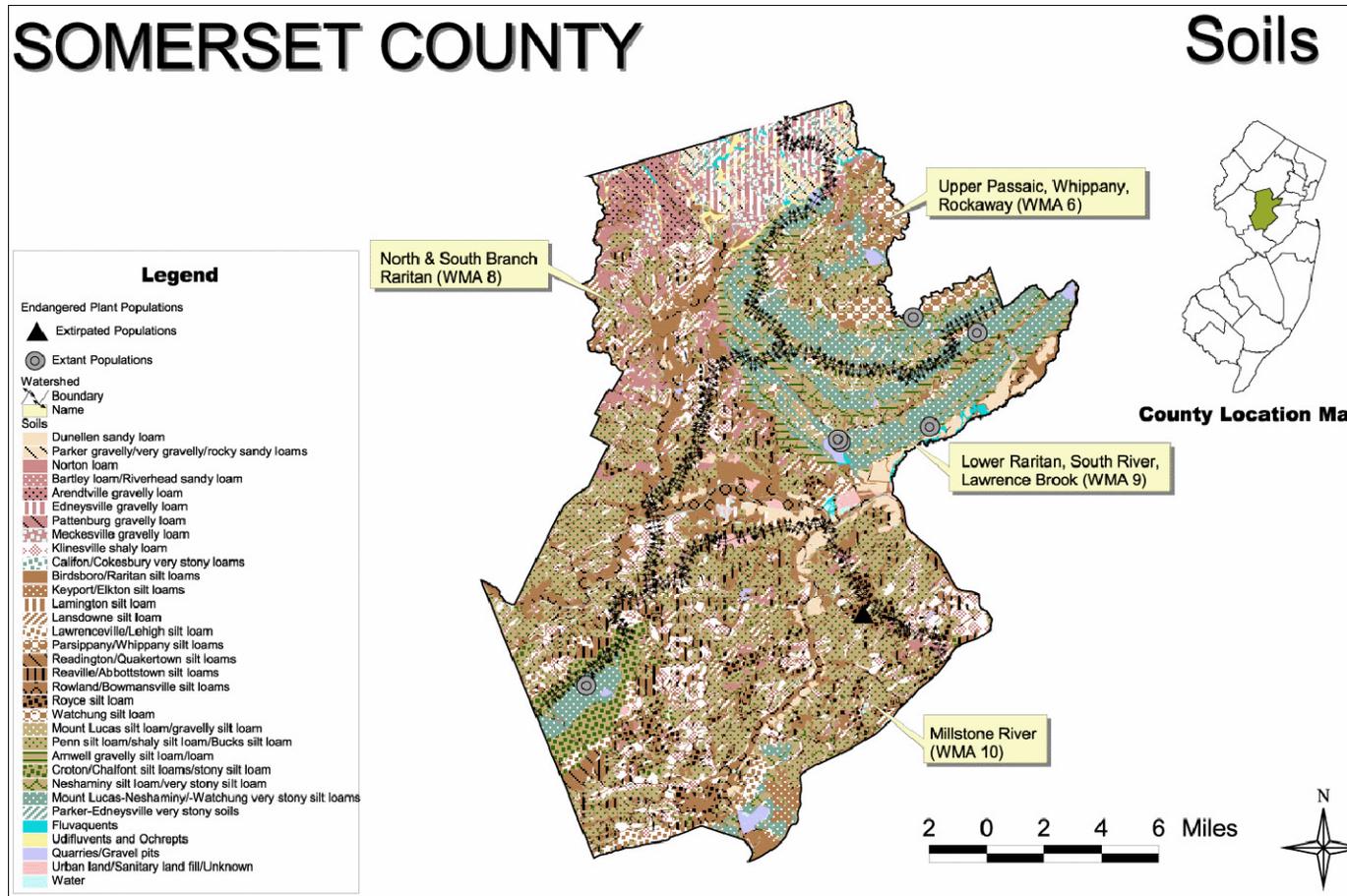
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B18.1. Extant and extirpated plant populations by land use/land cover in Somerset County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B18.2. Extant and extirpated plant populations by hydrology and primary geology in Somerset County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B18.3. Extant and extirpated plant populations by soil type in Somerset County.

Endangered Plant Species Populations **Sussex County**

There were 102 extant and extirpated species in Sussex County, including 188 extant populations and 27 extirpated populations (Table B19.1). Extant populations occurred mainly in forested, water, wetland, and barren areas (Table B19.2, Figure B19.1). The most common threats to extant populations included mining, succession, weeds, roadways, and recreation. Causes of extirpation included damming, mining, and peat mining.

Portions of the Upper Delaware River WMA, the Walkill, Pochuck, Papakating WMA, the Pompton, Pequannock, Wanaque, Ramapo WMA, and the Upper Passaic, Whippany, Rockaway WMA are found in Sussex County (Figure B19.2).

There were no clear patterns in population occurrence and soil type (Figure B19.3).

Endangered Plant Species Populations

Table B19.1. Plant species populations in Sussex County.

| SPECIES | POPULATIONS |
|-------------------------------------|------------------------|
| ANDROMEDA GLAUCOPHYLLA | 4 extant, 1 extirpated |
| ANEMONE CYLINDRICA | 4 extant, 2 extirpated |
| ANTENNARIA NEGLECTA var. CANADENSIS | 1 extant |
| ARCEUTHOBIUM PUSILLUM | 3 extant |
| ARMORACIA LACUSTRIS | 1 extirpated |
| ASTER BOREALIS | 4 extant, 1 extirpated |
| ASTRAGALUS CANADENSIS | 1 extirpated |
| BIDENS BECKII | 2 extant |
| BOUTELOUA CURTIPENDULA | 3 extant, 2 extirpated |
| CALYSTEGIA SPITHAMAEA | 1 extant |
| CAREX ALBURSINA | 1 extant |
| CAREX ALOPECOIDEA | 1 extirpated |
| CAREX ARCTATA | 1 extant |
| CAREX BRUNNESCENS | 1 extirpated |
| CAREX CRAWEI | 1 extant |
| CAREX DEWEYANA | 3 extant |
| CAREX HAYDENII | 2 extant |
| CAREX LEPTONERVIA | 2 extant |
| CAREX LIMOSA | 1 extant, 1 extirpated |
| CAREX LUPULIFORMIS | 2 extant |
| CAREX OLIGOCARPA | 3 extant |
| CAREX PSEUDOCYPERUS | 1 extant |
| CINNA LATIFOLIA | 1 extant |
| CONIOSELINUM CHINENSE | 4 extant |
| CRATAEGUS CALPODENDRON | 2 extant |
| DIPLAZIUM PYCNOCARPON | 5 extant, 1 extirpated |
| ELEOCHARIS COMPRESSA | 3 extant |
| ELEOCHARIS PAUCIFLORA | 1 extant |
| ELYMUS TRACHYCAULUS | 1 extant |
| EQUISETUM VARIEGATUM | 1 extant |
| GALIUM LABRADORICUM | 1 extant |
| GALIUM TRIFIDUM | 3 extant |
| GLYCERIA GRANDIS | 1 extant |
| HIERACIUM KALMII | 1 extant |

Endangered Plant Species Populations

| | |
|-----------------------------|------------------------|
| HYPERICUM MAJUS | 3 extant, 1 extirpated |
| HYPERICUM PROLIFICUM | 2 extant |
| KALMIA POLIFOLIA | 4 extant, 1 extirpated |
| KUHNIA EUPATORIoidES | 2 extant |
| LINUM SULCATUM | 3 extant |
| LONICERA CANADENSIS | 2 extant |
| LYCOPODIUM ANNOTINUM | 1 extant |
| MELANTHIUM VIRGINICUM | 2 extant |
| MUHLENBERGIA CAPILLARIS | 1 extant |
| NELUMBO LUTEA | 1 extant |
| ONOSMODIUM VIRGINIANUM | 1 extirpated |
| ORYZOPSIS ASPERIFOLIA | 3 extant |
| PANICUM FLEXILE | 2 extant, 2 extirpated |
| PLATANThERA HYPERBOREA | 1 extirpated |
| POLYMNIA UVEDALIA | 1 extant |
| POTAMOGETON CONFERVOIDES | 1 extant |
| POTAMOGETON ILLINOENSIS | 3 extant |
| POTAMOGETON PRAELONGUS | 2 extant |
| POTAMOGETON ROBBINSII | 2 extant |
| POTAMOGETON ZOSTERIFORMIS | 1 extant |
| PYCNANTHEMUM CLINOPODIOIDES | 1 extant |
| RANUNCULUS FASCICULARIS | 4 extant |
| RHYNCHOSPORA CAPILLACEA | 4 extant, 2 extirpated |
| RUBUS CANADENSIS | 1 extant |
| RUDBECKIA FULGIDA | 1 extant |
| SAGITTARIA CUNEATA | 5 extant |
| SALIX PEDICELLARIS | 5 extant, 2 extirpated |
| SANICULA TRIFOLIATA | 1 extant |
| SCHOENOPLectUS TORREYI | 1 extant |
| SCIRPUS MICROCARPUS | 4 extant |
| SCLERIA VERTICILLATA | 1 extirpated |
| SILENE NIVEA | 4 extant |
| SISYRINCHIUM MONTANUM | 2 extant |
| SPOROBOLUS NEGLECTUS | 2 extant |
| STREPTOPUS ROSEUS | 3 extant |
| THUJA OCCIDENTALIS | 1 extant |

Endangered Plant Species Populations

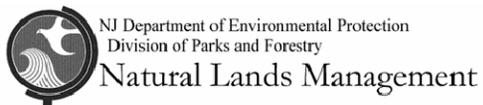
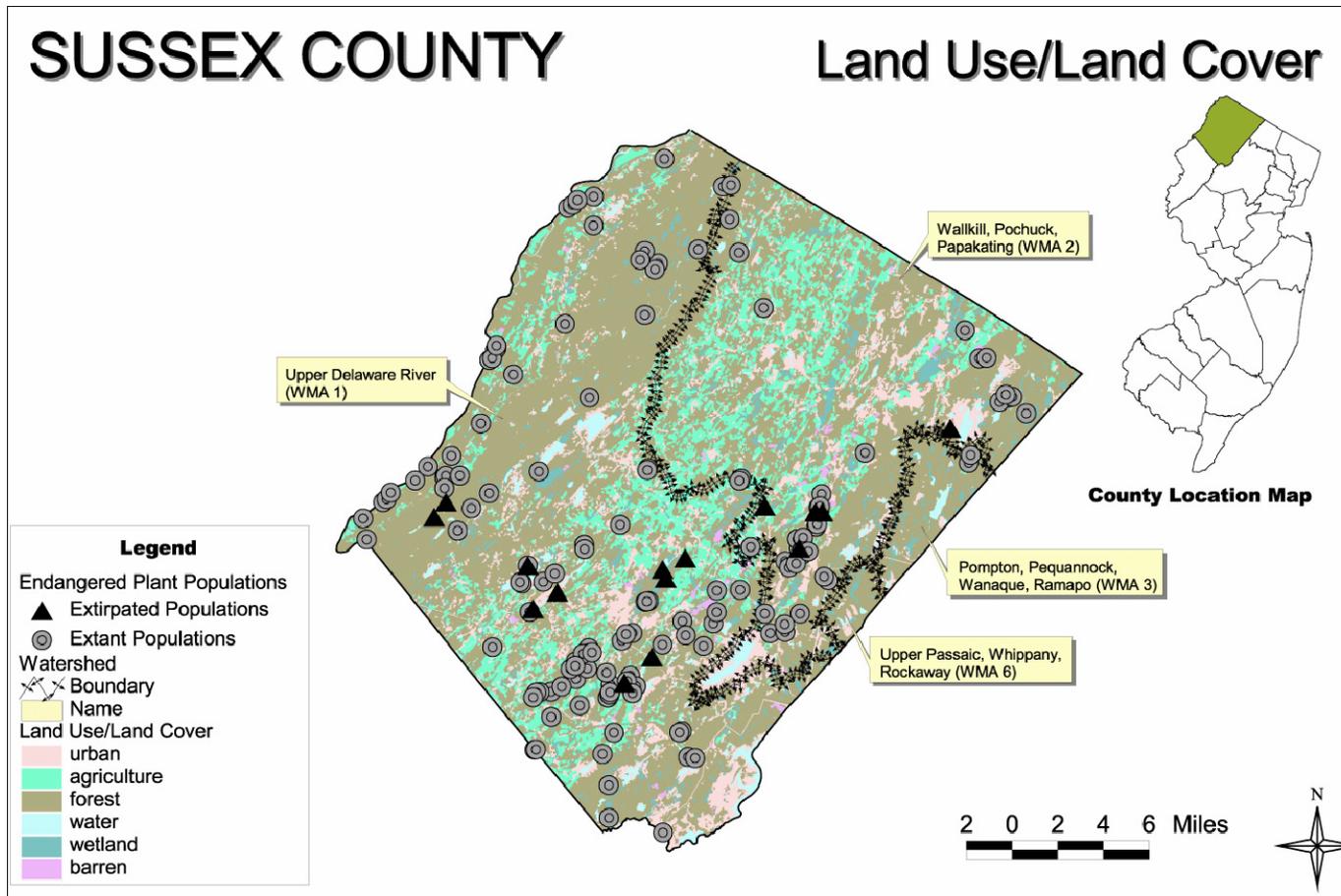
| | |
|---------------------|------------------------|
| TIARELLA CORDIFOLIA | 2 extant |
| UTRICULARIA MINOR | 2 extant |
| VIBURNUM ALNIFOLIUM | 1 extant |
| VITIS NOVAE-ANGLIAE | 1 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 3 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 2 extant, 2 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 3 extant, 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extant, 1 extirpated |
| SENSITIVE SPECIES* | 7 extant |
| SENSITIVE SPECIES* | 1 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

Endangered Plant Species Populations

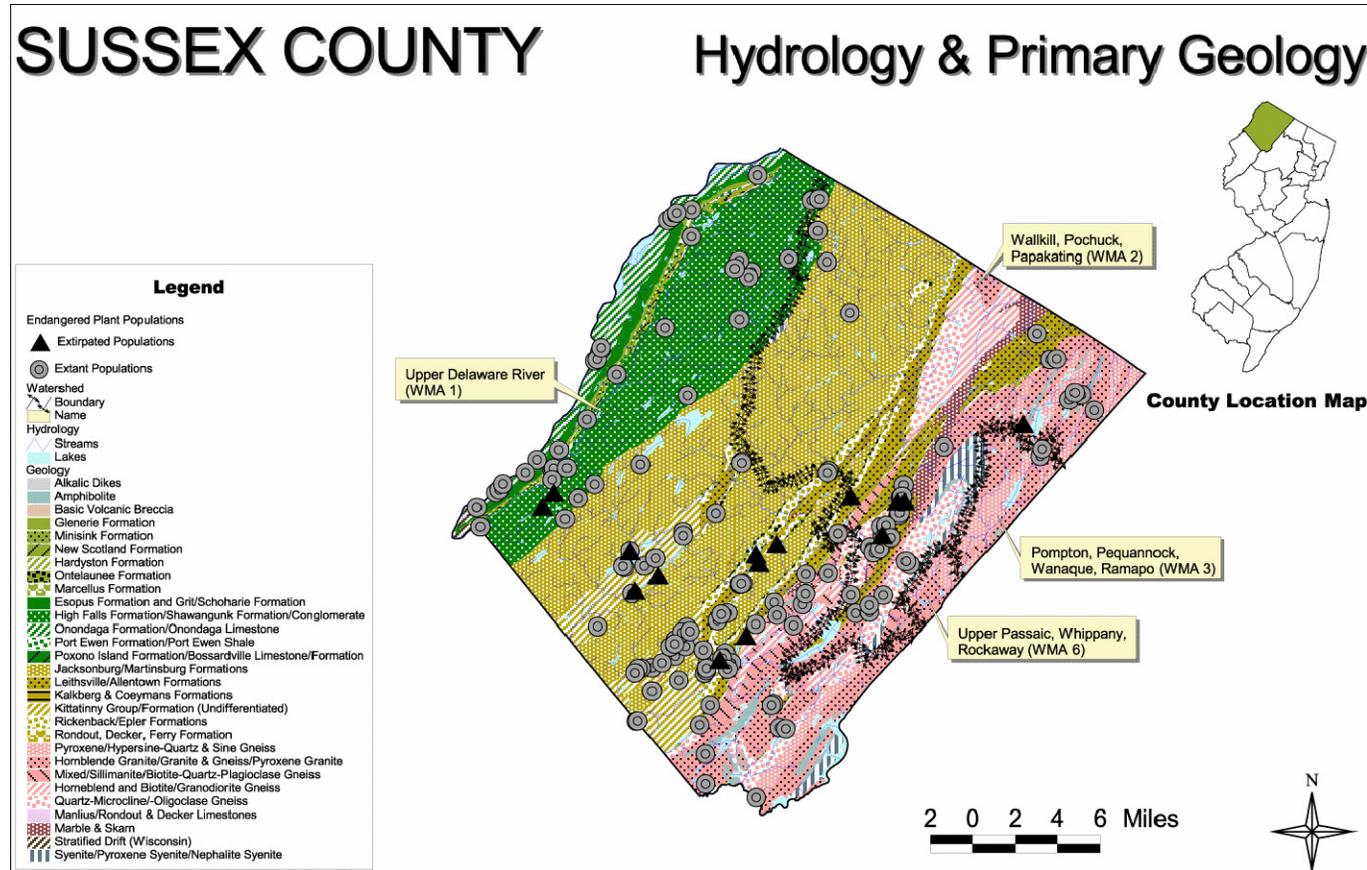
Table B19.2. Extant plant populations in Sussex County by land use.

| SUSSEX COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-------------------------------|---|
| Urban | 2 |
| Agriculture | 3 |
| Forest | 97 |
| Water | 39 |
| Wetlands | 34 |
| Barren | 12 |
| Undetermined | 1 |
| Total number of populations | 188 |



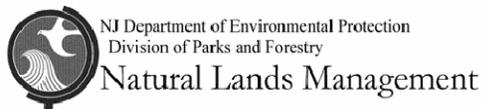
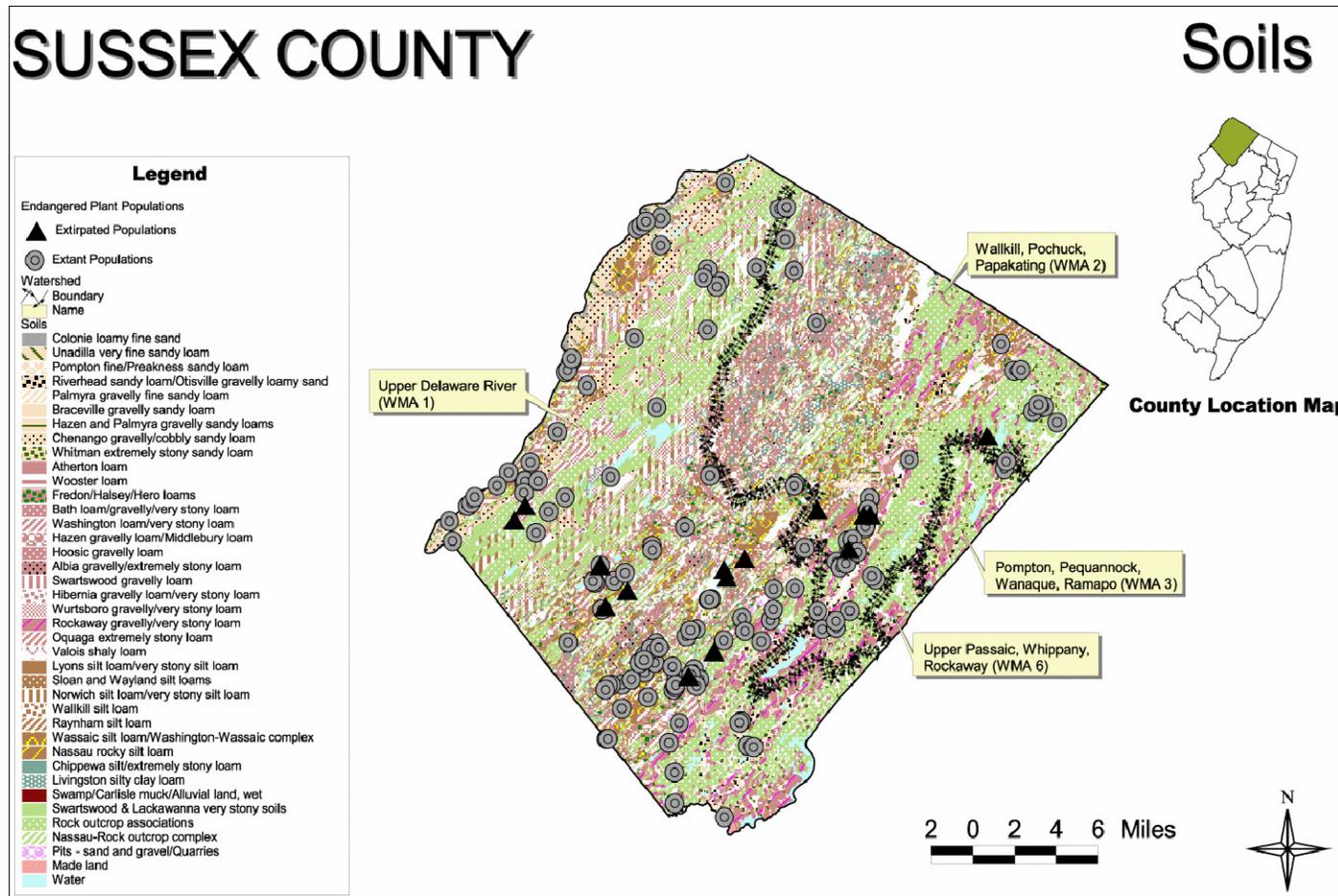
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B19.1. Extant and extirpated plant populations by land use/land cover in Sussex County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B19.2. Extant and extirpated plant populations by hydrology and primary geology in Sussex County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B19.3. Extant and extirpated plant populations by soil type in Sussex County.

Union County

There were only four extant and extirpated species in Union County, including one extant population and three extirpated populations (Table B20.1). The extant population (of *Muhlenbergia capillaris* or gulf muhlygrass) was found on forested land (Table B20.2, Figure B20.1). Population extirpations were attributed to development, roadways, and roadway construction.

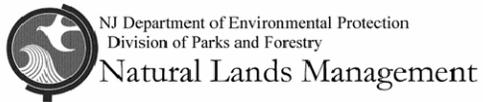
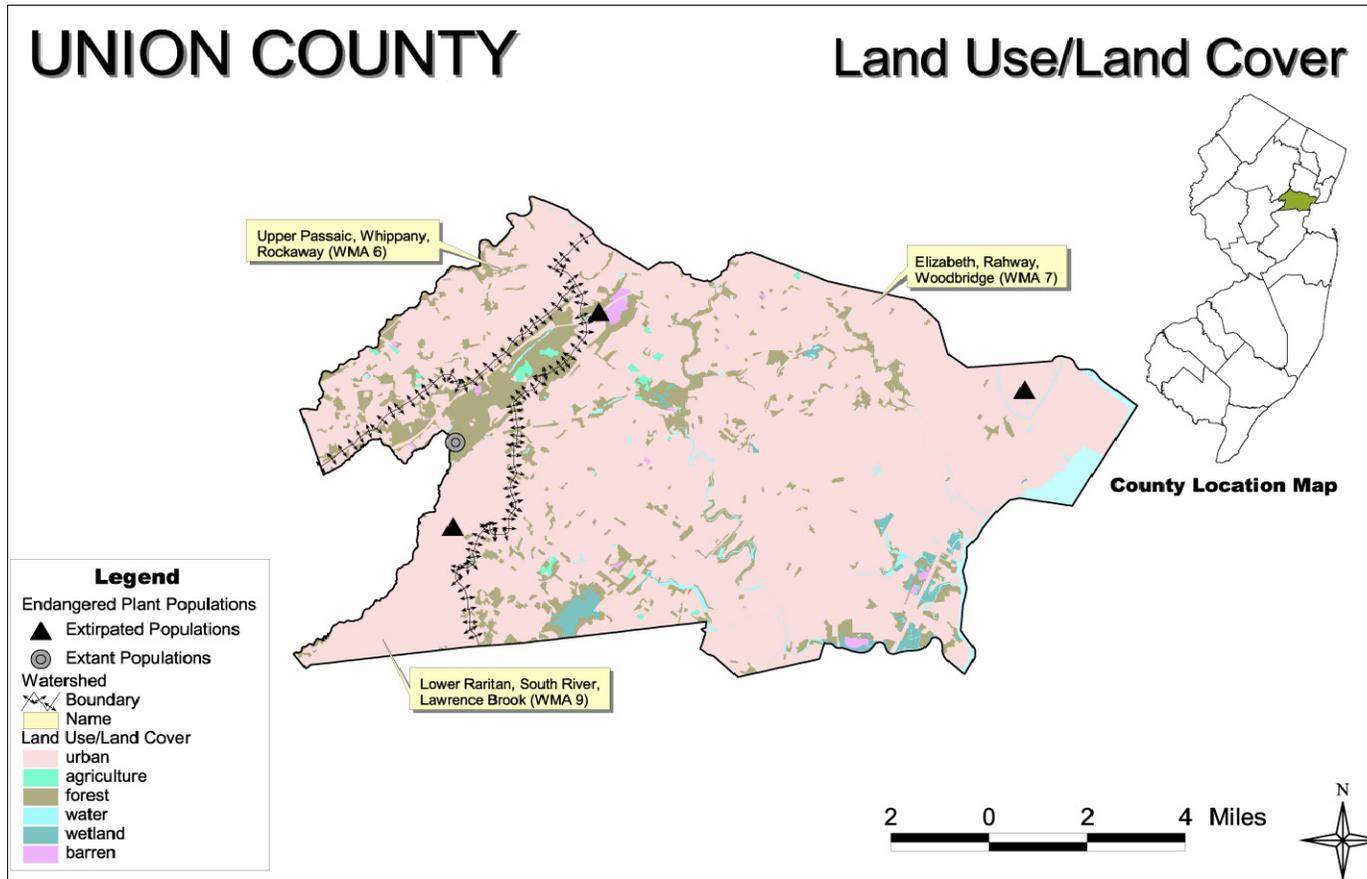
Portions of the Upper Passaic, Whippany, Rockaway WMA, the Elizabeth, Rahway, Woodbridge WMA, and the Lower Raritan, South River, Lawrence Brook WMA are located in Union County (Figure B20.2). The majority of the county is underlain by the Brunswick geologic formation, with some basalt. There were no clear patterns in population occurrence and primary hydrology and geology or soil type (Figures B20.2 and B20.3).

Table B20.1. Species populations in Union County.

| SPECIES | POPULATIONS |
|-------------------------------------|--------------|
| CAREX POLYMORPHA | 1 extirpated |
| LIATRIS SCARIOSA var. NOVAE-ANGLIAE | 1 extirpated |
| MONARDA CLINOPODIA | 1 extirpated |
| MUHLENBERGIA CAPILLARIS | 1 extant |

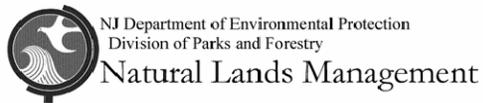
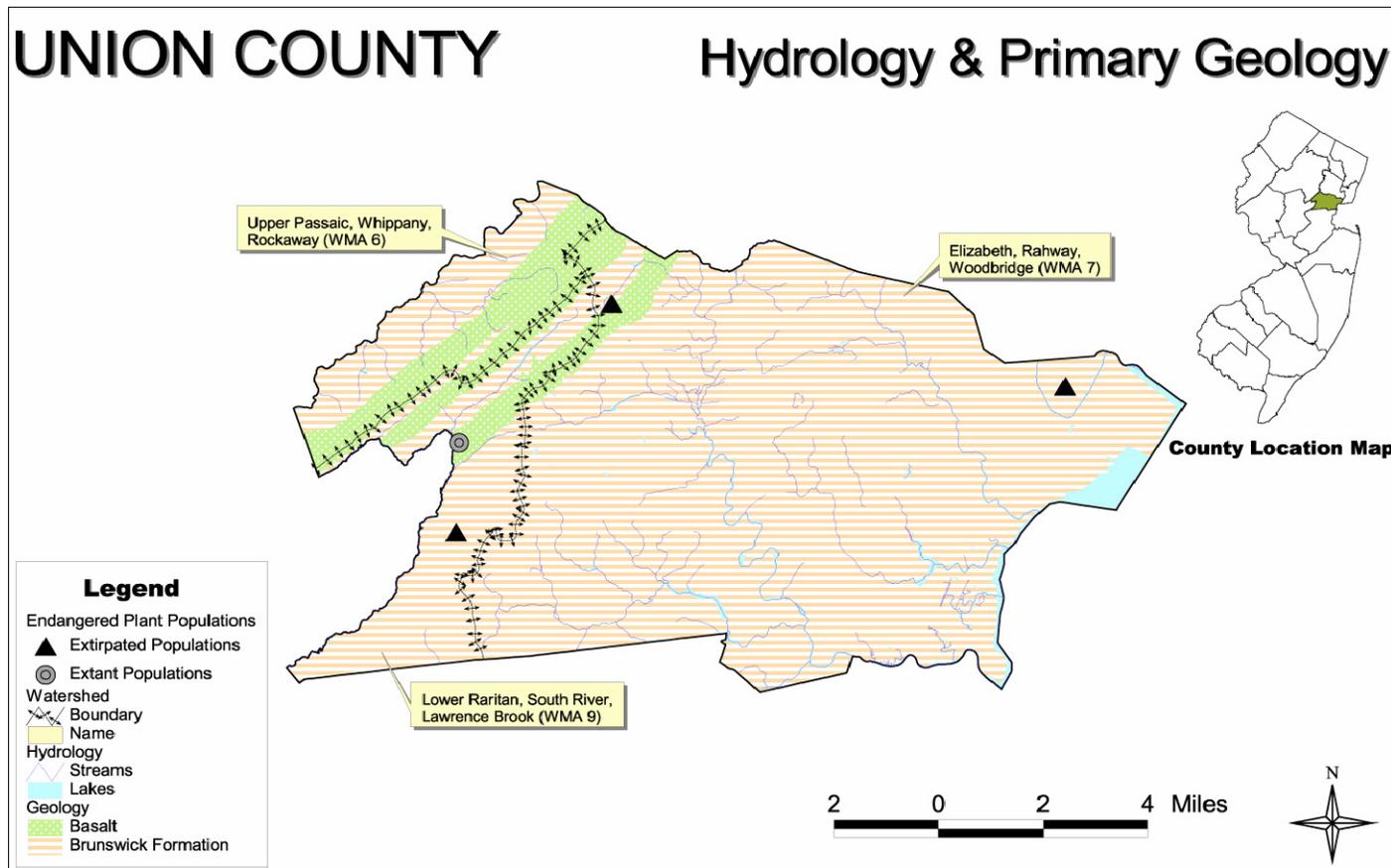
Table B20.2. Extant populations in Union County by land use.

| UNION COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 0 |
| Agriculture | 0 |
| Forest | 1 |
| Water | 0 |
| Wetlands | 0 |
| Barren | 0 |
| Total number of populations | 1 |



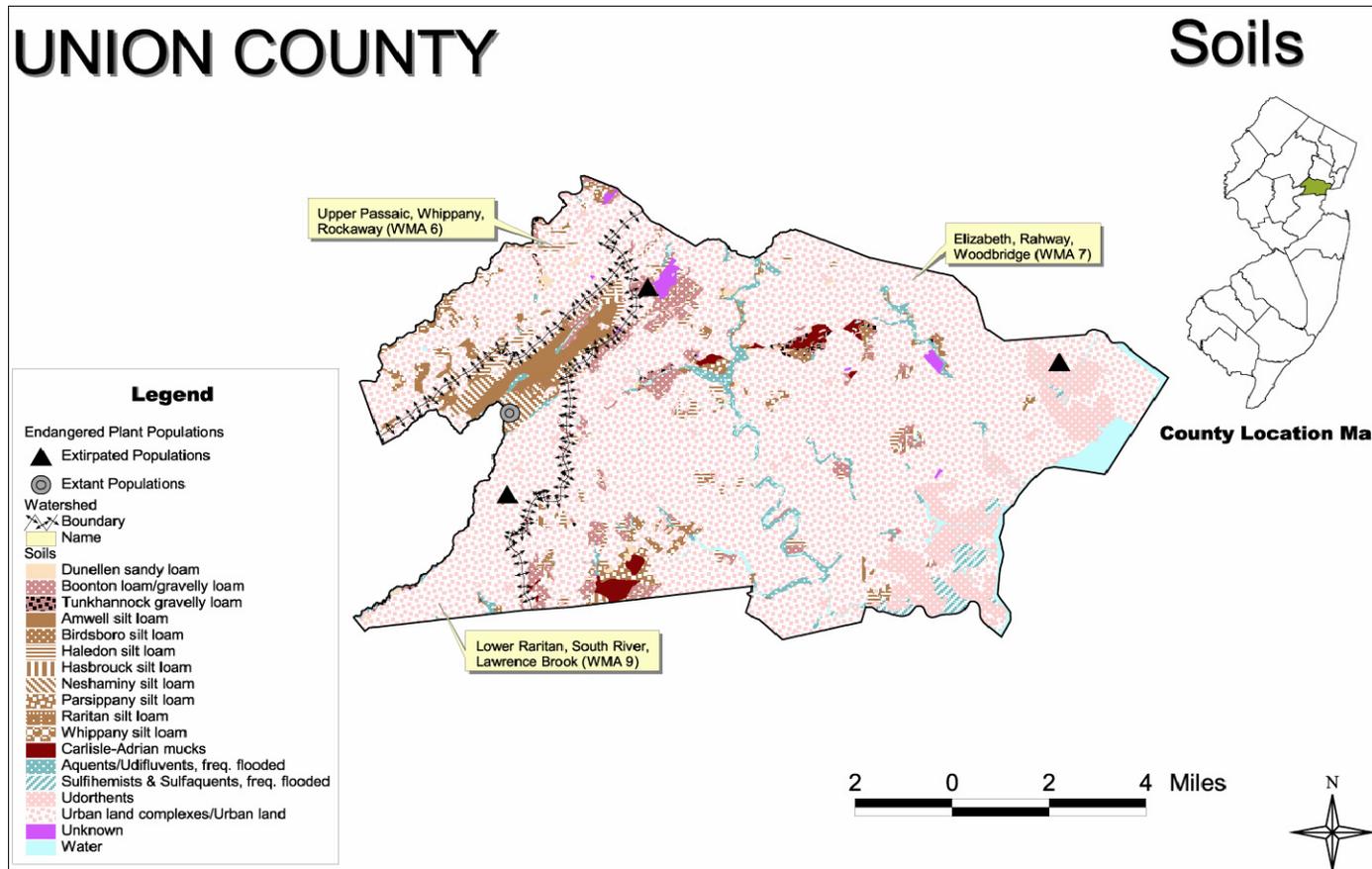
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B20.1. Extant and extirpated plant populations by land use/land cover in Union County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B20.2. Extant and extirpated plant populations by hydrology and primary geology in Union County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B20.3. Extant and extirpated plant populations by soil type in Union County.

Warren County

There were 51 extant and extirpated species in Warren County, including 58 extant populations and eight extirpated populations (Table B21.1). Extant populations were found in forested, water, and wetland areas (Table B21.2, Figure B21.1). Common threats to extant populations included roadways, railroads, infestation, woolly adelgid, and habitat disturbance. Common causes of extirpation included development, bulkhead/fill, and beaver.

The Upper Delaware River WMA is the only WMA in Warren County (Figure B21.2). A relatively large number of extant populations were found along the Delaware River in this county.

Soil types in Warren County included three sandy loams, seven loams, four gravelly stony loams, four stony loams, four silt loams, rock outcrop complexes, and mucks (Figure B21.3). There were a relatively large number of extant populations on Califon gravelly/stony loam and Pope fine sandy loam.

Table B21.1. Plant species populations in Warren County.

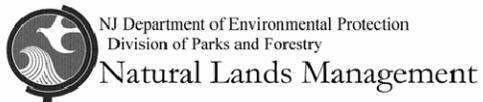
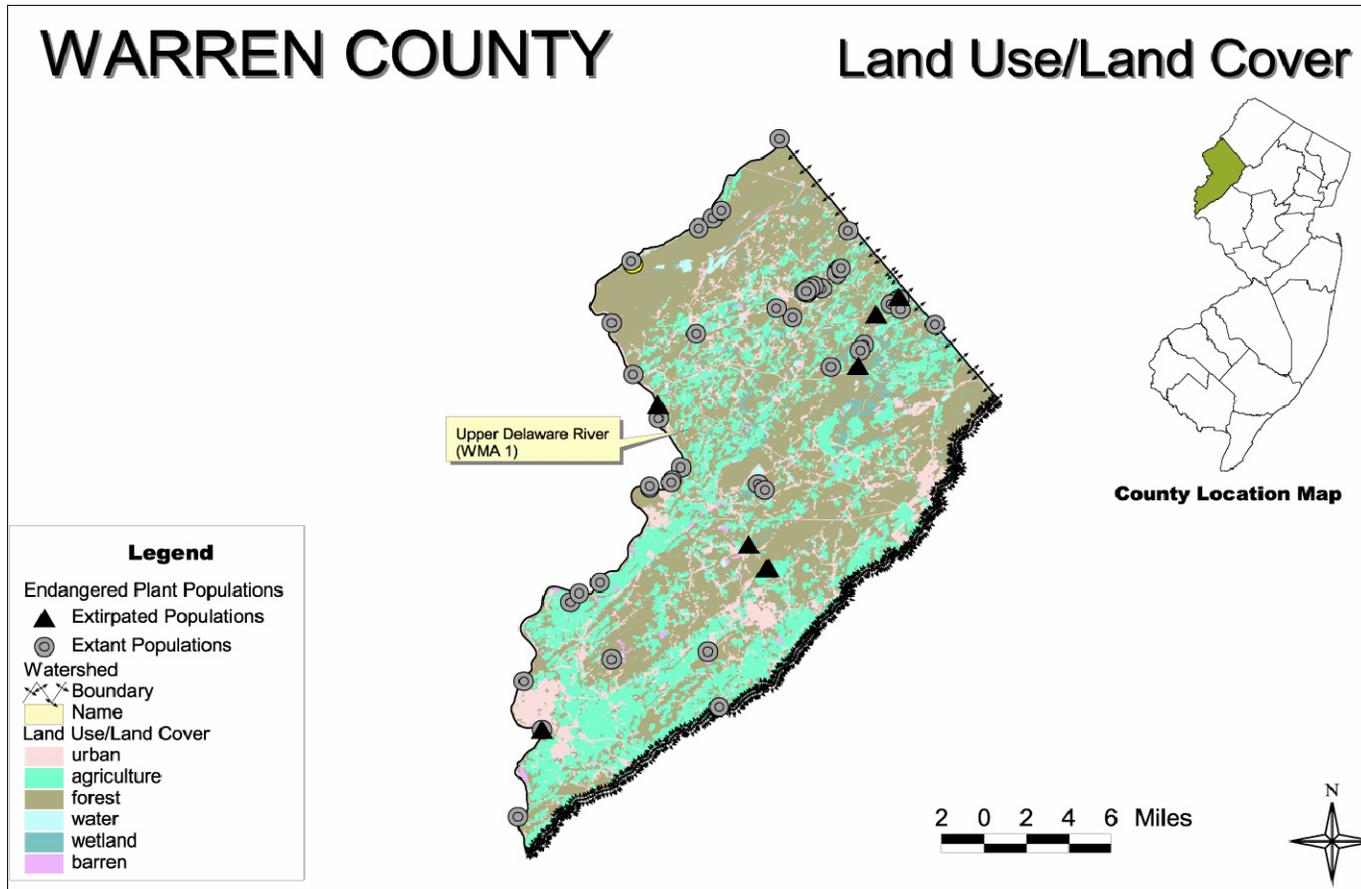
| SPECIES | POPULATIONS |
|--------------------------------|------------------------|
| ALISMA TRIVIALE | 1 extant |
| BOTRYCHIUM MULTIFIDUM | 1 extant |
| BOUTELOUA CURTIPENDULA | 1 extant |
| CARDAMINE ROTUNDIFOLIA | 1 extant |
| CAREX CRAWEI | 1 extirpated |
| CAREX HAYDENII | 1 extant |
| CAREX POLYMORPHA | 1 extirpated |
| CONIOSELINUM CHINENSE | 1 extant |
| CORNUS AMOMUM var. SCHUETZEANA | 2 extant |
| CRATAEGUS CALPODENDRON | 1 extant |
| CRATAEGUS SUCCULENTA | 1 extant |
| ELEOCHARIS COMPRESSA | 1 extant |
| ELEOCHARIS PAUCIFLORA | 1 extant, 1 extirpated |
| EQUISETUM VARIEGATUM | 1 extant |
| GALIUM LABRADORICUM | 2 extant |
| GALIUM TRIFIDUM | 2 extant |
| GLYCERIA GRANDIS | 1 extant |
| HYBANTHUS CONCOLOR | 1 extant |
| HYDROPHYLLUM CANADENSE | 4 extant |
| HYPERICUM PROLIFICUM | 2 extant |
| ILEX MONTANA | 1 extant |
| ISANTHUS BRACHIATUS | 1 extant |
| KUHNIA EUPATORIODES | 1 extirpated |
| ORYZOPSIS ASPERIFOLIA | 2 extant |
| PANICUM FLEXILE | 2 extant |
| PHLOX PILOSA | 1 extirpated |
| POLEMONIUM VANBRUNTIAE | 1 extirpated |
| POTAMOGETON ALPINUS | 3 extant |
| RHYNCHOSPORA CAPILLACEA | 1 extant |
| RUBUS CANADENSIS | 1 extant |
| SAGITTARIA CUNEATA | 1 extant |
| SALIX PEDICELLARIS | 1 extant |

| | |
|-----------------------|--------------|
| SCIRPUS MICROCARPUS | 1 extant |
| SCLERIA VERTICILLATA | 1 extant |
| SISYRINCHIUM MONTANUM | 1 extant |
| SPARGANIUM MINIMUM | 1 extant |
| SPOROBOLUS NEGLECTUS | 1 extant |
| UTRICULARIA MINOR | 2 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 1 extant |
| SENSITIVE SPECIES* | 1 extirpated |
| SENSITIVE SPECIES* | 2 extant |
| SENSITIVE SPECIES* | 2 extant |

* Sensitive species are those New Jersey plant species that are particularly susceptible to damage by over-collecting, trampling, or vandalism.

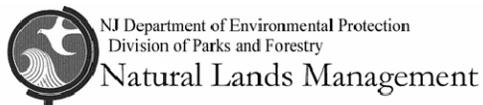
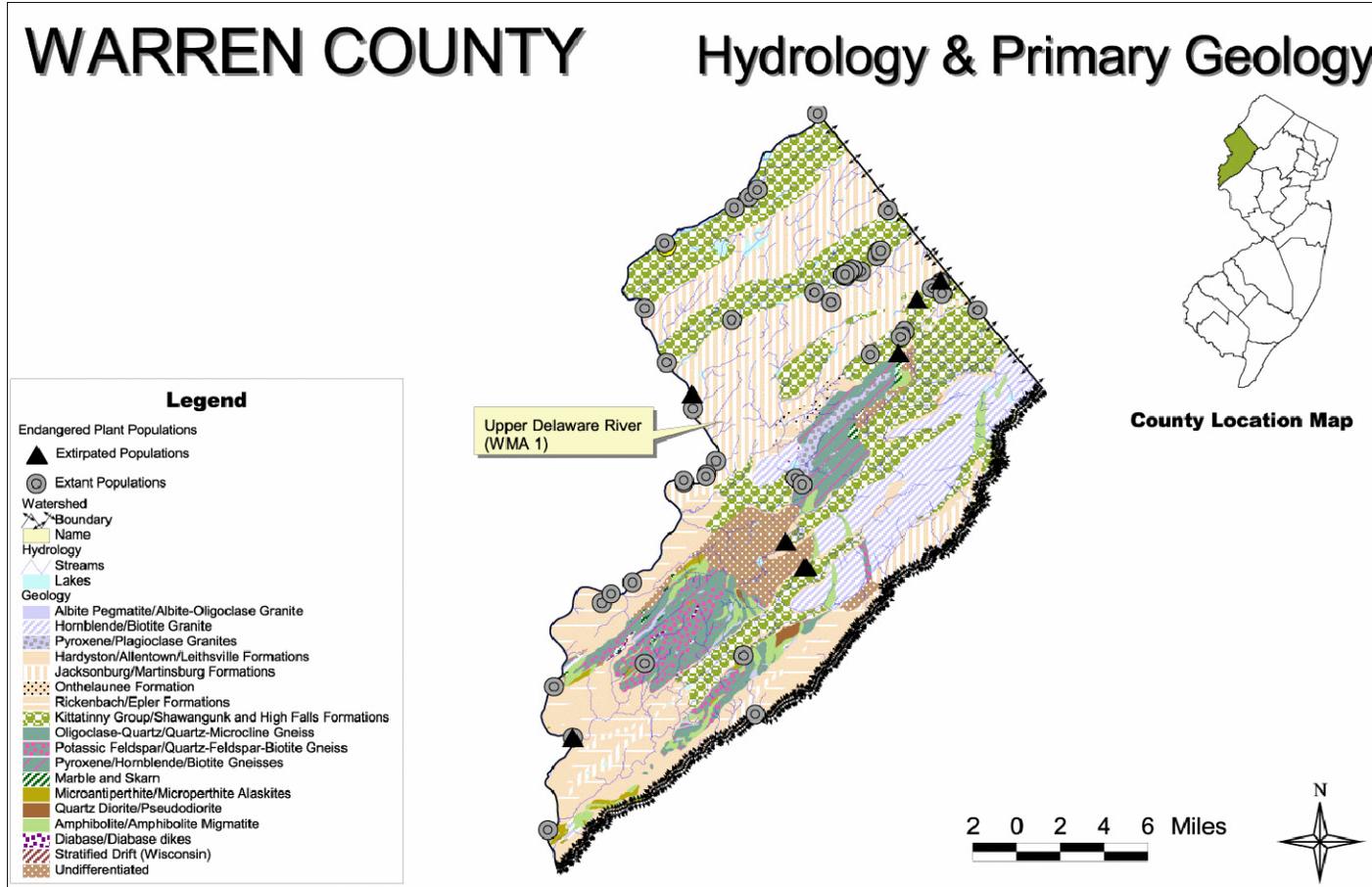
Table B21.2. Extant plant populations in Warren County by land use.

| WARREN COUNTY LAND USE | NUMBER OF EXTANT POPULATIONS |
|-----------------------------|------------------------------|
| Urban | 2 |
| Agriculture | 2 |
| Forest | 33 |
| Water | 11 |
| Wetlands | 10 |
| Barren | 0 |
| Total number of populations | 58 |



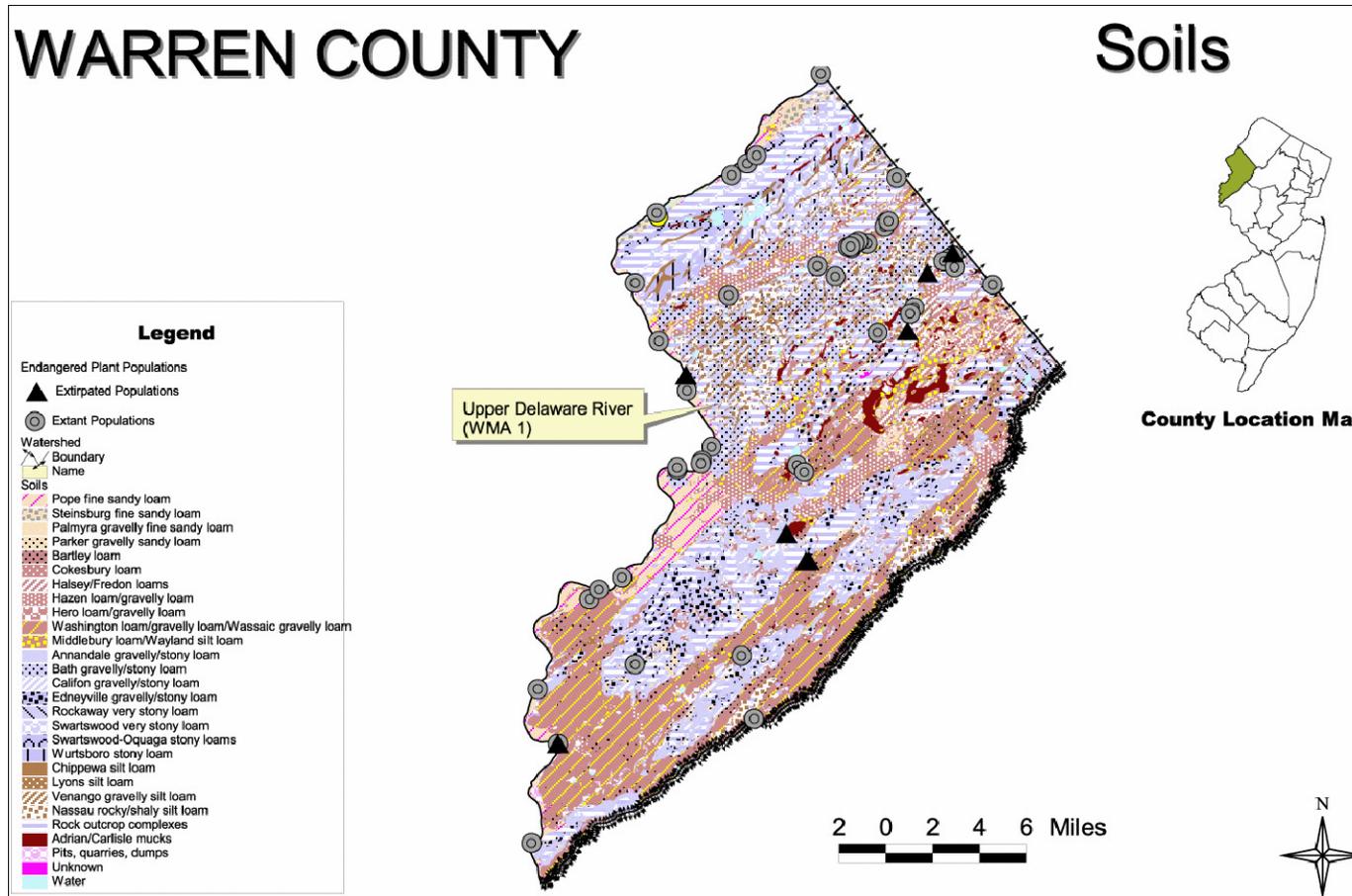
Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B21.1. Extant and extirpated plant populations by land use/land cover in Warren County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B21.2. Extant and extirpated plant populations by hydrology and primary geology in Warren County.



Source: Breden, Hartman, Anzelone and Kelly. 2006. Endangered Plant Species Population Health and Threats.

Figure B21.3. Extant and extirpated plant populations by soil type in Warren County.

Appendix C: GIS Software and Coverages Used

ARCView 3.1 software was used to manipulate the updated endangered plant population data. Locations and attribute data of these plant populations were obtained from a point coverage derived from the Natural Heritage Database of the Office of Natural Lands Management, NJDEP. With this point coverage, centrum points of all extirpated populations were used, and centrum points of all other precisely located (accurate within 1 second latitude or longitude) endangered plant species populations were incorporated into the GIS analysis. These data were then analyzed by various coverages, including habitat type, physiographic province, watershed, land use/land cover, county, and public open space.

All GIS coverages of New Jersey were obtained from CD-ROMs (NJDEP GIS CD-ROM Series 1), with the exception of watershed data, which were obtained separately from the NJDEP GIS office. The CD-ROMs provided spatial data about New Jersey (Pinelands, open space Green Acres 1991) and its 21 counties (land use) that were not in the Natural Heritage Database. The data provided on these CD-ROMs were uncompact, single precision ARC/INFO 7.0.3 EXPORT files in MS-DOS on a UNIX CD. All data were in North American Datum 1983 (NAD83) in New Jersey State Plane Feet. With regard to mapping accuracy and data limitations, base map feature positions were accurate to about +/- 20 feet or better. Delineated lines were accurate to about +/- 20 feet from locations.

Land use/land cover data layers used in each of the counties were extracted from countywide data sets called Integrated Terrain Unit Maps (ITUM). Land use/land cover was mapped using a modified Anderson et al. (1976) classification system with a minimum mapping unit equal to 2.5 acres. This data was interpreted from 1986 JSSCIR

(1:58000) photos. Geology was recompiled from 1906 (1:63360) atlas sheets.

Three statewide coverages of public open space were used and included NJDEP Natural Heritage Priority Sites (published in 2001), the NJDEP Green Acres Program Sites (1999 edition), and NJDEP Landscape Project Sites (published in 2001). Natural Heritage Priority Sites were, "created to identify the best habitats for rare plant and animal species and natural communities through analysis of information in the NJ Natural Heritage Database." These sites contain, "some of the best and most viable occurrences of endangered and threatened species and natural communities, but they do not cover all known habitat for endangered and threatened species in New Jersey." Each priority site is ranked according to its significance for biological diversity using a scale developed by The Nature Conservancy and the network of Natural Heritage Programs. The NJDEP Green Acres Program sites represent state owned, protected open space and recreation sites in New Jersey. The NJDEP Landscape Project, "identifies, delineates and ranks (based on the conservation status of species present) critical ...habitat statewide." Critical habitat categories included forest, beach, emergent wetlands, forested wetlands, and grasslands. Sites are coded for the number of special concern, state threatened, state endangered, and federally listed species present.

A statewide watershed map was created with the Watershed Management Area (wma) coverage. Again, this coverage was not included in the CD-ROM series but was also created by the NJDEP GIS department. These WMA's (20) were numbered and grouped into 5 color-coded water regions. Major rivers and streams were displayed by merging stream coverages for all 21 counties and selecting for waterways with rank 3 or greater. Extirpated and extant point feature coverage was displayed on two separate maps.