CHAPTER 1

INTRODUCTION

1.1 How This Report Is Organized

This report is a summation of a scientific project. While we endeavor to make it understandable for as general an audience as practicable, it will reflect the complexity of the project it describes. A glossary of terms is provided to aid the reader in its understanding, and for those seeking a detailed understanding of the subjects, the cited literature should be helpful. The organization of this report follows the general chronology of project development, beginning with the production of the individual data layers and concluding with analysis of the data. It diverges from standard scientific reporting by embedding results and discussion sections within individual chapters. This was done to allow the individual data products to stand on their own as testable hypotheses and provide data users with a concise and complete report for each data and analysis product.

We begin with an overview of the Gap Analysis mission, concept, and limitations. We then present a synopsis of how the current biodiversity condition of the project area came to be, followed by land cover mapping, animal species distribution prediction, species richness, and land stewardship mapping and categorization. Data development leads to the Analysis section, which reports on the status of elements of biodiversity (natural community alliances and terrestrial vertebrate species) for this state. Finally, we describe the management implications of the analysis results and provide information on how to acquire and use the data.

1.2 The Gap Analysis Program Mission

The mission of the Gap Analysis Program is to prevent conservation crises by providing conservation assessments of animals and their habitats and to facilitate the application of this information to land management activities.

This is accomplished through the following five objectives:

1) map actual land cover as closely as possible to the Alliance level (FGDC, 1997).
2) map the predicted distribution of those terrestrial vertebrates that spend any important part of their life history in the project area and for which adequate distributional habitats, associations, and mapped habitat variables are available. Map other taxa as cooperative opportunities allow.
3) document the representation of natural land cover types and animal species in areas managed for the long-term maintenance of biodiversity.
4) make all GAP Project information available to the public and those charged with land use research, policy, planning, and management.
5) build institutional cooperation in the application of this information to state and regional management activities.

To meet these objectives, it is necessary that GAP be operated at the state level but maintain consistency with national standards. Within the state, participation by a wide variety of cooperators is necessary and desirable to ensure understanding and acceptance of the data and forge relationships that will lead to cooperative conservation planning.

Pennsylvania gap analysis work was initiated in 1993 with the general goal of providing landscape-level perspective on the conservation status of reproductive habitats for vertebrates, considering not only terrestrial species but fishes as well. The intent has been to attain this overall goal of landscape perspective within the general framework of the national Gap Analysis Program, but with some latitude for adjustment of approach to accommodate Pennsylvania's special blend of strongly expressed physiography and longstanding imprints of human habitation. It was recognized from the outset that mapping actual species composition of vegetative communities directly from satellite remotely sensed image data would be problematic for Pennsylvania. Accordingly, the Pennsylvania GAP Project embodies a more generalized approach to land cover emphasizing physiognomy and disturbance. Pennsylvania's contemporary ecosystem stresses also weigh more heavily on aquatic habitats than terrestrial habitats. It has, therefore, been viewed as essential to incorporate at least a generalized assessment for fishes.

1.3 The Gap Analysis Concept

The Gap Analysis Program (GAP) brings together the problem-solving capabilities of federal, state, and private scientists to tackle the difficult issues of land cover mapping, vertebrate habitat characterization, assessment, and biodiversity conservation at the state, regional, and national levels. The program seeks to facilitate cooperative development and use of information. Throughout this report we use the terms "GAP" to describe the national program, "GAP Project" to refer to an individual state or regional project, and "gap analysis" to refer to the gap analysis process or methodology.

Much of the following discussion was taken verbatim from Edwards et al. (1995), Scott et al. (1993), and Davis et al. (1995). The gap analysis process provides an overview of the distribution and conservation status of several components of biodiversity. It uses the distribution of actual vegetation and terrestrial vertebrates and, when available, invertebrate taxa. Digital map overlays in a GIS are used to identify individual species, species-rich areas, and vegetation types that are unrepresented or under-represented in existing management areas. It functions as a preliminary step to the more detailed studies needed to establish actual boundaries for potential biodiversity management areas. These data and results are then made available to institutions as well as individual landowners and managers so that they may become more effective stewards through more complete knowledge of the management status of these elements of biodiversity. GAP, by focusing on higher levels of biological organization, is likely to be both cheaper and more likely to succeed than conservation programs focused on single species or populations (Scott et al. 1993).

Biodiversity inventories can be visualized as "filters" designed to capture elements of biodiversity at various levels of organization. The filter concept has been applied by The Nature Conservancy, which has established Natural Heritage Programs in all 50 states, most of which are now operated by state government agencies. The Nature Conservancy employs a fine filter of rare species inventory and protection, and a coarse filter of community inventory and protection (Jenkins 1985, Noss 1987). It is postulated that 85-90% of species can be protected by the coarse filter, without having to inventory or plan reserves for those species individually. A fine filter is then applied to the remaining 10-15% of species to ensure their protection. Gap analysis is a coarse filter method because it can be used to quickly and cheaply assess the 85-90% of species.

The intuitively appealing idea of conserving most biodiversity by maintaining examples of all natural community types has never been applied, although numerous approaches to the spatial identification of biodiversity have been described (Kirkpatrick 1983, Margules and Nicholls 1988, Pressey and Nicholls 1989, Nicholls and Margules 1993). Furthermore, the spatial scale at which organisms use the environment differs tremendously among species and depends on body size, food habits, mobility, and other factors. Hence, no coarse filter will be a complete assessment of biodiversity protection status and needs. However, species that fall through the pores of the coarse filter, such as narrow endemics and wide-ranging mammals, can be captured by the safety net of the fine filter. Community-level (coarse-filter) protection is a complement to, not a substitute for, protection of individual rare species.

Gap analysis is essentially an expanded coarse-filter approach (Noss 1987) to biodiversity protection. The vegetation types mapped in GAP serve directly as a coarse filter, the goal being to assure adequate representation of all types in biodiversity management areas. Landscapes with great vegetation diversity often are those with high edaphic variety or topographic relief. When elevation diversity is very great, a nearly complete spectrum of vegetation types known from a biological region may occur within a relatively small area. Such areas provide habitat for many species, including those that depend on multiple habitat types to meet life history needs (Diamond 1986, Noss 1987). By using landscape-sized samples (Forman and Godron 1986) as an expanded coarse filter, gap analysis searches for and identifies biological regions where unprotected or under-represented vegetation types and animal species occur.

A second filter uses combined species distribution information to identify a set of areas in which all, or nearly all, mapped species are represented. There is a major difference between identifying the richest areas in a region (many of which are likely to be neighbors and share essentially the same list of species) and identifying areas in which all species are represented. The latter task is most efficiently accomplished by selecting areas whose species lists are most different or complementary. Areas with different environments tend to also have the most different species lists for a variety of taxa. As a result, a set of areas with complementary sets of species for one higher taxon (e.g., mammals) often will also do a good job representing most species of other higher taxa (e.g., trees, butterflies). Species with large home ranges, such as large carnivores, or species with very local distributions may require individual attention. Additional data

layers can be used for a more holistic conservation evaluation. These include indicators of stress or risk (e.g., human population growth, road density, rate of habitat fragmentation, distribution of pollutants) and the locations of habitat corridors between wildlands that allow for natural movements of wide-ranging animals and the migration of species in response to climate change. These more detailed analyses were not part of this project, but are areas of research that GAP as a national program is pursuing.

1.4 General Limitations

Limitations must be recognized so that additional studies can be implemented to supplement GAP. The following are general project limitations; specific limitations for the data are described in the sections that describe them:

1. GAP data are derived from remote sensing and modeling to make general assessments about conservation status. Any decisions based on the data must be supported by ground-truthing and more detailed analyses.

2. GAP is not a substitute for threatened and endangered species listing and recovery efforts. A primary argument in favor of gap analysis is that it is proactive; it seeks to recognize and manage sites of high biodiversity value for the long-term maintenance of populations of native species and natural ecosystems before individual species and their plant communities become critically rare. Thus, it should help to reduce the rate at which species require listing as threatened or endangered. Those species that are already greatly imperiled, however, still require individual efforts to assure their recovery.

3. GAP data products and assessments represent a snapshot in time generally representing the date of the satellite imagery. Updates are planned on a 5-10 year cycle, but users of the data must be aware of the static nature of the products.

4. GAP is not a substitute for a thorough national biological inventory. As a response to rapid habitat loss, gap analysis provides a quick assessment of the distribution of vegetation and associated species before they are lost, and provides focus and direction for local, regional, and national efforts to maintain biodiversity. The process of improving knowledge in systematics, taxonomy, and species distributions is lengthy and expensive. That process must be continued and expedited, however, in order to provide the detailed information needed for a comprehensive assessment of our nation's biodiversity. Vegetation and species distribution maps developed for GAP can be used to make such surveys more cost-effective by stratifying sampling areas according to expected variation in biological attributes.

1.5 The Study Area

Pennsylvania has three primary and four minor physiographic components (Myers 2000), as shown against a backdrop of terrain hillshading in Figure 1.1. The minor components include a narrow strip of Atlantic coastal plain (ACP) along Delaware Bay, a correspondingly narrow strip of Erie Lake Plain (ELP) along the shore of Lake Erie, the

South Mountain extremity of the Blue Ridge (BR:SM) in south-central Pennsylvania, and the so-called Reading Prong of a New England formation (NE:RP) in eastern Pennsylvania. The three primary components and their subregions can be considered in a progression beginning in the southeast then moving north and west.

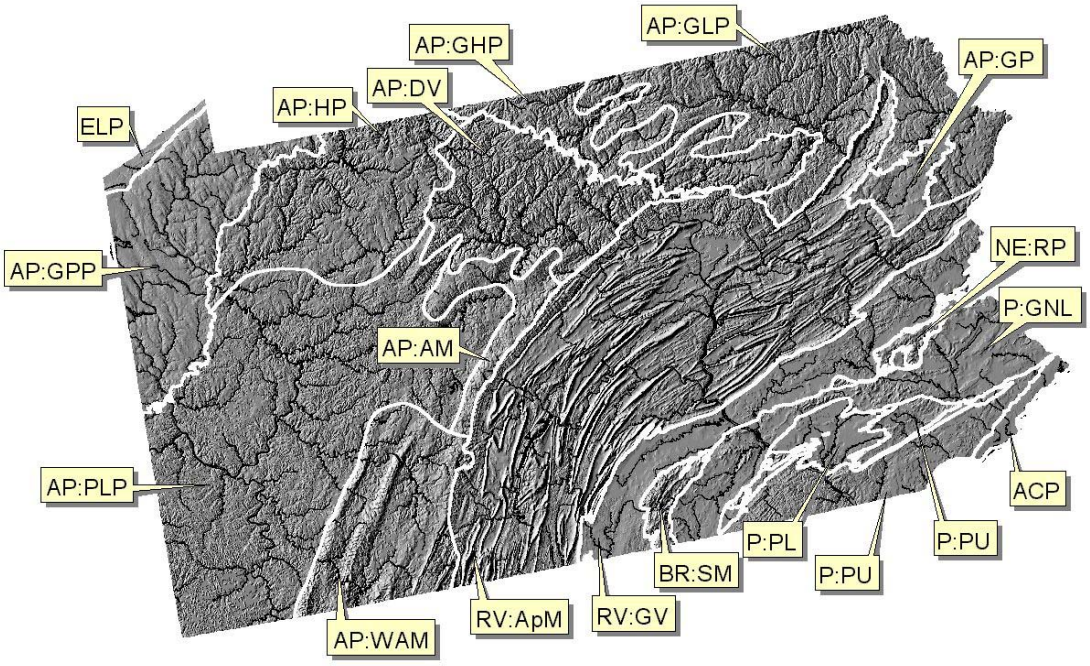

Figure 1.1. Ecoregional physiography of Pennsylvania. AP = Appalachian Plateaus; P = Piedmont; RV = Ridge & Valley; ACP = Atlantic Coastal Plain; BR = Blue Ridge; ELP = Erie Lake Plain; NE = New England formation.

The Piedmont (P) is a geological complex with fertile soils. Agricultural and urbanized developments are the primary land uses. Remaining forests in this region are restricted mostly to the more rugged topography where relatively resistant parent materials produce shallower soils. The southeast portion of the Piedmont contains higher elevations than the more northerly and westerly portions. From south to north, this region includes the Piedmont Uplands (P:PU), Piedmont Lowlands (P:PL), and Gettysburg-Newark Lowlands (P:GNL).

The Ridge and Valley (RV) region arches around the Piedmont through south-central and east-central Pennsylvania, with one finger extending northeast forming the Wyoming Valley and another extending south of the Poconos to the Delaware River. This region consists primarily of the strongly folded Appalachian Mountains (RV:ApM), with the Great Valley subregion (RV:GV) comprising the southern portion of the area. The

mountains are interlaced ridges as remnant sides of much higher arches. Through time the centers eroded as a consequence of fracturing at the top of the fold. The forested ridges are rocky with thin infertile soils. Soil fertility increases as one moves into the valleys, particularly where limestone parent material is found. The mountain ridges separate sequences of narrow anticlinal and broader synclinal valleys.

The most extensive physiographic area is the Appalachian Plateaus (AP), covering most of western and northern Pennsylvania. A thick horizontal layer of resistant sandstone is the major formative element of the region. The resistant sandstone generally weathers slowly resulting in shallow, infertile soils that are more suited to forests than to agriculture. The sandstones of the plateaus contain inter-bedded shales that are more easily eroded, giving rise to differential dissection. Glaciation in the northern portions has contributed further to differentiation of this region.

The Allegheny Plateaus encompass nine subregions. The Western Allegheny Mountains (AP:WAM) in southern Pennsylvania is bordered on the north by the narrow Allegheny Mountains area (AP:AM), followed by the Deep Valleys area (AP:DV). These three subregions lie along the western edge of the Ridge and Valley region. The Pittsburgh Low Plateau (AP:PLP) occupies southwestern Pennsylvania. The Glaciated Pittsburgh Plateau (AP:GPP) occupies the northwest below the Lake Erie plain. The High Plateau (AP:HP) is situated between the Glaciated Pittsburgh and the Deep Valleys. Bordering the northeastern edge of the Deep Valleys is the Glaciated High Plateau (AP:GHP) with lobes that extend eastward into the Glaciated Low Plateau (AP:GLP). The remaining area is the Glaciated Poconos (AP:GP) nestled between the fingers of the Ridge and Valley region.

Pennsylvania's contemporary habitats are largely a legacy of historic human disturbance. Major modes of disturbance have included strip mining, marginal agriculture, and extensive forest clearcutting often followed by fire. Physiography has been a major determinant of erosive degradation for exposed soils, leading to abandonment of lands and their eventual reversion to the public domain. Regrowth and reforestation along with restoration of mine spoils have given rise to created habitats that harbor a considerable variety of terrestrial vertebrates. Some of these created habitats serve to enrich the fauna beyond levels normally associated with extensive high forest that represents culmination of natural succession for the region. A case in point is habitat for grassland avifauna resulting from restoration of former strip mine lands. Thus, physiography, physiognomy, disturbance, and wetland occurrence have become major determinants of habitat for terrestrial and wetland associated species. Species composition and density of vegetation are somewhat secondary as habitat factors at landscape scales. Physiography, physiognomy, disturbance, and wetland occurrence are also subject to more definitive mapping than vegetative composition in Pennsylvania. For these reasons, the landscape scale habitat models for Pennsylvania gap analysis are formulated primarily in terms of physiography, physiognomy, disturbance, and wetland occurrence; whereas National Gap Analysis protocols give emphasis to vegetation types (at the alliance level) instead.

Water and wetlands have not been as resilient as terrestrial systems. Impacts by humans upon landscapes become amplified through watershed processes to impart stresses on wetlands and waters. Pennsylvania history is replete with negative human influences on aquatic ecosystems. Erosion of exposed soils generates sediment that compounds loss from filling of wetlands for development. Point sources and non-point sources of pollution from industry, agriculture, urbanization, and transportation generate toxic chemicals, acidification, and eutrophication. Acidic deposition and acid mine drainage have been especially problematic for Pennsylvania. Hydrologic engineering for transportation, flood control, cooling, and power generation have disrupted natural hydrologic regimes over centuries. Location of major urban centers in the state is strongly associated with large rivers, estuaries, and Lake Erie. Drainage divides between major river basins constitute virtually complete barriers to dispersal and recolonization by aquatic species. This multitude of long-term stresses coupled with physiographic segregation has put several of the state's aquatic species in jeopardy, and a number of others are already presumed extirpated from entire geographic sectors.

1.6 Commonwealth Conservation Chronology

The ensuing provides a brief retrospective on conservation in the Commonwealth of Pennsylvania which serves as a backdrop for gap analysis. This chronology of conservation was compiled by Dr. Robert Hill, Biodiversity Coordinator and Section Chief of Ecological Services, Pennsylvania Department of Conservation and Natural Resources, Bureau of Forestry, Harrisburg, PA. Although the gap analysis process for Pennsylvania has been somewhat protracted, the chronology shows that collaborative work on the project has been underway during a crucial period for conservation and the results are pertinent to prospective progress.

The call to create a class of "protected lands" in Pennsylvania has been heard at various times in the Commonwealth's history. While not specifically articulated as bioreserve strategies, different ages have comprehended the need to protect, in special ways, the state's natural resources. The rationales and mechanisms for designating protected lands have varied over the centuries, resulting in multiple schemes with diverse outcomes. For example, on July 11, **1681**, in a *Charter of Rights* to the colonists, William Penn made the provision that "in clearing the ground, care be taken to leave one acre of trees for every five acres cleared (Birkinbine, 1886).

Championing nature "reserves" was a hallmark of Mira L. Dock. In **1899**, *The Forester* reported that she gave lectures in the Commonwealth on the topics of national reserves, state reserves, municipal reserves, and local reserves (DeCoster, 1995).

From **1899-1920**, public lands were labeled "State Forest Reservation" lands.

As early as **1908**, the Forestry Department recommended preservation of remnant virgin forests. From the beginning, state forestry informally set aside areas of special beauty or interest on state lands. In **1920**, an act "Regarding Unique and Unusual Groves of Trees" was approved by the legislature; the Forestry Department quickly began operating several

forest parks covering more than 200 acres. By **1921** there were nine Forest Monuments encompassing 1,200 acres, and two special Scenic Areas. Forest Monuments were forerunners of today's Natural Areas.

In **1970** the Pennsylvania Department of Environmental Resources (DER) was created. The functions of the State Forest Commission were transferred to the state Environmental Quality Board. The DER Bureau of Forestry's resource plans incorporated a new objective, "to protect areas of scenic, historic, geologic, or ecological significance through the establishment of Natural Areas which will remain in an undisturbed state, with development and maintenance being limited to that required for health and safety.

In **1971** on May 18th, the State General Assembly passed Article 1, Section 27, the "environmental rights clause" to the Pennsylvania Constitution. It states that "Pennsylvania's public resources are the common property of all the people, including generations yet to come. As trustees of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people."

In **1975** The Environmental Quality Board reaffirmed the state's Natural Areas policy. Slight modifications added better protection to this class of protected land. The Board approved, in April, thirteen original Natural Areas and 31 proposed new ones.

In April of **1979**, 18 of the original Natural Areas were designated by the Bureau of Forestry and the Fish & Boat Commission as "special regulation areas" for the protection of all amphibians and reptiles. Only a valid collectors permit allowed the taking, catching, killing, and possessing of any species of Pennsylvania amphibians or reptiles.

In February of **1982**, 7 Natural Areas were added to the Bureau of Forestry's Natural Area system special regulations areas for amphibian and reptile protection.

In April of **1985**, 3 Natural Areas were added to the Bureau of Forestry's Natural Area system special regulations areas for amphibian and reptile protection. This brought the total of amphibian and reptile special protection areas to 28 sites.

In September of **1993**, 18 new Natural Areas and one Wild Area were added to the system. One previously designated Natural Area was enlarged, and one designated Natural Area was re-designated as a "Special Use Area."

A brief history of forestry's role in designating special protection lands is found in Hill (1997). To date, 61 State Forest Natural Areas have been designated, encompassing more than 69,000 acres. Additionally, various groups or individuals have recommended that the Commonwealth revisit its noteworthy history of designating special lands, to continue to build on it, with biological diversity as the focus.

In **1993** the Bureau of State Parks began the Natural Areas program with designation of 9 sites. The program is the result of the *State Parks 2000* initiative. By **1999** it contained 22 Natural Areas comprising nearly 12,000 acres. Very little active management is

allowed in these areas. They are set aside for scientific observations of natural processes, to protect examples of unique and typical plant and animal communities, and to protect outstanding examples of natural interest and beauty.

In **1993** the Bureau of State Parks began the Special Management Areas program. By **1993** it contained 8 sites of less than 1000 acres. Areas are actively managed to protect the resources that prompted designation.

In **1995** a special task force, the Pennsylvania Biodiversity Technical Committee, in *A Heritage for the 21st Century: Conserving Pennsylvania's Native Biological Diversity*, recommended expanding and coordinating existing programs for establishment of biological reserves in Pennsylvania (S. G. Thorne et al. 1995). Additionally, they recommended establishing a long-term monitoring and inventorying program, and challenged state agencies to review species management programs where management for single species may have negative effects on natural diversity.

In **1995** The Bureau of Forestry published a "blueprint for the management of our forest resources," called *Penn's Woods: Sustaining Our Forests*. This document committed the agency to biodiversity conservation; ecosystem management; establishing a system of public and private wild plant sanctuaries; developing a strategy to promote old-growth forest systems on state lands; reviewing the effects of timber management on landscape ecology; and retaining the wild character and ecological integrity of state forest lands.

In **1995** the Bureau of Forestry initiated the Public Wild Plant Sanctuary program pursuant to the Wild Resources Conservation Act (1982). The Pennsylvania Natural Diversity Inventory (PNDI) estimated that 40% of the state's species of special concern occur on public lands. Lands eligible for inclusion in the Public Wild Plant Sanctuary program are State Forest lands, State Parks, and lands managed by the Game and Fish & Boat Commissions.

In August of **1996** the Pennsylvania Biological Survey sponsored its first major conference titled *"Inventorying and Monitoring Biotic Resources in Pennsylvania."* Attendees stated that building partnerships, integrating state supported inventories, garnering government support for fuller inventory and monitoring efforts, standardizing protocols, protecting habitats, and educating stakeholders are essential.

In **1997** the Pennsylvania General Assembly, Joint Legislative Air and Water Pollution Control and Conservation Committee issued the *Report of the Forestry Task Force Pursuant to House Resolution 263* which states that species loss in Pennsylvania is due to habitat loss and fragmentation, interference in ecosystem processes, excessive harvesting of species, pollution, and the increasing prevalence of exotic species. The publication reported a suggestion to create a Governor's School for Environment and Ecology. It asserts that information about old growth is scarce and incomplete; the Bureau of Forestry should make lands available for experimental forests in each of the forest types for long-term research on forest renewal and the conservation of biological diversity; a portion of the Forest Regeneration Restricted Revenue Account should be dedicated to

forest research; and the then existing "Interagency Natural Resources Working Group" should be elevated to cabinet level to ensure the incorporation of ecosystem management and preservation of biodiversity into existing programs, policies, and regulations on state-owned lands.

In September of **1998** Governor Tom Ridge's *21st Century Environment Commission Report* was published (Seif and Glotfelty, 1998). Under the section on Natural Diversity Conservation, the Commissioners warn of "an urgency" in the need for natural diversity conservation. They call for defining and setting conservation priorities for species, habitats and biological communities; developing a common set of criteria for identifying the elements deserving attention; establishing comprehensive long-term programs to inventory, assess, research, monitor and manage natural diversity; and develop and implement a comprehensive and dynamic natural diversity management policy and strategy for public (mandated) and private (voluntary) lands.

In October of **1998** a third-party, independent review team led by *Scientific Certification Systems*, in *Evaluation of the DCNR Bureau of Forestry*, deems the Bureau of Forestry's management practices sustainable and certified. There are conditions (requirement to make an inadequate score meet the minimum requirements for certification) and recommendations (means to improve passing scores). The evaluation offers recommendations for a bioreserve strategy for Pennsylvania: areas *"reserved and protected from resource extraction"* can be classed into three categories based on their degree of uniqueness, purpose for protection, and size. (1) *Unique sites* – places with unique ecological features that are quite rare such as endangered species habitats. These will be typically less than 100 ha. (2) *Management benchmark reserves* – representative samples of typical natural habitats that are intended to serve as natural "controls" against which to compare the ecological consequences of management practices. These areas are necessary for adaptive management of forests. They will be from 100 – 5000 ha in size. They are to be established where plantation or other ecologically simplified forest communities created by management equal at least 10% of the total forest land under commercial management. (3) *Biodiversity maintenance reserves* – unfragmented, contiguous areas encompassing a range of natural communities, disturbance patterns, and evolutionary processes. They will range typically >10,000 ha. The certifiers asked that over the next three years, the Bureau of Forestry develop and implement an Ecological Reserve Program based on ecological analysis and conservation biology principles. Its components should include the establishment of large ecological reserves, a system of smaller reserves within the managed forest, and a system of corridors connecting them, in a comprehensive plan and system that should cover a minimum of 10-20% of the land base, with no arbitrary upper limit.

In November of **1998** the Pennsylvania Biological Survey held a second major conference titled, *"Conserving Pennsylvania's Natural Diversity: Creating a Cooperative Framework for Action."* This conference was preceded by a series of workshops to set the stage for the November meeting. The resulting cooperative framework calls for a comprehensive bioreserve strategy for Pennsylvania.

In September of **1999** the third-party, independent review team led by *Scientific Certification Systems* issued its Annual Audit. The Audit provided Bureau of Foresty comments to Recommendation 18, Ecological Reserve Program, which noted that the *Ecosystem Management Advisory Committee* (EMAC) had designated a bioreserve subcommittee to develop guidelines for a bioreserve system in Pennsylvania for State Forest Lands.

In **1999** the Bureau of State Parks designated 3 Conservation Areas and one Preserve. This program is Bureau-level and is based on deed restrictions and covenants that limit development and the types of recreational use.

In **1999** the Bureau of State Parks participated in the Public Plant Sanctuary Program with one site designated and a second area under consideration.

In **1999** the Bureau of Forestry elected to make the Public Wild Plant Sanctuary program a formal part of the Forest Resource Plan.