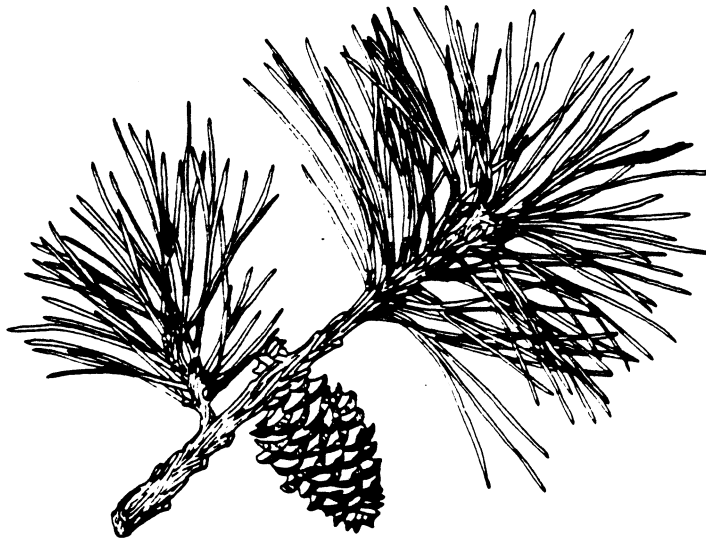

A LONG TERM RESEARCH AND MANAGEMENT PLAN FOR THE NEW JERSEY PINELANDS

1991 UPDATE



**COUNCIL ON PINELANDS
RESEARCH AND MANAGEMENT**

July 1991

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FOR THE NEW JERSEY PINELANDS
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Council on Pinelands Research and Management

July 1991

NEW JERSEY PINELANDS COMMISSION
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I. BACKGROUND AND PURPOSE

The Pinelands are a one million acre semi-wilderness located in the southern part of New Jersey, the most densely populated state in the nation. Eighty five percent of the Pinelands is forested, making the region the most extensive tract of undeveloped land along the Boston to Washington corridor.

The Pinelands represent a unique ecosystem and landscape that has been shaped by fire, sandy and impoverished soils, acid, nutrient poor waters, and human exploitation. Pine and oak dominated upland complexes and extensive wetland systems combine to form an irreplaceable ecological mosaic that supports a diversity of specialized plant and animal communities. Included among these communities are endemic, disjunct, and relict species, plants and animals that reach the limits of their geographic range, and species that are adapted to the region's stressful environment.

Human history is reflected not only in the landscape but also through the artifacts that have been left by native American and early American cultures. Native Americans are known to have used the area extensively for hunting and gathering. This is supported by the existence of more than 1000 prehistoric archaeological sites. Remains associated with 18th and 19th century grist and saw mills and iron forges and furnaces contribute to a rich historic resource that characterizes early American exploitation of the region's natural resources. Many indigenous industries such as cranberry and blueberry cultivation, timber harvesting and shellfishing are still dependent on these natural resources.

In 1978 the federal government formally recognized the national and international significance of the Pinelands by designating the region as this country's first National Reserve. This was accomplished through the passage of the National Parks and Recreation Act of 1978. In addition to creating the 1.1 million acre Pinelands National Reserve, the federal legislation authorized the establishment of a planning entity that would be responsible for preparing a comprehensive management plan for the region. The goal of this plan was to preserve, protect and maintain the essential character of the Pinelands. In June of 1979, the New Jersey Legislature passed the Pinelands Protection Act, thereby endorsing the planning directive of the federal legislation. The act established the 934,000 acre Pinelands Area and created the Pinelands Commission as the regional planning entity.

Employing an ecological approach to land use planning and management, the Pinelands Commission developed the New Jersey Pinelands Comprehensive Management Plan. The Plan was completed in the fall of 1980 and was approved by the Governor of the State of New Jersey and the Secretary of the Interior in January 1981. Taking its direction from both the federal and the state Pinelands legislation, the Plan reflects both a regional planning strategy that assigns varying levels of development intensities according to the environmental sensitivity and ecological value of an area, and a site specific approach dependent on the use of environmental performance standards. Development of the Plan

was facilitated by an extensive data base and the findings provided by past and current research efforts. The successful implementation of the Plan is similarly dependent on the continued dedication of those committed to furthering our understanding of the structure and function of the Pinelands ecosystem.

II. COUNCIL ON PINELANDS RESEARCH AND MANAGEMENT

There is a recognized need for a long-term, comprehensive approach to solving research problems that have an impact on the effective management of the Pinelands. The resolution of many critical management issues requires that investigations be conducted over several years, and in certain instances, over a period of decades. Coordination of research and monitoring among those parties involved in Pinelands studies can provide a focus on these critical issues, and facilitate the achievement of common goals and objectives.

A long-term research and management plan can serve as a vehicle that guides and encourages research that is essential to the preservation and maintenance of the Pinelands, and assist in sound resource allocation. Such a plan must reflect the needs identified by the region's principal research and management bodies. To accomplish the objective of developing a coordinated long term Pinelands research plan, the Pinelands Commission initiated the establishment of the Council on Pinelands Research and Management.

The Council is composed of representatives of the Governor, the United States Department of the Interior, the Commissioner of the New Jersey Department of Environmental Protection, the Presidents of Rutgers University and Stockton State College, and the Chairman of the Pinelands Commission. In order to better coordinate and focus Pinelands research efforts, the Council will: 1. pursue, with its member agencies, efforts to address priority research topics included in this plan; 2. disseminate this plan to other research organizations and institutions to inform them of the Council's research related decisions; 3. endorse those specific research proposals which seek to address priority research topics, and help to secure the necessary financial support to undertake them; 4. identify current research initiatives as an appendix to this plan which highlights progress made in addressing priority research topics, presents specific research priorities which the Council's member agencies or other organizations should pursue, and identifies criteria used in the selection process; and 5. periodically review the research plan.

III. HISTORY OF PINELANDS RESEARCH

The Pinelands have long been an area where research, both pure and applied, has been conducted. The knowledge developed over the years was invaluable in developing the Pinelands Comprehensive Management Plan. The Rutgers University Division of Pinelands Research has reviewed this extensive body of knowledge and, in cooperation with the Pinelands

Commission, developed a *Compendium of New Jersey Pine Barrens Literature*, a *Compendium of Archaeological, Cultural and Historical Literature of the New Jersey Pine Barrens*, and a *Survey of Current Research in the New Jersey Pine Barrens*. These reviews, which are periodically updated, provide a detailed summary of past and current Pinelands research. Several major natural resource publications included in these reviews are listed in the reference section presented at the end of this plan.

During the development of the Comprehensive Management Plan, the Pinelands Commission was assisted by agencies now represented on the Council of Pinelands Research and Management. The Department of the Interior provided administrative and financial assistance, while Rutgers University and the Department of Environmental Protection, acting as consultants to the Commission, completed several studies used in the Plan's development. The studies completed by member agencies addressed such varied topics as threatened and endangered vascular plants, an inventory of game birds and mammals, forestry practices, fire management, and air quality.

Cooperation has continued through the Plan's implementation phase. During this period, several studies, addressing research needs identified in the Comprehensive Management Plan, have been completed or are ongoing. Among the recently completed or ongoing projects are those concerning acid rain, the relationship between water quality and Pinelands aquatic species composition, effects of development related water quality impacts on wetlands, and sand mine reclamation. Important resource management related studies include a wetlands buffer delineation model intended to provide a means of developing strategies to protect Pinelands wetlands, and a management plan for the Warren Grove Weapons Range, a federal facility that is located within the boundaries of the East Plains pygmy forest. The informally structured relationship developed among the participating agencies has demonstrated the value of coordinating and directing research efforts.

In April, 1982, Rutgers University convened a group of 35 researchers with the goal of developing recommendations for an organized collection of ecological and environmental information about the Pinelands. The conference blended research and management issues in an attempt to provide ecological solutions to environmental management concerns. It focused on four major areas of environmental management concerns: 1) ecosystem fragmentation; 2) fire management; 3) nutrient dynamics; and 4) hydrology. The proceedings of the conference provide a sound basis for the development of a long-term research program directed towards the management of the Pinelands.

The incentive to develop a long-term research program was further enhanced by an action taken by the United Nations. In 1983 the Pinelands National Reserve was designated as a component of the Atlantic Coastal Plain Biosphere Reserve by the United Nations Educational Scientific and Cultural Organization (UNESCO) under the Man and the Biosphere (MAB) Program. This designation provides international recognition to the Pinelands National Reserve and may serve to encourage additional research on the interrelationships between human activities and the Pinelands ecosystem.

IV. LONG TERM RESEARCH AND MANAGEMENT PLAN

Through the development of a long-term research plan, the Council on Pinelands Research and Management seeks to enhance and direct the role that research plays in Pinelands preservation efforts. Independently conducted study efforts have greatly increased our general knowledge of the complexities of this unique ecosystem. The full benefit of these programs, however, has not been realized due to the absence of a comprehensive and coordinated ecosystem level approach.

The Council's current plan is natural resource oriented. The Council recognizes the importance of the region's cultural resources, and intends to address these areas of study as a later phase of its plan when the natural resources program is well established. This natural resource oriented plan identifies priority research topics that reflect the following Council objectives:

1. to develop a better understanding of the dynamics of the Pinelands ecosystem;
2. to develop and implement natural resource allocation and management strategies consistent with federal and state Pinelands legislation;
3. to evaluate the ecological implications of current and potential future land uses;
4. to evaluate resource management strategies, including the Comprehensive Management Plan, that are employed to protect the Pinelands; and
5. to formulate strategies for the effective allocation of financial and professional resources to carry out the intent of this plan.

The first and most important step in meeting these objectives is the collection of baseline natural resource data. This monitoring function is an integral part of our effort to gauge the actual impact of land use and resource management strategies on the ecosystem.

It is difficult and perhaps somewhat naive to attempt to provide a simple characterization of the Pinelands ecosystem, and consequently, to identify separate areas of study. For example, in a region where an immense, high quality water table aquifer exerts such a tremendous effect on plant and animal communities, the study of Pinelands water resources and biota becomes inseparable. For the purposes of planning, it is, however, necessary to create such artificial distinctions while at the same time recognizing the interrelationships which exist. This is the approach employed by the Council. Individual areas of study are

identified, but an attempt has been made to incorporate each as part of an overall, comprehensive program that includes research, basic monitoring, and data management elements.

The Council has, therefore, arranged research problems according to three general resource strategies. These are: 1. preservation and enhancement of water resources (quality and quantity); 2. maintenance of characteristic landscapes; and 3. protection and enhancement of plant and animal populations and communities.

The Council's plan is not an attempt to identify all possible areas of potential research. It is intended as a summary of those topics which are considered critical to the successful preservation and management of the Pinelands. Furthermore, it should be noted that many of the research problems have been addressed in part by past studies, while other studies are ongoing. For example, recent research has added greatly to our understanding of development related water quality and wetland impacts, and there is extensive literature on forestry management. Yet, a more complete knowledge of the selected areas is needed.

IV A. Water Resources

The chemistry of Pinelands waters must be considered atypical when compared to that found in other parts of the state and the nation. The region's surface and ground waters are naturally acid; pH values of 3.5-5.0 are characteristic of ponds and streams within forested watersheds, while ground water pH values are slightly higher. Undisturbed Pinelands waters are also low in hardness, alkalinity, suspended solids, and total dissolved solids, and are high in humic acids and iron. Concentrations of biologically important nitrogen and phosphorus compounds are exceptionally low. For example, nitrate-nitrogen and total phosphorus levels of less than 0.20 mg/l and about 0.02 mg/l, respectively, have been reported as being characteristic of undisturbed streams.

The nature of Pinelands waters is determined largely by the characteristics of the region's dominant surficial geologic formation, the Cohansey. The Cohansey sands are generally chemically inert and highly permeable, and the overlying soils have little ion exchange or absorption capacity. The Cohansey, considered to be one of the nation's most important aquifers, is therefore highly susceptible to ground water contamination resulting from the introduction of pollutants.

Ground water and surface water are integrally connected in the Pinelands. Because of the permeable nature of Pinelands soils, surface runoff is minimal, and streams are recharged from ground waters flowing from upland areas. This recharge accounts for nearly ninety percent of stream flow.

Because of the inability of the region's sands and gravels to attenuate introduced pollutants, Pinelands surface and ground waters are highly susceptible to human induced changes in water quality. Degradation of Pinelands waters has been attributed to certain land uses such

as residential development and agriculture. Contamination of surface and ground waters associated with landfills and toxic waste disposal sites is an especially critical issue. Developed stream basins generally display a lesser water quality, e.g., increased pH, nutrients, than undeveloped, forested watersheds, and this degradation is reflected in changes in aquatic and wetland communities. The principal changes noted in affected watersheds are a loss of typical Pinelands plant and animal species and the introduction of less tolerant non-native species.

A concern has also been raised regarding the potential effect of acid precipitation on Pinelands plant and animal communities. Reports on the acidification of Pinelands streams are conflicting, and there is a continuing need to assess the problem through extensive monitoring. An increased understanding of the biological and geochemical processes that control ecosystem acidity is also required.

IV A-1. Water Quality

The resolution of several important water resources research problems is needed to adequately protect the Pinelands irreplaceable natural resources. These concern the characterization of important biological and human health related parameters, the biogeochemical processes affecting water quality, the relationship between land use and water quality, and the movement of contaminants through the ground water system. These problems are described in the following research questions.

1. *What are the relationships between various categories of land use and water quality?*

This problem can be addressed through a comparative study of several typical land use categories such as forested land, residential development, and agriculture. Among the important parameters to be monitored are various forms of nitrogen and phosphorus, pH, and selected toxicants such as agricultural pesticides and heavy metals. Monitoring should be accomplished through both short term, intensive study schedules, and long term programs, conducted at subwatershed and development project levels. Coordination among data collecting institutions and data management are essential components of this monitoring program.

The results of these programs will provide a more complete characterization of the degree to which various land uses affect water quality, and can be used in land use planning and regulatory affairs. The principal goal is to provide environmental agencies with the information required to develop comprehensive water quality protection programs. In the long term the accumulation of such data throughout the region will provide the basis for sound land use decisions.

2. *How effective are current technologies in attenuating degradation of ground and surface waters?*

The generation and disposal of all classes of waste materials present special problems in the Pinelands because of the nature of the region's water resources, soils, and geology. Both sewage sludge and septage are disposed of primarily through landfilling. Less commonly used sludge disposal methods are composting and land application as part of agricultural operations. Remediation of hazardous waste sites may involve the on-site treatment of wastes and disposal of treated effluent, creating the potential for contamination of adjacent areas.

In addition to the standard septic system designs used for most unsewered development, several alternative designs have been developed. These are generally designated for use in areas which are unsuitable for the installation of standard systems, such as areas with high water tables, or to more effectively reduce the amount of nutrients introduced to the groundwater. The effectiveness of both standard and alternative systems has not been adequately assessed in the Pinelands, and research directed in this area can provide the basis for evaluating the effectiveness of the various systems in meeting mandatory water quality standards. Better management decisions can be made regarding the types of septic systems permitted, and the conditions under which they should be used.

3. *What factors influence the direction and rate of movement of a contaminated groundwater plume within the Cohansey and how can quantitative estimates of groundwater flux be made for this aquifer?*

The ability to accurately predict the direction of a groundwater plume and the concentration of chemicals along the plume dispersion gradient is important for understanding the impact of waste treatment systems and water extraction proposals for the Pinelands. While the Cohansey is often thought of as a "simple" hydrologic system, it is clear from recent studies in the McDonald's Branch watershed that certain factors such as clay lenses and peat deposits may alter flow patterns within the aquifer. Without a suitable understanding of the quantitative groundwater flux within the Cohansey, remedial measures for waste issues within the Pinelands will be difficult to develop with any degree of accuracy.

4. *What are the biological and geochemical processes that regulate ground water and surface water chemistry?*

A greater understanding of the natural processes that regulate Pinelands water chemistry is needed to fully assess land use related changes in water quality. Research of this nature can also contribute to our knowledge of the acid rain phenomenon. Maintenance of stream acidity, for example, has been attributed to several mechanisms. Among these are oxidation and hydrolysis of iron, humic acids and carbon dioxide produced in swamps and transported to streams, and absorption of bases by *Sphagnum* moss and peat. It has also been suggested that Pinelands wetlands play an important role in reducing nutrients originating from upstream land uses.

Pinelands soils are generally considered to be chemically inert, and dilution has been identified as the principal mechanism responsible for attenuating introduced contaminants. Additional research is needed to fully determine the capacity of Pinelands soils to buffer inputs to the ecosystem, especially as this relates to phosphorus, agricultural pesticides, and toxic substances.

IV A-2. Water Quantity

The Cohansey Formation, a water table aquifer with an estimated storage capacity of 17 trillion gallons, underlies most of the Pinelands and exerts a tremendous influence on the structure and function of the ecosystem and landscape. This regional water table is generally close to the surface, ranging in depth from 0-70 ft and occurring within 5-10 ft of the surface over large areas. The shallow water table is a major determinant of the distribution and abundance of characteristic plant and animal communities. The abundant supply of surface and ground waters is also critical to the maintenance of water quality and estuarine ecosystems located along the periphery of the Pinelands, as well as berry agriculture, one of the Pinelands most important industries.

In addition to its ecosystem role, the Cohansey is recognized as an important water supply source for areas located both within and immediately outside its boundaries. A conservative estimate places the use rate at 98 million gallons per day. Preemptive, consumptive use of this important aquifer can have important ecological implications. The need to develop a balance between water supply needs and ecosystem requirements is perhaps the most critical environmental issue that must be addressed in New Jersey's program to preserve, protect, and maintain the Pinelands.

Two research problems are created by conflicting human needs and ecosystem requirements. These are associated with the effects of ground water withdrawals on ground water levels and stream flows, and the ecological impacts associated with such changes.

1. *Within the context of normal environmental fluxes, what is the local and regional magnitude of ground water level and stream flow changes associated with existing and proposed ground water withdrawals?*
2. *What changes in the Pinelands ecosystem will result from potential local and regional changes in ground water level and stream flow, and what can be considered to be ecologically safe water yields?*

These problems can be addressed through a coordinated modeling and field investigation program. As the state's water supply problems increase due to population growth and degradation of existing water supply systems, greater consideration will be given to using the Cohansey as a major water source for areas located outside its boundaries. The results of related research can be used to develop environmentally sound, state-wide water supply policies and programs that affect the

ecological integrity of the Pinelands. Included within this area of study is a determination of current and future water supply demands and distribution.

IV B. Landscape Integrity

The present Pinelands landscape reflects more than 300 years of human exploitation. Perpetuation of this landscape, therefore, requires an understanding of both the ecological processes and the human related disturbances, such as fire, logging, and berry cultivation, that have shaped it.

Several topics are included within the general subject of landscape management. By integrating basic and applied research objectives, the results of research in ecosystem fragmentation, succession, population ecology, and community ecology can be transferred to land use planning, forestry, and fire management programs which have a direct effect on the maintenance of the Pinelands' unique and diverse landscape elements.

Historically, fire and cutting have been the dominant Pinelands landscape shaping factors. These have been mainly responsible for the creation of an ecological mosaic composed of a patchwork of habitat types. Agricultural activities, especially berry cultivation, have also had an effect. More recently, the fragmenting effect of residential, commercial, and industrial development and resource extraction (sand and gravel mining) has resulted in a more permanent and potentially destructive impact on the integrity of the landscape. Concerns for the effects of recreational use also exist. The following research questions address the issues associated with management and use of the landscape and its preservation. The resolution of each one will contribute to our understanding of the factors responsible for the existing landscape and how changing disturbance regimes are affecting this landscape, and lead to the development of more comprehensive management strategies.

1. *What are the characteristic elements of the Pinelands landscape and ecological mosaic, how are these elements spatially distributed, and how do they change over time?*

The Pinelands landscape is comprised of a variety of habitat patches, each reflecting a unique combination of environmental conditions and past histories. One level of patch classification employs broad habitat type designations such as oak-pine forest and pine-oak forest. This approach does not, however, accurately reflect the actual diversity of habitat patches which occur in the region. A more detailed classification of the nature and structure of Pinelands plant communities, one that addresses both ecological and forest production (i.e., timber quantity and quality) objectives, is required along with a determination of the spatial distribution, status and dynamics (change) of these habitat patches and forest types. Special attention should be given to important landscape elements such as Atlantic white cedar swamps, ephemeral ponds, bogs, and the Pine Plains. The landscape must be defined

and characterized for effective management and to enable better monitoring of subtle changes over time.

2. *What ecological criteria can be used to determine the size and sequence of woodland harvests?*
3. *Can superior native seedlings for reforestation be developed for use under special conditions?*
4. *What forestry management practices can be employed to preserve and maintain characteristic landscape elements, especially Atlantic white cedar swamps?*

Use of Pinelands forest products is an important economic activity that if properly conducted can be compatible with the maintenance and enhancement of the landscape. Cutting is in fact an ecological necessity if the present landscape is to be preserved. However, conflicts between timber production and preservation objectives can arise. It is necessary to view forestry from a broader context, that is, as a means of managing Pinelands forests for a wide range of preservation compatible objectives ranging from production to landscape maintenance. To this end, forestry management concerns are related to the size of ecologically acceptable wood harvests, management of Atlantic white cedar swamps, best management practices, and natural lands management, and the ecological impacts of the use of exotic species in reforestation.

5. *What are the characteristics of the historical and current fire regimes and what are the long term and short term ecological effects of these regimes?*
6. *What alternative fire management strategies can be employed to preserve and maintain the Pinelands landscape?*

Like forestry management, fire presents a paradox. It is also an ecological necessity, yet it conflicts with generally accepted timber production and fire suppression objectives. A decrease in frequency and areal extent of fires since the earlier part of the century has been reported, and it has been suggested that this has resulted in a significant change in the landscape. The essential role of fire must be better documented, ecologically sound fire management strategies should be developed, and the feasibility of implementing such strategies should be assessed.

7. *What are acceptable ecological limits of fragmentation created by destructive land uses such as residential development and mining?*
8. *What ecologically acceptable materials and methods can be used to reclaim sand and gravel mines?*

Both development and resource extraction have long term (usually permanent) impacts on the landscape. By the end of the 1970's approximately ten percent of the Pinelands was developed land, and there was an increase in piecemeal and scattered development. The majority of

development is now directed to limited areas, yet low density development still occurs throughout extensive forested areas. The ecological implications of both levels of development must be addressed.

Unlike development, resource extraction is a land use that affects extensive areas of unbroken forest land in the least developed regions of the Pinelands. More than 3,000 acres have already been mined in the Pinelands, and there is a potential for mining a total of more than 10,000 acres. Reclamation of these lands is essential if the impact of this land use is to be mitigated, and if the industry is to continue as an acceptable economic activity.

9. *How do recreational uses such as canoeing and motor vehicle use affect the quality of Pinelands resources?*

Concerns have been raised over the environmental impacts of recreational use in the Pinelands. The issue of conflicting uses has been actively debated in recent years. Principal among the issues are the effects of motorized vehicles, especially off-the-road vehicles (ORV's), and the potential overuse of Pinelands rivers by canoeists.

IV C. Management of Plant and Animal Populations and Communities

The Pinelands support a unique assemblage of plant and animal species. Botanical interest in the region has a long and rich history which continues through the present. This has resulted in an extensive literature on the distribution and status of both rare and common species such as broom crowberry and pyxie moss. The region's wildlife also contribute substantially to the uniqueness of the region. This is especially true of the Pinelands herpetofauna which includes rare species such as Pine Barrens treefrog, timber rattlesnake, and cornsnake. An increased knowledge of the ecology of individual plant and animal species, especially those which are rare or serve as key indicators of Pinelands environmental quality, will better enable resource managers to preserve their populations, thereby contributing to the maintenance of the essential character of the Pinelands.

Similar attention must be given to the region's outstanding communities and ecosystem complexes. Included among these are Atlantic white cedar swamps, wetland complexes, abandoned cranberry bogs, and naturally occurring acid water plant and animal communities. The Pine Plains, the largest pygmy forest in the nation, deserves special consideration.

Each of the following research topics must be reviewed in concert with previous sections of this plan. Management of certain rare plant species, for example, requires a greater understanding of fire ecology, while preservation of unique aquatic communities is dependent on the maintenance of water quality and quantity. Some topics, such as management of Atlantic white cedar swamps and Pine Plains management have been discussed under previous sections.

1. *What is the relationship between water quality and the structure and function of Pinelands aquatic communities?*

Specialized plant and animal communities have evolved and adapted to the unique and ecologically stressful conditions created by the acid, nutrient deficient Pinelands waters. These include aquatic communities comprised of acid water algae, characteristic invertebrate communities that are low in species diversity, attached plant assemblages that are markedly different from those found in adjacent areas of the Inner Coastal Plain, and fishes with restricted ranges. A large number of the approximately sixty species of the region's herpetofauna are similarly adapted and dependent on the atypical water quality found in the Pinelands.

Several studies have demonstrated that Pinelands aquatic communities are adversely affected by water quality degradation. Further research is needed to clarify the relationship between water quality and community composition, identify key indicator species, and develop critical threshold levels for certain water quality parameters.

2. *What effects do development related impacts such as elevated pH, increased nutrients, and altered ground water flow have on the structure and function of Pinelands wetlands, and how effective are buffers in mitigating development related impacts to Pinelands wetlands?*

Pinelands wetlands serve a multitude of important ecological and cultural functions. These lowlands communities, which include pitch pine lowlands, Atlantic white cedar swamp, hardwood swamps, bogs, inland and coastal marshes, lakes, ponds, and streams, cover nearly one third of the Pinelands ecosystem. Their preservation is a primary objective of New Jersey's Pinelands protection program. These ecologically important communities are affected by impacts associated with residential development and agriculture. Further research is needed to quantify development induced changes and to develop strategies to protect these resources. One strategy currently employed is the establishment of upland buffer areas between wetlands and development. The second problem presented above addresses the need to assess the effectiveness of such buffers in protecting the ecological viability of wetlands.

3. *What factors affect the population status of recreationally important wildlife species and selected key indicator species?*

This problem relates to research in the biology of selected animal species populations. This research is essential to the development of successful transplant and reintroduction programs, such as New Jersey's attempts to enhance rare species populations and to establish viable populations of previously extirpated species such as the turkey. Included within this area of study is the potential impact of exotic species on Pinelands communities.

4. *What are the specific habitat requirements of selected key indicator animal species, and what is the minimum size of natural reserves required to support viable populations of selected key indicator animal species?*

Progressive environmental degradation and landscape fragmentation associated with the increasingly intensive nature of land use in the Pinelands have had an impact on the region's animal populations. The site specific effects of habitat destruction are obvious, but the more subtle impacts of creating increasingly smaller areas of contiguous forest are more difficult to assess. The two questions which have been presented here are intended to highlight the need for a comprehensive definition of critical habitat as it relates to the maintenance of viable populations of wildlife species.

5. *What types of landscape compatible management practices can be employed to enhance native wildlife species?*

Existing Pinelands habitats can be managed to benefit wildlife populations while maintaining and enhancing characteristic Pinelands landscapes and environmental quality. Such strategies involve minimal use of chemicals and fertilizer, dependence on native plant materials, and the proper use of cutting and fire as management tools. Research in this area will benefit not only wildlife, but the entire ecosystem.

6. *What are the detailed life histories of selected rare plants and what management practices can be employed to enhance their populations?*

Certain rare plants such as broom crowberry and curly grass fern are Pinelands symbols, while all contribute to the natural diversity of the region. Little is known, however, about individual life histories and the environmental factors such as various types of disturbance that affect their abundance and distribution. Intensive ecological studies of selected species will definitely aid in the protection and management of these important components of the region's natural heritage.

V. DATA MANAGEMENT

Information collected on the Pinelands ecosystem should be placed in a centralized data management system. The purpose of this system would be to:

1. keep a current computer file on publications relating to the Pinelands;
2. summarize key findings from studies, including a geographic component;
3. organize land use, recreational and resource management data in a geographical database system;
4. facilitate access to continuous monitoring data collected by federal, state and local governments and academic institutions;

5. develop resource allocation alternatives and review Comprehensive Management Plan impacts utilizing data synthesis techniques for graphical and statistical analyzes.

Any computerized database management system should provide ready access to available information on the Pinelands and provide a focal point for holistic analyses of the impact of past resource allocation decisions. The Council will pursue strategies and identify the means to accomplish this objective.

VI. SUMMARY

The long term research and management plan for the New Jersey Pinelands presented by the Council on Pinelands Research and Management is currently a natural resource based program intended to increase our knowledge of this unique ecosystem and contribute to its proper management and long term preservation. The plan represents the collective expertise and opinion of individual representing institutions with a major commitment to the Pinelands. It is hoped that it will prove to be a successful vehicle for encouraging and coordinating research both within and outside the member institutions.

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VIII. APPENDIX I, CURRENT RESEARCH INITIATIVES

As indicated in its long term research and management plan, the Council on Pinelands Research and Management will identify current research initiatives which identify specific research priorities that the Council's member agencies or other organizations should pursue.

The Council has currently identified four priority research topics for study. These include: 1. an assessment of the effectiveness of buffer areas in protecting wetlands; 2. the establishment of a regional surface water quality monitoring program; 3. the effect of ground water withdrawals on Pinelands hydrology and the impact of altered hydrologic regimes on wetlands; and 4. a comprehensive inventory of Atlantic white cedar swamps and implementation of regeneration strategies.

Several factors were considered in identifying research topics. These are: 1. the relationship of the topic to the Council's plan; 2. the potential contribution of the related studies to our existing knowledge of the Pinelands ecosystem; 3. the potential land use and resource management application of the related study results; and 4. the urgency with which the results are needed to resolve critical land use and management issues.

The Council will encourage member agencies and other interested parties to conduct research in the specified study areas. It is the Council's intention to lend support to interested researchers in their pursuit of necessary funding. The Council will not serve as a source of research funds. Rather, it will identify relevant research proposals and provide a unified approach to identifying and securing research dollars. The four factors used to identify the priority research areas will also be used to review proposals presented to the Council. In addition, the Council will consider the following factors: 1. originality of the proposal; 2. quality of the research design; 3. expertise of the investigators and their ability to complete the proposed research; and 4. program and budgetary planning. Each factor is intended to provide guidance in selecting those proposals which are most consistent with the intent of the long term plan and which demonstrate an ability to effectively implement the proposed project.

The following narrative outlines each study topic, the research question which is addressed, a suggested approach, potentially interested agencies and institutions, and a study schedule. The study schedule presents general milestones which will be used to evaluate the Council's effectiveness in implementing the work plan.

VIII. A. Wetland Buffers

A-1. Research question to be addressed: What effects do development related impacts such as elevated pH, increased nutrients, and altered ground water flow have on the structure and function of Pinelands wetlands, and how effective are buffers in mitigating development related impacts to Pinelands wetlands?

A-2. Suggested approach. One way to address this issue is through the completion of a long term monitoring program which assesses the quality of wetlands vegetation, ground and surface water quality, and hydrology in relation to varying development/wetland buffers. Such a study should include a broad range of development intensities.

A-3. Interested agencies and institutions. Rutgers University - Division of Pinelands Research, has taken the initiative, in cooperation with the Pinelands Commission, in pursuing this important research topic. The Division has completed the first three years of a long term study to assess the effectiveness of upland buffer zones. This will provide the basis for determining long term changes in the quality of wetlands located near development.

A-4. Financial support. Funding was received from a private foundation for the initial three year wetlands buffer study. Rutgers University - Division of Pinelands Research and the Pinelands Commission provided additional resources for this first phase. There is a need, however, to secure additional funding sources to enable implementation of a long term program over an 8-10 year period.

A-5. Study schedule. As a long term research project, the suggested study should extend over an 8-10 year period.

VIII B. Water Quality Monitoring

B-1. Research question to be addressed. What are the relationships between various categories of land use and water quality?

B-2. Suggested approach. The Council suggests that this research topic be addressed primarily through the establishment of a long term, regional surface water quality monitoring network. This network should ultimately include every major Pinelands river and selected tributaries, representing drainage basins that may be characterized as developed, agricultural, and forested. Efforts should be concentrated on those parameters, such as pH and nutrients, that have a demonstrated effect on Pinelands flora and fauna. Important elements of the program are data collection, quality assurance, and data management and dissemination. A regional approach is the preferred strategy; however, until a comprehensive, regional approach can be implemented, individual projects that address the goals of a regional network will be encouraged.

B-3. Interested agencies and institutions. The Pinelands Commission has established a regional surface water quality monitoring program in cooperation with the Cape May County, Burlington County and Ocean County health departments. Reports describing water quality at selected stream stations are published annually by the Pinelands

Commission. The Commission is also in the early stages of designing a long term environmental monitoring program for the Pinelands. It is envisioned that a number of indices, including water quality, will be monitored within selected study areas that are representative of the Pinelands.

B-4. Financial support. The regional surface water monitoring network is currently funded by the Pinelands Commission and participating health departments. Outside funding may become necessary if budget constraints continue for more than one or two years.

Until the long term environmental monitoring program is designed, it is premature to predict funding needs. With respect to water quality, the existence of the surface water monitoring network may help to alleviate the need for extensive funding on the water quality component.

B-5. Study schedule. The surface water monitoring network is an ongoing effort and reports are published on an annual basis. The long term environmental monitoring program is in the early stages of design. Identification of the study units and final design of monitoring program will require at least one or two years to complete.

VIII C. Effects of Altering Pinelands Hydrology

C-1. Research question(s) to be addressed. a) Within the context of normal environmental fluxes, what is the local and regional magnitude of ground water level and stream flow changes associated with existing and proposed ground water withdrawals? and b) What changes in the Pinelands ecosystem will result from potential local and regional changes in ground water level and stream flow, and what can be considered to be ecologically safe yields?

C-2. Suggested Approach. The first question, which deals with the direct physical impact of ground water withdrawal, can be addressed at two levels. First, the impacts of selected withdrawal schedules can be estimated using appropriately calibrated models. Secondly, existing or currently approved wells and well fields can be the subject of in-depth field study. The second question can be addressed in several ways. We suggest that at this time, attention be given to the effects of altered hydrologic regimes on Pinelands wetlands. This requires a greater understanding of the relationship between various Pinelands wetlands types and ground water levels, and the response of these communities to changing water table levels.

C-3. Interested agencies and institutions. A research consortium which includes the United States Geological Survey, the New Jersey Department of Environmental Protection, Rutgers University and the Pinelands Commission has been formed to undertake a study of the hydrologic and ecological effects of withdrawing water from the Kirkwood - Cohansey aquifer. The evaluation of ecological effects will rely on assessments of altered hydrologic regimes on Pinelands wetlands.

The Pinelands Commission has completed hydrologic budgets for the Mullica River Basin in lower Camden County and for two major tributaries of the Great Egg Harbor River (Babcock Creek and Gravelly Run) in Hamilton Township, Atlantic County. The results of these studies are directly transferable to water supply management within Pinelands regional growth areas. The Commission also completed a study of the relationship between hydrology and Pinelands lowland plant communities.

C-4. Financial support. The five year study of the hydrologic and ecological effects of withdrawing water from the Kirkwood - Cohansey aquifer is estimated to cost \$6.1 million. Although each of the participating agencies has pledged financial support, additional funding amounting to \$5.7 million will be needed.

C-5. Study schedule. The Kirkwood - Cohansey study proposal envisions a five year schedule which is predicated upon the timing and amount of funding received. Until full funding becomes available, the council encourages researchers to pursue individual components of the comprehensive research program.

VIII D. Atlantic White Cedar Management

D-1. Research question to be addressed. What forestry management practices can be employed to preserve and maintain characteristic Pinelands landscape elements, especially Atlantic white cedar swamps?

D-2. Suggested Approach. Effective management of Atlantic white cedar swamps - with maintenance and enhancement of diversity as a goal - requires that a detailed inventory of the resource be developed. This involves both mapping and describing extant stands. The latter includes an assessment of timber quality and age (forest type, species, age, DBH, height, volume and reproduction). Secondly, strategies must be implemented to maintain the resource. An important element of this implementation phase is a program to monitor the effectiveness of selected management strategies.

D-3. Responsible parties. The Department of Environmental Protection, Bureau of Forest Management, has mapped Atlantic white cedar stands and classified them according to the proportion of cedar within the stands. As described above, more detailed inventory information is still need.

Dwight Stoltzfus, a Rutgers University Ph.D. candidate associated with the Division of Pinelands Research, recently completed a dissertation that addressed the relationship of Atlantic white cedar swamp community structure to disturbance and ecosystem fragmentation. George Zimmerman of Stockton State College is conducting an investigation of management techniques to regenerate Atlantic white cedar which is funded by the Department of Environmental Protection. The Council endorsed Dr. Zimmerman's project and agreed to recommend that the Department of Environmental Protection continue its support.

D-4. Financial support. The Department of Environmental Protection has supported much of the work undertaken to date. Because of its federal monitoring and planning role in the Pinelands National Reserve and its coordinator role with the U.S. Forest Service, the National Park Service should take the lead role in securing financial support for the balance of the studies needed in this area.

D-5. Schedule. The mapping effort and the dissertation addressing the relationship of Atlantic white cedar swamp community structure to disturbance and ecosystem fragmentation have been completed. Only one of the other areas of study is underway.