CONSERVATION GOALS AND OBJECTIVES FOR THE ALBANY PINE BUSH PRESERVE

Stephanie B. Gebauer
Eastern New York Chapter,The Nature Conservancy
1736 Western Avenue, Albany, New York 12203
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TABLE OF CONTENTS

INTRODUCTION

The Albany Pine Bush Preserve contains a pine barrens ecosystem of global ecological importance. The Preserve supports a variety of elements that are rare in New York state including: six rare plant species, two rare plant communities, 14 rare insect species and four rare species of reptiles and amphibians (Schneider, et al., 1991), many of which depend on fire to provide conditions suitable for their long-term survival. One of these species, the Karner blue butterfly is federally endangered.

Broad-scale urbanization and development of advanced fire-fighting technology during recent decades have disrupted the historical fire regime in the Albany Pine Bush by essentially eliminating fire as an ecological force. Consequently, many characteristic pine barrens plants and animals have experienced severe adverse effects, particularly those that are directly or indirectly maintained by fire (i.e. the Karner blue butterfly, pitch pine-scrub oak barrens and pine barrens vernal ponds). Owing to the current condition within the Preserve (i.e. safety hazards, loss of pitch pine-scrub oak barrens habitat, dissection of the landscape, etc.) fire can no longer occur as a natural process.

Recognizing that the long-term integrity of pine barrens depends on periodic disturbances, such as fire, active management by land managers is essential to restore and maintain the ecosystem. Successful management requires a clear direction determined by well-defined conservation goals. Methods to achieve

and monitor progress toward management objectives must be developed, implemented and continually refined as new information becomes available.

The purpose of this report is to define clearly general conservation goals and to describe primary biological objectives for the Albany Pine Bush Preserve. A brief justification and quantitative description for each objective are presented. Ecological models and their applications to directing management approaches are discussed. Research and monitoring programs currently being used to measure management effects and success are also briefly described along with an outline of future research and management needs. More thorough discussions regarding current or proposed research cited herein are on file at the Eastern New York chapter of The Nature Conservancy.

It should be stressed that, due to limited quantitative data, specific objectives and mechanisms described are approximate and should be revised as research yields new information; this process is essential for making accurate management decision and refining management activities. In the meantime, we can use information currently available to develop specific objectives and hypotheses for how to achieve overall goals.

CONSERVATION GOALS AND OBJECTIVES

Successional changes have occurred throughout most of the Albany Pine Bush Preserve, resulting in the degradation of the

globally rare pitch pine-scrub oak barrens, Karner blue butterfly and other pine barrens features. In light of this finding, the general conservation goal is:

> To restore and maintain good examples of existing pine barrens plant and animal species and communities within the Albany Pine Bush Preserve in perpetuity.

To provide direction for how to achieve this goal, the most important conservation and management objectives are identified and described below.

Karner blue butterfly

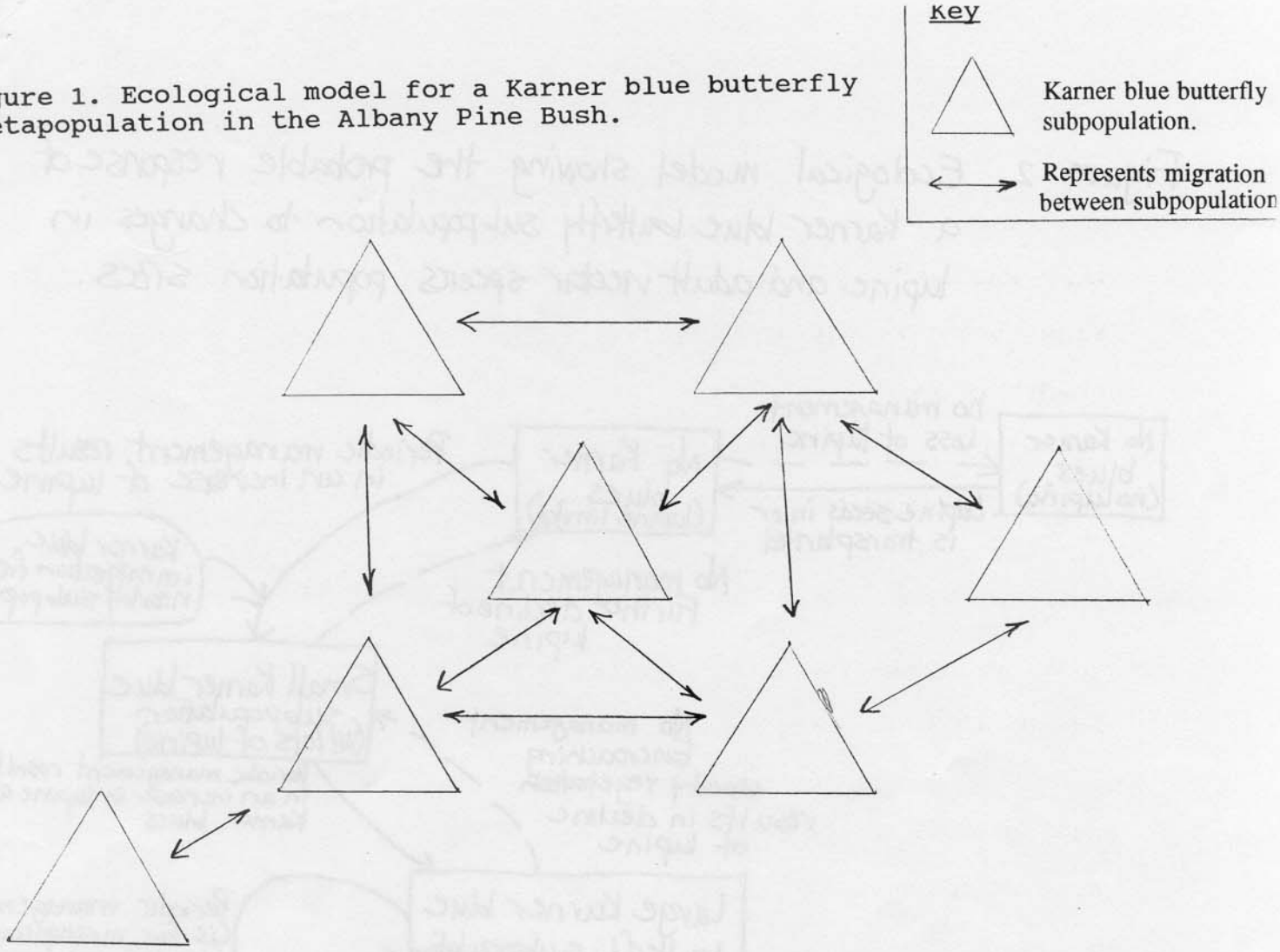
Justification: Since it is the only federally endangered species in the Pine Bush, the Karner blue butterfly, more so than any other animal, has been the focus of protection efforts within the Preserve. Within the past decade, the Karner blue butterfly has experienced a catastrophic collapse in numbers by more than 98% within the Albany Pine Bush (Schweitzer, 1989). Because of the significant loss of Karner blue populations throughout its range, assessing the current number of populations and their sizes, managing for suitable habitat and detecting changes in population dynamics through time are essential if the species is to persist long-term.

Objectives: According to a panel of three ecologists, the long-term survival of a Karner blue metapopulation within the Albany Pine Bush requires that no fewer than five quasi-discrete subpopulations of Karner blue butterflies be established and maintained. Each subpopulation must be capable of producing spring broods of roughly 1,000 butterflies in a typical year and each must be situated within dispersal range of at least one other subpopulation and yet occupy a sufficiently dissected landscape that it would be unlikely for a single fire to eliminate all subpopulations (Givnish et al., 1988, p61-62).

Ecological Model and Mechanisms: Ecological models for a Karner blue metapopulation and subpopulation are presented in Figures 1 and 2, respectively. Figure 1 illustrates the type of structure required to maintain a Karner blue metapopulation in the Albany Pine Bush. The information in Figure 1 reflects conditions stated in the above objective and is based on recommendations of three ecologists during their assessment of the minimum area requirements for the long-term conservation of the Karner blue butterfly and the Albany Pine Bush (Givnish et al., 1988). The Karner blue depends on availability of suitable habitat, specifically wild blue lupine and adult nectar species, as Figure 2 illustrates.

Because the survival of the Karner blue ultimately depends on the availability of suitable habitat, stewards must work to: 1) improve habitat in areas that currently support Karner blue butterfly subpopulations by enhancing lupine and nectar species

Figure 1. Ecological model for a Karner blue butterfly metapopulation in the Albany Pine Bush.



Comments:

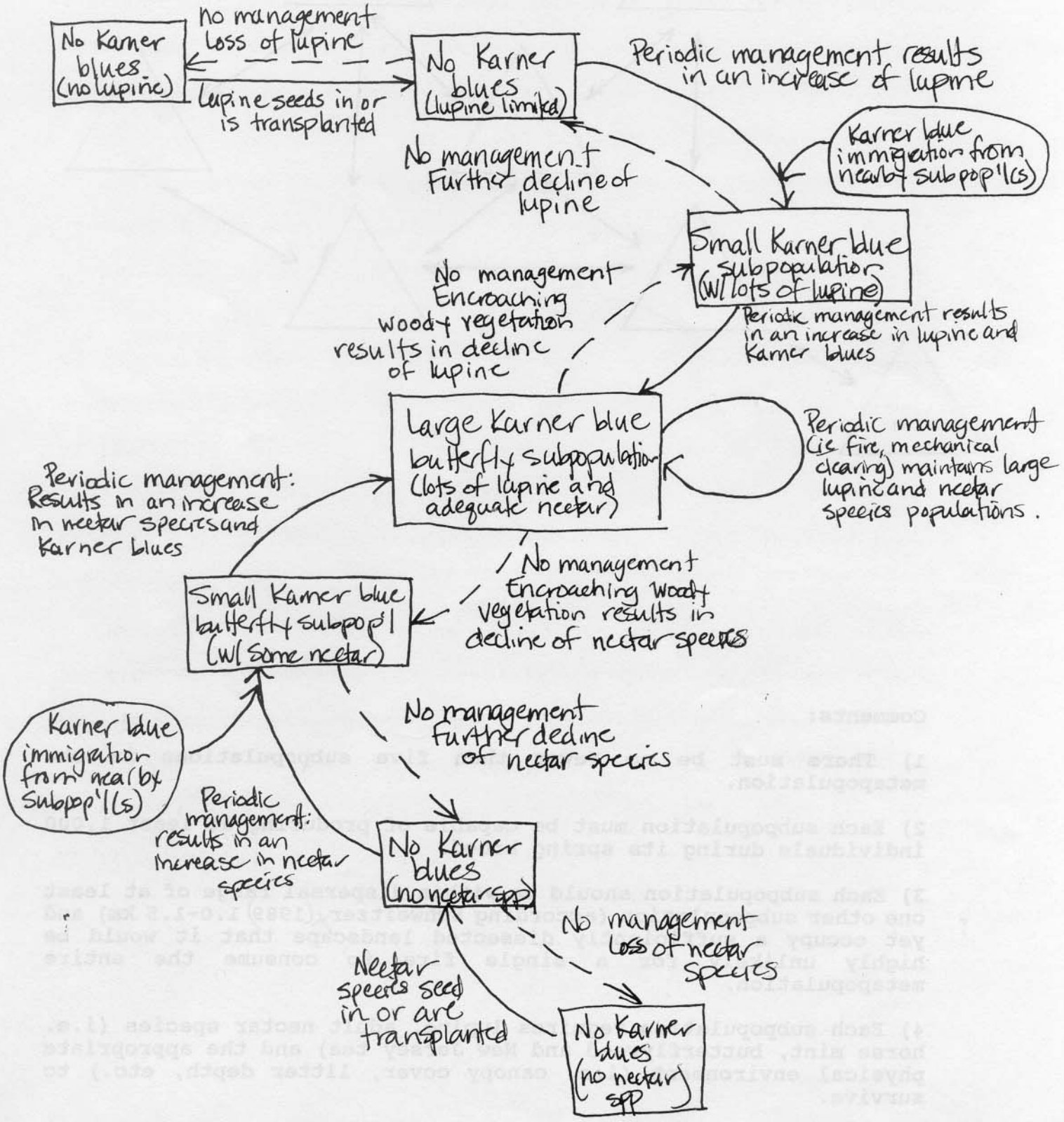
1) There must be no fewer than five subpopulations in the metapopulation.

2) Each subpopulation must be capable of producing at least 1,000 individuals during its spring brood.

3) Each subpopulation should be within dispersal range of at least one other subpopulation (according Schweitzer (1989) 1.0-1.5 km) and yet occupy a sufficiently dissected landscape that it would be highly unlikely for a single fire to consume the entire metapopulation.

4) Each subpopulation requires lupine, adult nectar species (i.e. horse mint, butterflyweed and New Jersey tea) and the appropriate physical environment (i.e. canopy cover, litter depth, etc.) to survive.

Figure 2. Ecological model showing the probable response of a Karner blue butterfly subpopulation to changes in lupine and adult nectar species population sizes.



populations, 2) create good quality habitat in areas that do not currently support Karner blues by establishing and maintaining lupine and nectar species populations and 3) ensure that the spatial arrangement of areas with good quality habitat permits migration of Karner blues to and from them. Research should focus on quantitatively assessing what the appropriate environmental conditions are for lupine and nectar species.

Research and Monitoring: To date, several research and management efforts have been implemented in the Albany Pine Bush Preserve to monitor the Karner blue butterfly and enhance its habitat. For example, to expand or restore good quality habitat, woody vegetation was cleared from around several lupine populations known to currently or historically support Karner blues (Pickering et al., 1991a). Unfortunately, no information was collected regarding pre-treatment vegetation characteristics or the status of the Karner blue butterfly subpopulations. Therefore, only observations can be used to assess potential management effects. However, a recent study in Michigan, designed to investigate effects of several management practices on vegetation structure and its relationship to Karner blue butterfly population dynamics, may provide useful information (Ballard and Sferra, 1991).

Other studies in the Albany Pine Bush have been implemented to determine the most effective way to propagate lupine (Zaremba et al., 1991) and improve our understanding of lupine ecology (Pickering et al., 1991b).

To establish baseline information regarding the present distribution and size of Karner blue butterfly subpopulations in and around the Albany Pine Bush Preserve a monitoring program was implemented in 1991 (Gebauer, 1992a). It is anticipated that this work will continue long-term to document changes in the status of Karner blue butterfly populations through time (Higgins et al., 1991, Gebauer, 1992a, Meyer et al., in prep.). Reports describing these studies in greater detail are on file at the Eastern New York Chapter of The Nature Conservancy.

Future Research and Management Plans:

1) Collect information to improve our understanding of management effects on vegetation characteristics and Karner blue butterfly populations. Although information regarding management effects on Karner blues will become available as areas near Karner blue subpopulations are managed, small butterfly subpopulations and limited resources preclude an intensive study. In 1993, it may be possible to collect baseline information regarding vegetation characteristics in areas that are located adjacent to Karner blue subpopulations (i.e. the Route 155 dune cut and the Willow Street powerline right-of-way). Until then, the Albany Pine Bush must largely rely on information from other sites (i.e. information from the study being conducted in Michigan).

2) By 1994, conduct a controlled burn adjacent to a Karner blue butterfly population to expand suitable habitat. Assess management effects on subpopulation size.

3) Continue lupine habitat management until fire management effectively increases lupine population sizes, so that sites already treated are kept fairly open and so that new sites can be established.

4) By 1994, create three new lupine populations in areas that may be used as corridors either between a Karner blue subpopulation and a large population of lupine that is currently not supporting Karner blues or between two existing Karner blue subpopulations.

5) Complete the lupine propagation study by 1993 and the summary lupine demography study by 1994.

6) Develop and implement Preserve-wide lupine and Karner blue management strategies as recommended in the final lupine reports being prepared during fall 1992. The ability to implement Preserve-wide management recommendations will depend on specific recommendations and available resources. It is anticipated that recommendations will describe: 1) how to establish lupine and corresponding nectar species populations that are capable of supporting Karner blue subpopulations and 2) where to establish the lupine and nectar species such that Karner blue immigration can occur.

Inland barrens buckmoth

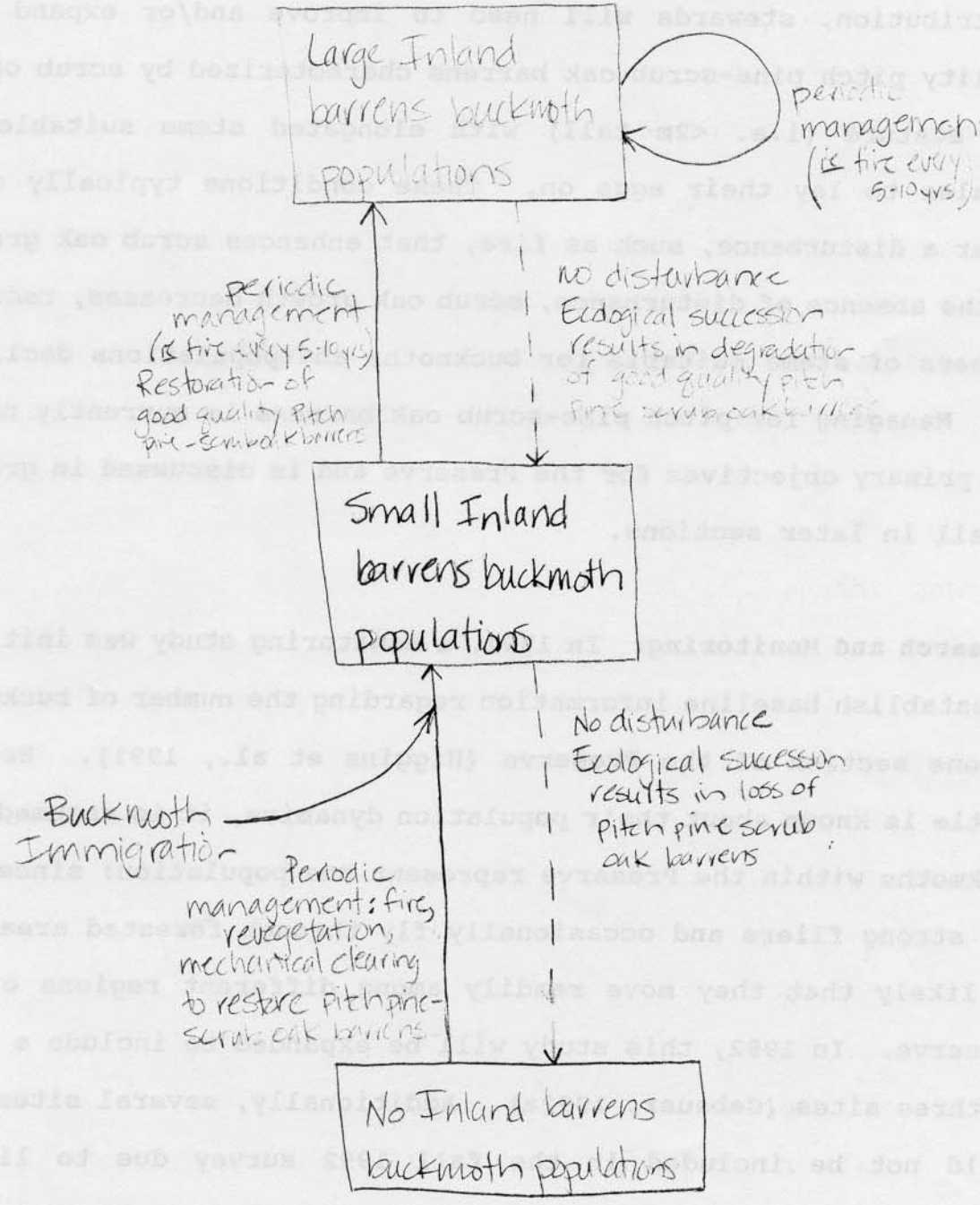
Justification: Besides the Karner blue, little or no quantitative data are available on historic population sizes of other

Lepidoptera characteristic of the Pine Bush. However, it is widely believed that inland barrens buckmoth population has declined within the Albany Pine Bush Preserve (Givnish, et al., 1988). This subspecies prefers to oviposit only in very open areas on scrub oaks less than two meters high with small twigs and widely spaced leaves. Because of fire suppression, suitable buckmoth habitat has declined. The inland barrens buckmoth is not officially listed in New York as endangered or rare. However, because of the presumed decline and our lack of information regarding its ecology, it is classified as a species of special concern by New York State. Within the Albany Pine Bush and other areas, the inland barrens buckmoth is regarded as an indicator of good-quality pine barrens.

Objective: Given that little is known about population dynamics and how many inland barrens buckmoth are within the Preserve, primary conservation objectives for this animal are to: 1) establish baseline data on the current population sizes and distribution within the Albany Pine Bush, 2) document changes in the status of population sizes and distribution through time and 3) enhance or maintain current population levels. If it is determined that buckmoth populations are declining and/or that they need to be expanded, objective three should be modified.

Ecological Model and Mechanism: Figure 3 presents an ecological model for the inland barrens buckmoth. This model illustrates that, like the Karner blue, the survival of the buckmoth within the

Figure 3. Ecological model showing the possible response of Inland barrens buckmoth (*Hemileuca maia* sspp.) to periodic management and ecological succession in the Albany Pine Bush



Albany Pine Bush Preserve depends on availability of suitable habitat; however, the buckmoth is a strong flier and can probably find scrub oak well if the patch is large enough. Thus, if it becomes necessary to increase buckmoth population size and/or distribution, stewards will need to improve and/or expand good quality pitch pine-scrub oak barrens characterized by scrub oak of low stature (i.e. <2m tall) with elongated stems suitable for females to lay their eggs on. These conditions typically occur after a disturbance, such as fire, that enhances scrub oak growth. In the absence of disturbance, scrub oak growth decreases, reducing numbers of stems suitable for buckmoths and populations decline.

Managing for pitch pine-scrub oak barrens is currently one of the primary objectives for the Preserve and is discussed in greater detail in later sections.

Research and Monitoring: In 1991, a monitoring study was initiated to establish baseline information regarding the number of buckmoths in one section of the Preserve (Higgins et al., 1991). Because little is known about their population dynamics, it is assumed that buckmoths within the Preserve represent one population: since they are strong fliers and occasionally fly through forested areas, it is likely that they move readily among different regions of the Preserve. In 1992, this study will be expanded to include a total of three sites (Gebauer, 1992a). Additionally, several sites that could not be included in the fall 1992 survey due to limited personnel resources, were surveyed for the presence or absence of

buckmoth larval masses during early July 1992. Detailed methodology for both the fall 1992 surveys and larval mass census are recorded in Higgins et al., 1991 and Gebauer, 1992a.

Future Research and Management Plans:

1) If, after several years of monitoring using the current methods, more detailed information regarding inland barrens buckmoth population characteristics is needed, more intensive studies will need to be implemented (i.e. mark-release-recapture).

2) By 1994, burn 40 acres in the City Preserve (City Preserve, Karner barrens east) to improve buckmoth habitat and assess management effects on population levels.

Natural Communities

Justification: Management of natural communities within the Albany Pine Bush can be justified in several ways. Many animals depend on habitat conditions that are created and maintained by fire. Without fire, or some form of vegetation management, these species would be lost from the Preserve. Similarly, numerous plant species in the Pine Bush cannot persist without conditions created by fire. For example, New Jersey tea (Ceanothus americana) has a hard seed coat that requires heat or scarification for it to germinate; wild blue lupine (Lupinus perrenis) grows best in open areas typically maintained by fires, and scrub oaks nearly stop producing acorns during long fire-free periods. Additionally, non-fire-adapted

species increase in abundance in the absence of fire, resulting in the suppression and eventual loss of many native pine barrens species. Because the assemblage of characteristic pine barrens plant and animal species cannot persist without some kind of management, neither can the globally rare pitch pine-scrub oak barrens and vernal pond communities.

Long periods of fire suppression have already significantly impacted the composition, structure and distribution of plant communities throughout the Albany Pine Bush Preserve. The spatial extent of the pitch pine-scrub oak barrens variants has decreased greatly as a result of fire suppression. Due to the decrease in fire frequency, many areas that would have been maintained as pitch pine-scrub oak barrens by fire become later successional communities, such as successional northern and southern hardwoods, and possibly Appalachian oak-pine forests and pine-northern hardwood forests. These changes, in conjunction with dissection of the landscape, have altered the fire regime within the pine barrens ecosystem. Additionally, the proximity of urban development prohibits fires that are not controlled. Consequently, the current and future capacity of fire to act as a natural process that shapes the pine barrens depends entirely on the ability of land stewards to make and implement appropriate fire management decisions.

Since the pitch pine-scrub oak community is the most globally rare within the Preserve, research and management efforts should focus on protecting this natural community. In particular, land managers need to restore and maintain good quality pitch pine-scrub

oak barrens and its variants. Spatial distribution of pitch pine-scrub oak barrens should be expanded to the greatest extent possible in order to maximize the amount of its rare variants. However, other rare communities, such as the pine barrens vernal pond, should also be carefully managed. The following objectives serve to provide a clear direction for achieving this goal.

Objectives:

Objectives for pitch pine-scrub oak barrens communities include:

1) Expand the spatial distribution of the rare pitch pine-scrub oak barrens variants to the greatest extent possible.

2) Restore and maintain the natural plant species composition and structure of pitch pine-scrub oak variants.

3) Enhance the abundance of plant species that are particularly limiting to rare animal species (i.e. wild blue lupine and adult Karner blue butterfly nectar species).

To achieve the goal of expanding pitch pine-scrub oak barrens communities to the greatest extent possible, the following objectives for the other plant communities in the Pine Bush must be achieved:

1) Convert communities, such as southern successional hardwood forests, brushy cleared land and sand mines to pitch pine-scrub oak variants wherever possible. In areas where it is not possible to restore such communities to pitch pine-scrub oak, they should be

converted to other native pine barrens communities

2) Reduce the spatial extent of fire-intolerant communities that are native to the Pine Bush by converting them to a pitch pine-scrub oak variant. These communities include Appalachian oak-pine forest, pine-northern hardwood forest, successional northern hardwood forest and pitch pine-oak forest.

Other objectives for managing non-pitch pine-scrub oak barrens that are native to the Albany Pine Bush include:

1) In areas where fire-intolerant, native Pine Bush communities (i.e. Appalachian oak-pine, pine-northern hardwood, pitch pine-oak and successional northern hardwood forests) are to be maintained, restore and maintain the natural species composition and structure.

2) Restore the characteristic relative abundance of native Pine Bush plant communities in areas where pitch pine-scrub oak barrens cannot be restored.

3) Restore and protect wetland communities in the Albany Pine Bush, especially the globally rare pine barrens vernal ponds.

Table 1 quantitatively reviews objectives for natural communities management outlined above and Map 1, prepared by Environmental Design and Research (1993), illustrates current locations of several community categories. Total acreage is approximate and includes land (both inside and outside existing Preserve boundaries) that can be managed to some extent. Acreage

values are based on the current condition of the Pine Bush, our presumed ability to manage for the desirable natural community characteristics and our established goals. Detailed descriptions and maps showing current locations of various communities are presented in Schneider et al. (1991) and Environmental Design and Research (1993).

Table 1. Ecological communities and vegetation management goals for the Albany Pine Bush Preserve

Ecological Community	No. Acres (1991)	Relative Abundance (1991)	No. Acres (goal)	Relative Abundance (goal)
Pitch Pine-scrub oak barrens	950	41.0	1640	71.1
Pitch pine-oak forest	250	11.0	140	6.1
Pine barrens vernal pond	35	1.5	35	1.5
Pine-northern hardwood forest & Appalachian oak-pine forest	200	9.0	115	5.0
Red maple-hardwood swamp	100	4.0	100	4.3
Shallow emergent marsh	5	0.5	5	0.5
Successional northern hardwoods (Poplar dominated)	160	7.0	90	3.9
Successional southern hardwoods (Black locust dominated)	340	14.5	0	0
Unpaved road/path	50	2.0	50	2.0
Sand mine	5	0.5	0	0.0
Brushy cleared land	80	3.5	0	0.0
Landfill	130	5.5	130	5.5
Total	2305	100.0%	2305	100.0%

Successional southern hardwoods occur on sites that have been cleared or otherwise disturbed and are not native to the Albany Pine

Bush ecosystem. These hardwood or mixed forests typically occur on sites that have been cleared (for farming, logging, etc.), disturbed or protected from fires. According to Schneider et al. (1991), there is a total of about 340 acres of successional southern hardwoods, most of which (335 acres) is dominated by black locust. Approximately 80 acres of brushy, cleared land and five acres of sand mines occur in areas that have been clearcut, cleared by brush-hog or excavated. This means that there are approximately 425 acres of anthropogenic communities that can potentially be restored to pitch pine-scrub oak barrens (see Table 1).

Abundant throughout northeast America, Appalachian oak-pine forests, pine-northern hardwood forests and pitch pine-oak forests are natural components of the pine barrens ecosystem. Likewise, successional northern hardwoods (most of which is poplar-dominated) historically occurred in the pine barrens ecosystem. However, the abundance of young, even-aged stands of aspen suggests that this community has increased its spatial distribution in many areas of the Preserve (pers. obs.). These forested communities should not be eliminated from the Preserve, but their acreages should be reduced to reflect their historical abundance or to accommodate expansion of pitch pine-scrub oak barrens. Therefore, it is recommended that a total of approximately 265 acres (70 acres of successional northern hardwoods plus 110 acres of pitch pine-oak forest and 85 acres of pine-northern hardwood and Appalachian oak-pine forests) of these communities be restored to pitch pine-scrub oak barrens (see Table 1).

If land managers achieve the stated natural community management goals, a total of 690 acres will be converted to pitch pine-scrub oak

variants. The resulting total number of acres of pitch pine-scrub oak barrens will then be approximately 1640, or 70% of the Preserve.

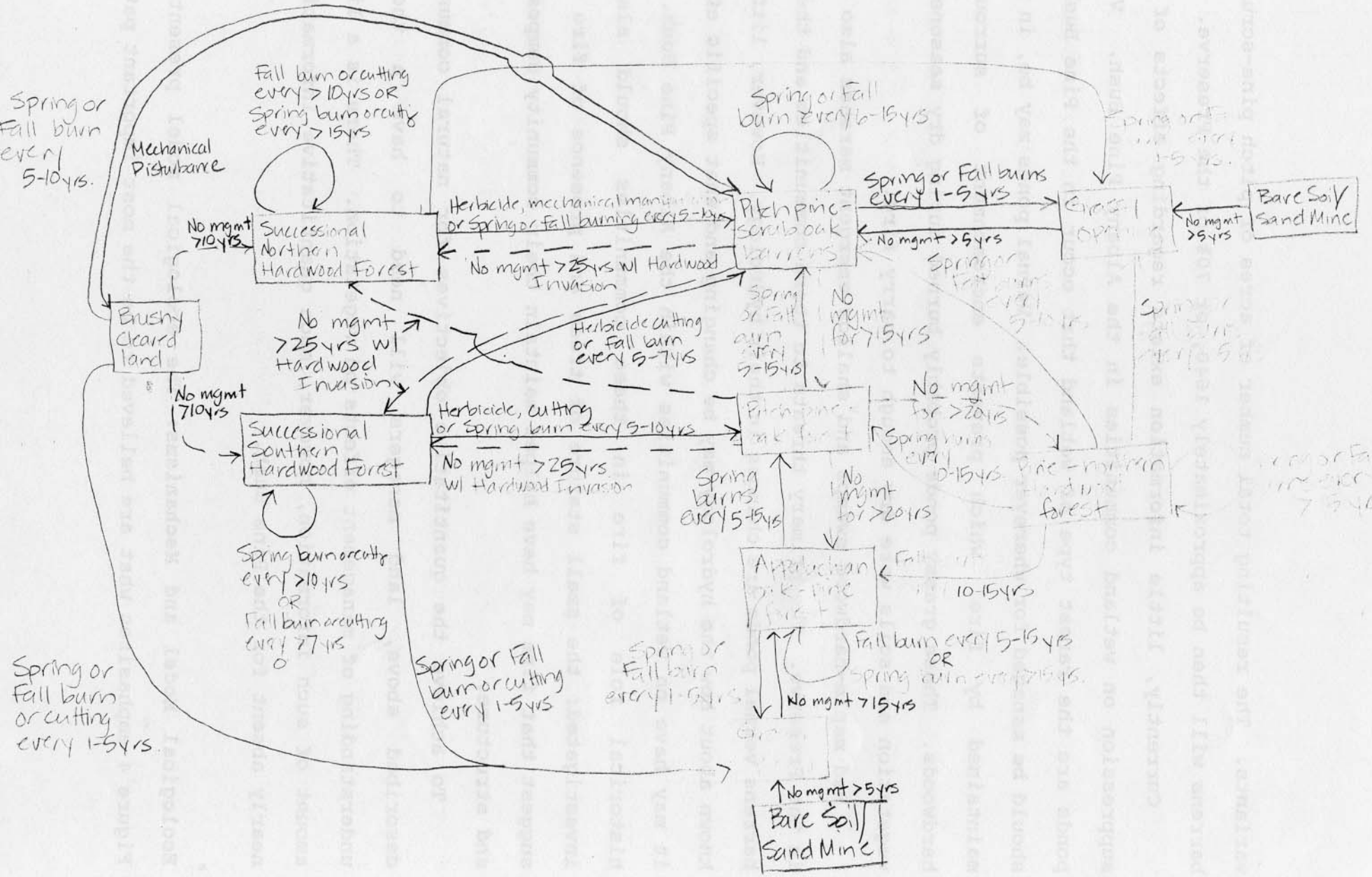
Currently, little information exists regarding effects of fire suppression on wetland communities in the Albany Pine Bush. Vernal ponds are the rarest type of wetland that occur in the Pine Bush and should be managed for wherever possible. Vernal ponds may be, in part, maintained by fire, which prevents encroachment of surrounding hardwoods. These grassy ponds probably burned during dry seasons when vegetation and soils were dry enough to carry fire.

Red maple-hardwood swamps and shallow emergent marshes also occur in the Preserve. The primary threats to these communities and the pine barrens vernal ponds are changes in their hydrology. However, little is known about how the hydrology may be changing and what specific effects it may have on wetland communities within the Albany Pine Bush. The historical role of fire in these communities should also be investigated: the small stature of trees and presence of fire scars suggest that fire may have helped maintain their community composition and structure.

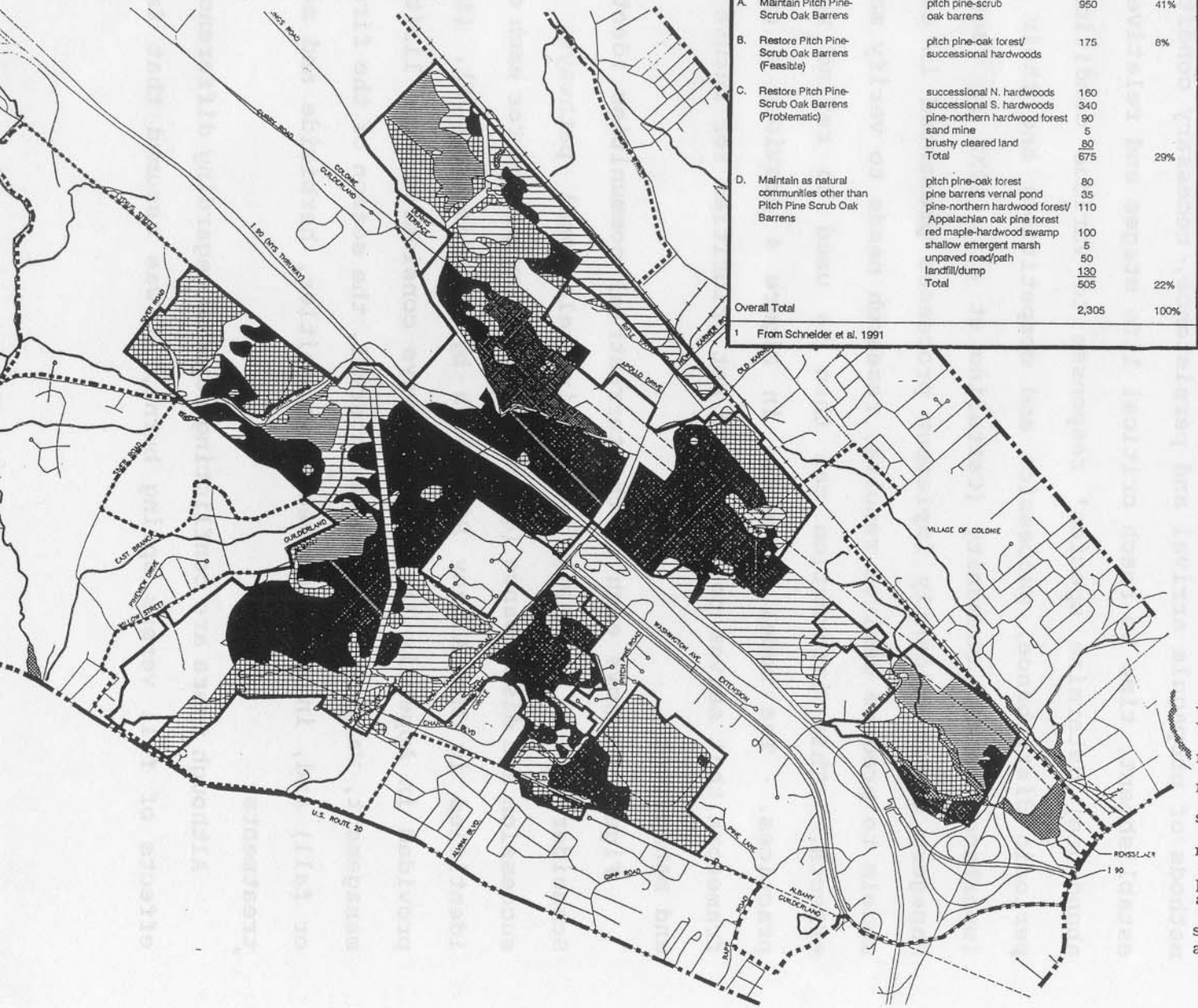
To achieve the quantitative objectives for natural communities described above, land managers will need to have a thorough understanding of management effects on vegetation. There is a limited amount of such information, however, such quantitative information is nearly absent for the Pine Bush.

Ecological Model and Mechanisms: The ecological model presented in Figure 4 emphasizes what are believed to be the most important pathways

Figure 4. Ecological model showing the probable response of the forested community to management and ecological succession in the Albany Pine Bush



ap 1. Current distribution of natural community categories within the Albany Pine Bush Preserve



Vegetation management categories.

Category	Community[1]	Approximate Acreage[1]	Percent of Total
A. Maintain Pitch Pine-Scrub Oak Barrens	pitch pine-scrub oak barrens	950	41%
B. Restore Pitch Pine-Scrub Oak Barrens (Feasible)	pitch pine-oak forest/ successional hardwoods	175	8%
C. Restore Pitch Pine-Scrub Oak Barrens (Problematic)	successional N. hardwoods	160	
	successional S. hardwoods	340	
	pine-northern hardwood forest	90	
	sand mine	5	
	brushy cleared land	80	
	Total	675	29%
D. Maintain as natural communities other than Pitch Pine Scrub Oak Barrens	pitch pine-oak forest	80	
	pine barrens vernal pond	35	
	pine-northern hardwood forest/ Appalachian oak pine forest	110	
	red maple-hardwood swamp	100	
	shallow emergent marsh	5	
	unpaved road/path	50	
	landfill/dump	130	
	Total	505	22%
Overall Total		2,305	100%

1 From Schneider et al. 1991

Management Plan For The

Albany Pine Bush Preserve

VEGETATION MANAGEMENT ZONES

Environmental Design & Research, P.C.

N scale: 0 .50 1 mile

October 1992

M A P K E Y

Category A

Category B

Category C

Category D

To be determined

L E G E N D

water

roads

railroads

study area boundary

municipal boundaries

primary protection area boundary

secondary protection area boundary

for land managers to understand to achieve specific management goals. The pathways presented are based on limited quantitative information, observations, assumptions of ecological succession and management effects and current knowledge and assumptions about attributes of different species within the communities. Species attributes (such as methods of propagule arrival and persistence, necessary conditions for establishment, time to reach critical life stages and relative species abundance) determine species' responses to various conditions (i.e. periodic disturbance, succession and competition) and their relative importance in the community (Cattelino et al., 19XX). Before land managers can confidently implement processes presented in ecological models to produce desired results, research needs to verify management effects. This information can then be used to refine management practices. The model presented in Figure 4 provides a conceptual framework that serves to direct and set priorities for future research and management.

Figure 4 shows each of the terrestrial communities identified by Schneider et al. (1991) and their relational pathways, such as succession and disturbance (quantitative descriptions for each community identified in the Albany Pine Bush by Schneider et al. (1991) are provided in Appendix I). The pathways considered were limited to no management, varying fire-return interval, the season of the fire (spring or fall) and, in cases of weedy communities, herbicide and mechanical treatments.

Although there are conflicting reports regarding differences in the effects of fall versus spring burns, it was assumed that fall fires

favor hardwood species, while spring fires favor softwoods. Some fire ecologists speculate that topkilling hardwood species in the fall reduces evapotransportation during winter months (Ron Myers, pers. comm.). This may result in larger root reserve of carbohydrates available for the next season's growth. Topkilling a softwood in the fall, however, may result in smaller root reserves due to the reduced ability to photosynthesize during the winter. Conversely, if softwoods are burned in the spring their root reserves may be larger due to photosynthesis during winter months. Because softwoods do not compete for light as well as broad-leaved hardwoods, softwoods are left at a competitive disadvantage during the next growing season.

Fire intensity (measured by flame length and rate of spread) and severity (measured by percent litter and duff consumed) were not considered in this model. Due to the high density of urban development surrounding the Preserve, it is necessary to limit prescribed fire behavior to narrow ranges. For instance, smoke management concerns preclude letting areas burn for long periods of time, thus limiting the amount of litter and duff consumed during a single fire event. In general, prescribed fires are likely to burn cooler than natural fires historically did. Consequently, differences in fire behavior among prescribed burns will be reduced resulting in similar species' responses to different fires. To simulate effects of severe and intense fires that historically occurred throughout the Preserve land managers will need to use many frequent fires of low intensity and severity or investigate the effectiveness other management techniques such as mechanical clearing.

Fire is a primary management tool for managing natural communities in the Albany Pine Bush Preserve. However, observations of fire management effects to date suggest that fire may be inefficient for restoring some weedy communities pitch pine-scrub oak communities, especially successional southern hardwood forests. Therefore, herbicide applications and cutting treatments are indicated as pathways in some cases.

Research and Monitoring: The New York Natural Heritage Program (Schneider et al., 1991) and an environmental consulting firm (Environmental Design & Research, 1992) produced maps indicating distribution of each community throughout the Preserve (see Map 1 for an summary of current community distributions).

To date, ecological research in the Pine Bush has focussed on establishing baseline information on the current species composition and structure of each community identified. Long-term monitoring of permanent plots will provide information about rates and directions of ecological succession in the absence of management. As some plots are burned or otherwise treated we will learn more about management effects on each of the plant communities. For a full description of this research see Gebauer, 1992b.

A study on effects of different management treatments (burning and repeated cutting) on black locust was initiated in 1991. As resources become available, effects of herbicides may be investigated as well. For a full description of this research see Mueller and Gebauer, 1992.

Future research and management plans:

1) Continue long-term landscape-level research to assess successional changes in natural communities both in the presence and absence of fire (see Gebauer, 1992).

2) By 1993, establish a well developed photopoint system to assess general fire effects. Photopoints are quick and easy tools that are extremely useful for subjectively assessing fire effects.

3) As resources become available, implement more intensive studies to investigate pathways/processes indicated in the ecological model. Quantifying fire effects is very difficult due to the high degree of variability inherent in fire management. Yet, if managers are to use it successfully, they must understand its effects.

4) Utilize historical maps and other information to more accurately assess the historical condition of the Pine Bush and changes in the relative abundances and composition of its native communities.

5) Compare current and future maps and aerial photographs to help determine how successfully areas are being restored and/or converted to pitch pine-scrub oak barrens and whether the relative abundances of all natural communities are being restored to desirable levels.

6) As more resources become available, collect more information regarding effects of fire and fire suppression on wetlands, particularly pine barrens vernal ponds. In the absence of fire, hardwoods may be invading vernal ponds. If this is true, these areas will need management to survive.

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PERSONAL COMMUNICATIONS

Myers, Ronald. Director, Fire Management and Research Program, The Nature Conservancy, Route 1, Box 678, Tallahassee, Florida 32312.

APPENDIX I

Quantitative descriptions of plant communities identified in the Albany Pine Bush by Schneider et al. (1991).