FOREST VEGETATION OF THE PINELANDS

Prepared for the
NEW JERSEY PINELANDS COMMISSION

by
ANDROPOGON ASSOCIATES
Ecological Planning & Design
490 Shawmont Avenue
Philadelphia PA 19128

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EXECUTIVE SUMMARY

Pinelands vegetation was mapped on 50 transparent mylar overlays of 1:24,000-scale U.S.G.S. quad sheets. This detailed mapping provides an inventory of current forest types and their distribution, as well as habitat base-maps for coordinating and recording the information of other natural-resource consultants. Comparisons with the previous (1973) vegetation mapping were valuable in discerning trends in the intervening period.

As of today, the Pinelands retains its essential character as a vast, relatively undisturbed natural area of great scientific, aesthetic, economic, and cultural importance. Recent developments, however, at both large and small scales have proceeded at an accelerated pace and with little regard for the natural or historic character of the area. The potential threat of such development is a matter not only of its effect but also of its nature. Whereas historical uses tended to leave basic natural systems intact, new development more often than not destroys them. Significant encroachment of development into the Pinelands has occurred on the northwest boundary, and extensive sprawl from developing shore areas on the eastern boundary has moved inland along major roads. Expansion of urban areas within the Pinelands has also occurred, and increased surface excavation is widespread.

Wetland habitats of the Pinelands have long been recognized for their role in maintaining water quality. While the major wetland systems remain intact, they have been impacted by development pressures, especially near the coast. Also, significant reduction in the amount of cedar due to logging was noticed, although cedar may regenerate in the larger swamps.

The recommendations offered for review in chapter 5 address three major needs in maintaining the essential character of the Pinelands landscape: (1) the need for a 'core-preserve' of wilderness-type forest within the preservation area; (2) the need to define the nature of the core-preserve, the preservation area outside the core-preserve, and the protection area, and the uses that can be permitted within

each of these three management areas; and (3) the need to develop guidelines and controls aimed at maintaining the nature and integrity of each of the three areas.

Maintenance of the area's natural drainage system and controls designed to protect major portions of upland vegetation are the principal tools suggested for minimizing the impact of development.

ACKNOWLEDGEMENTS

The authors would like to thank Haig Kasbach, Chief of the Bureau of Groundwater Management, Division of Water Resources, New Jersey Department of Environmental Protection, and Wayne Hutchinson, Principal Geologist, Division of Water Resources, for the aerial photography used in this study. Dr. Silas Little was consulted in the course of this study, and his review comments on the draft report were especially helpful. The assistance provided by Robert Zampella and members of the staff of the Pinelands Commission, and also Sean Reilly, former Pinelands Coordinator, is much appreciated. We are deeply indebted to the late Dr. Jack McCormick, who instilled in all of us a love of the Pine Barrens and who shared his knowledge of the area so generously.

Peter Benton, of Andropogon Associates, was involved in every phase of the mapping. Diane Dale assisted with mapping graphics, James Bryan helped with editing the text of this report.

TABLE OF CONTENTS

ILLUSTRATIONS

1. INTRODUCTION

Covering well over a million acres, the Pine Barrens of New Jersey is the most extensive wildland in the Middle Atlantic Seaboard region. A vast sea of trees within a corridor of intensive development, the Pine Barrens has likely been imagined to be like some mythical ocean: seemingly invulnerable, uniform, and constant. And despite centuries of logging, repeated burning, and the rise and fall of various local industries, the Barrens has looked remarkably resilient, the forest rebounding with little change perceptible to those who passed through it. Yet change is very much part of the Pine Barrens landscape, and the impacts of human use are of increasing concern. We know that, like any real ocean, it is vulnerable, changing, and made up of remarkably interrelated components.

While the area's valuable water resources have long been recognized -- leading in part to the eventual establishment of several large tracts of public land -- a comprehensive program for development planning and resource management of the Pine Barrens as a whole has been lacking. Yet the acceleration of development pressures in recent years has been pronounced, and the effects of cumulative change have been becoming ever more visible, from the destruction of cedar swamps to local environmental degradation, particularly water pollution. Plans for a major jetport as well as recent large-scale developments and increased piecemeal developments spurred efforts to achieve coordination among federal, state, and municipal agencies and local organizations in guiding future growth in the Pine Barrens. With the passage of section 502 of the federal National Parks and Recreation Act of 1978 and the Pinelands Protection Act of the State of New Jersey of 1979, the Pinelands Commission was established as a "regional planning and management commission empowered to prepare and oversee the implementation of a comprehensive management plan for the pinelands area".

The Pine Barrens is located on the outer section of the Atlantic Coastal Plain, a geological formation extending northward through Long Island to Cape Cod and southward along the coast into Mexico. The Coastal Plain is an exposed sea bottom, characterized by deep beds of

sedimentary deposits of sand and gravel, with occasional lenses of silt and clay. It is a formation of low relief and gentle undulations in topography, with droughty, infertile, and naturally acid soils.

Perhaps more than any other natural feature, the unique vegetation on this land gives the Pine Barrens its distinctive, essential character. The low, dense forests of pine and oak contrast sharply with the tall hardwood upland forests found to the north and west of the Pine Barrens. Large tracts of tillage agriculture are generally not found in the Pine Barrens, and the expanse of undeveloped forest further distinguishes the Barrens with a wilderness quality.

A rich diversity of plants is present in the Pine Barrens, numbering at least 800 species. Over 15 per cent of the flora here is made up of species reaching either their northern or southern limit of distribution, including over 100 species of southern plants which do not range farther north than southern New Jersey (McCormick, 1970).

The forest vegetation found in the Pine Barrens today has been shaped primarily by three major forces in addition to the soils noted above: water regimen, fire, and disturbance by man.

Water regimen accounts for the two distinct complexes of forest vegetation -- the upland forest types and the lowland forest types. In the sandy, porous soils of the uplands, the availability of moisture is a major factor in vegetation composition; the lowlands are swampy due to high watertable elevations, and here plant composition is affected both by groundwater fluctuations and by the duration of standing water. Moreover, the effects on water regimen of the low relief and gentle undulations of the topography produce a complex mosaic of vegetation, where even slight changes in elevation can yield marked differentiations in the plant communities. In turn, the vegetation is very important in maintaining stream regimen, by retarding flood flow and preventing an increase in flood peaks; lowland vegetation also takes up nutrients and slows down the movement of suspended solids.

The successional history of Pine Barrens vegetation is closely linked to its fire history. The plants of the Pine Barrens are well adapted to fire. The vegetation of the uplands is at once highly flammable and resistant to killing by fire, with virtually all the plants capable of sprouting after burning. Indeed, of the two strains of pitch pine found in the Pine Barrens, the closed-cone (serotinous) strain will release its seed only after exposure to high temperatures and can deposit this minute seed on the favorably open and mineral soil-bed formed after burning. The swamp forests have often served as firebreaks. However, in particularly droughty periods, severe fires have often occurred, burning the organic soils and the root systems of trees; and both the cedar and hardwood trees found in the swamps are more easily injured even by light fire than the trees of the upland forests.

Among disturbances by man, logging has certainly played an important role in shaping the vegetation of the Pine Barrens: most of

the forest has been clearcut four or five times in the past, and some areas even more repeatedly. Intensive logging, as well as the cycle of fire as it was modified by settlers, has resulted in a dramatic reduction in the distribution of cedar swamps in the last two centuries. Cedar was formerly the predominant swamp forest type, and individual cedar swamps were often up to a mile in width and several miles in length. Although some repeatedly clearcut areas have produced successive crops of cedar, there has been a widespread replacement of cedar swamp by hardwood swamp, and many of the remaining cedar stands are too small or narrow and too isolated to make cedar reestablishment likely after logging.

Indigenous agriculture has also played a role in shaping the present landscape. Commercial blueberries, hybrids of several native species, are grown often in transitional lowland environments between the swamps and uplands, and numerous impoundments have been made along streams for cranberry culture; the resulting flooded swampland as well as abandoned cranberry fields often support native bog or grassland vegetation. Even the impacts of relatively recent attempts at tillage agriculture can be seen in the forests today, often appearing as nearly rectangular plots devoid of shrub growth.

Numerous other lakes and ponds have been established on old borrow pits, reflecting the impact of excavation operations. Finally, wildlife, too, has had a part in shaping vegetation, with deer browsing, especially on young cedar, and flooding due to beaver dams markedly affecting plant composition in some areas.

Despite these past and current impacts on its vegetation, the Pine Barrens is a unique wilderness area of tremendous ecological importance to southern New Jersey, the region, and the nation. But these disturbances have begun to recede in terms of real impact on the Pine Barrens compared with the potential destruction of the system threatened by the increasing residential development and urbanization pressures.

The purpose of this forest vegetation study is to provide a series of base maps delineating the natural habitats of the Pinelands area by vegetation type, to assess the actual and potential impacts to the forest vegetation, and to provide, for review, related recommendations for land-use controls and management guidelines.

2. MAPPING METHODS

In addition to the five Pine Barrens forest types mapped, four non-forest habitats, three land-use categroies, and a final category for non-Pine-Barrens vegetation were mapped. The following listing shows the symbols used on the maps for these thirteen categories and includes a brief explanation of the categories not taken up in chapter 3.

Pine Barrens Forests

Upland Forest Types

P Pine/Oak Forest

O Oak/Pine Forest

Lowland Forest Types

C Cedar Swamp

H Hardwood Swamp

L Pitch-Pine Lowland Forest

Non-Forest Habitats

M Marsh. Coastal marshes and intertidal wetlands are included in this category.

I Inland Marsh. Includes inland marshes and wet meadows, which support herbaceous vegetation, predominantly sedges (*Carex* spp.) and grasses (*Gramineae*).

B Bog. Three bog types are included in this mapping category: (1) active cranberry bogs; (2) recently cleared or burned lowland sites which support thickets of lowland shrubs and developing swamp forest species; and (3) open bogs, where seasonal high water table is at or above the surface. The predominant vegetation is shrubs, including leatherleaf (*Chamaedaphne calyculata*), sheep laurel (*Kalmia augustifolia*), highbush blueberry (*Vaccinium corymbosum*), swamp azalea

(*Rhododendron viscosum*), sweet pepperbush (*Clethra alnifolia*), and staggerbush (*Lyonia mariana*). Peat mosses (*Sphagnum* spp.) often carpet the ground surface. Generally, the cranberry bogs can be distinguished from the open bogs and cleared swamp sites through reference to the current United States Geological Survey quadrangle maps. However, there are recent cases of cranberry bogs having been converted to blueberry culture, and some of these changes may have been overlooked in the mapping due to their indistinguishability in the aerial photography used for it.

W Water. Includes rivers, streams, ponds, impoundments, and coastal water areas.

Land Uses

Note: only very generalized land-use mapping was undertaken here, with no effort made, for example, to delineate small holdings of residential land from surrounding agricultural use; detailed information on land use should be obtained from the land-use maps to be prepared by the Pinelands Commission.

D Developed Land. Includes residential, industrial, and urban land uses.

A Agricultural Land. Includes blueberry fields, pasture, croplands, and orchards.

N Other Non-Forest Areas. Includes sand and gravel operations, borrow pits, cleared disposal sites, and other unforested land.

Other

V Non-Pine-Barrens Vegetation. Because the boundaries of the Pinelands extend beyond the areas where typical Pine Barrens vegetation occurs, this mapping category for non-Pine-Barrens vegetation was included. At the northern and western boundaries, this category was used for the broadleaved forests, predominantly oak and beech/maple, characteristic of the Delaware Valley region; in the eastern portion of the Pinelands, it was used for the vegetation of the narrow coastal strip and the barrier-beach vegetation of Island Beach Island State Park.

It should be noted that while these mapping categories correspond to those used in the vegetation mapping of the Pine Barrens prepared by McCormick and Jones in 1973, the category "inland marsh" has been added here (inland marshes were previously included in the "bog" category). Also, because the current mapping boundaries extend to Island Beach Island State Park, the vegetation of that barrier island is here included in the "non-Pine-Barrens vegetation" category.

For the current mapping, true-color transparencies (scale, 1:12,000, or 1"=1,000 feet) from aerial photography carried out in

November 1978 and March 1979 were used. The mapping categories identified in the photographs were transferred optically onto mylar overlays of United States Geological Survey 7.5 minute topographic quadrangle maps (scale, 1:24,000, or 1"=2,000 feet) for the Pinelands area; features on the quadrangle maps such as roads, rights-of-way, streams, buildings, and topography were used to register the transfer. Generally, no area smaller than two acres was distinguished in the mapping.

Of the fifty photographic flight-lines that traverse the Pinelands area, three were not available at the time of the mapping, and no black-and-white winter photography more recent than 1963 was obtained by the Pinelands Commission within the contract period for the missing flight lines. So in the absence of data from appropriate current photography, the vegetation mapping prepared by McCormick and Jones in 1973 from 1956 and 1963 black-and-white photography was transferred to the affected areas of the present maps. No major changes in forest type are likely to have occurred since the previous mapping, though some increase in the area of lowland forest is probable for some areas, as well as some minor changes in upland forest due to fire. However, this earlier mapping distinguishes no area smaller than twenty acres -- is less fine-grained than the current mapping -- and substantial new development may have occurred in these areas since the earlier mapping (the eventual completion of current land-use maps by the Pinelands Commission will provide an updating). The affected quadrangles are: Mt. Holly, Medford Lakes, Hammonton, Newtonville, Dorothy, Tuckahoe, Woodbine, and Stone Harbor, for which two adjacent flight lines were unavailable; and Moorestown, Clementon, Williamstown, Buena, Five Points, Point Elizabeth, and Heislerville, for which the third flight line was unavailable. The Moorestown quadrangle was not mapped in the 1973 study; so the third missing flight line in that area could not be mapped even with the earlier data and has been left blank.

During the contract period, five days were spent in the field verifying 'signatures' of the vegetation types as identified in the aerial photographs and reviewing areas of major change. The field checking was necessarily limited by the short time available for the task of mapping. However, the generally high quality of the current photography substantially compensated for the relatively inextensive field checking; it permitted, in fact, a much more refined interpretation of the vegetation than had been achieved in the 1973 mapping.

A comprehensive literature search was not within the scope of this study. However, the mapping data was supplemented and cross-checked through several sources; this included references to 'standard' texts on the New Jersey Pine Barrens, frequent consultation with the other natural-resource consultants working on the Pinelands inventory, and study of the previous mapping.

The major task of this study was to identify and map current vegetation types from the available aerial photography. The resulting

maps provided the primary data and basis of comparison (with the 1973 mapping study) from which the observations contained in this report were derived. However, in view of the possible future uses of the maps in formulating planning policy, it is important to underline some of the limitations of this type of mapping. First, generally only the canopy layers of vegetation can be easily identified in aerial photographs. Second, reliability of the mapping tends to be reduced in areas of disturbance or recent changes in land use, and sometimes due to variability in the quality of the photographs themselves. (Stereo photography, which could partially resolve these problems, was not available.) Third, it should also be understood that any area assigned to a vegetation type is essentially a generalization appropriate to the mapping scale; small variations within the type are deliberately overlooked and the boundaries themselves are sometimes almost arbitrary points on a continuum of change. The present mapping does give an excellent overview of the location and distribution patterns of the major vegetation types in the area. It cannot, however, substitute for field investigation prior to determining vegetation management and planning issues in any given subarea.

3. FOREST VEGETATION OF THE PINE BARRENS

3.1. Pine Barrens Forest Types

The forest vegetation of the New Jersey Pine Barrens is characterized by two major forest complexes -- the lowland and upland forests.* The lowland forest complex is generally confined to areas which are sometimes flooded or where watertable elevations are at or near the surface for part of the year. The upland forest complex occurs in the remaining areas. In the subdued topography of the Atlantic Coastal Plain, however, the boundaries between these forest complexes are often not sharply defined, and slight depressions and small drainage swales in areas of upland forests often support small enclaves of lowland vegetation. Likewise, islands of upland vegetation can be found in lowlands of shallow relief.

3.1.1. Upland Forest Types

The upland forests of the Pine Barrens support pitch and shortleaf pines (*Pinus rigida, P. echinata*) and a variety of oak species usually not found in the lowlands. Among the oaks prominent in the uplands are black oak (*Quercus velutina*), post oak (*Q. stallata*), white oak (*Q. alba*), chestnut oak (*Q. prinus*), scarlet oak (*Q. coccinea*), southern red oak (*Q. falcata*), and blackjack oak (*Q. marilandica*). Scrub oak (*Q. ilicifolia*) is an important shrub. Pitch pine is the predominant pine, although shortleaf pine can be found in most areas; Virginia pine (*Pinus virginiana*) occurs at the fringes of the Pine Barrens. While the canopy of the uplands may be more varied in composition than that of the lowlands, understory and shrub growth is less diverse. Lowbush blueberry (*Vaccinium vacillans*) and black huckleberry

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* Sources consulted in addition to the mapping and field work in developing the descriptions of the forest vegetation types: Good, R.E., Good, N.F., and Andresen, J.W., 1979; Harshberger, 1916; Little, S., 1950; Little, S., 1979; McCormick, J., and Buell, M.F., 1968; McCormick, J., 1970; McCormick, J., 1979; also helpful were review comments from Dr Silas Little, 1980.

(*Gaylussacia baccata*) are the most prominent shrubs, although mountain laurel (*Kalmia latifolia*), sweet fern (*Comptonia peregrina*), and inkberry (*Ilex glabra*) also occur. The herbaceous and moss-lichen flora is likewise markedly reduced; only bracken fern (*Pteridium aquilinum*) and teaberry (*Gaultheria procumbens*) are commonly found in the litter of the forest floor.

For mapping purposes, the upland forests were divided into two types; those predominantly pine were typed as pine/oak (P), and those predominantly oak were typed as oak/pine (O).

Pine/Oak Forest (P). The pine/oak forest, typical of the uplands of the central portions of the Pine Barrens, supports pitch pine as the predominant forest tree, commonly associated with blackjack, black, chestnut, white, scarlet, and post oaks as well as southern red oak in the southern portions of the Pine Barrens. Pine/blackjack oak is the most extensive canopy type; pine/post oak and pine/black oak forests also occur but are generally scattered and limited in size. The most common oak is the shrub-form scrub oak, occurring in the understory; lowbush blueberry and black huckleberry also are widespread shrubs. The most extreme example of the pine/oak forest is found in the Plains, or pygmy forests, where repeated burning has eliminated the tree-form oaks and the pitch pine is dwarfed. Shrub-form oaks, blackjack and scrub oaks, are present along with lowbush blueberry and black huckleberry. Low shrub species are well developed, including pyxie moss (*Pyxidanthera barbulata*), bearberry (*Arcostaphylos uva-ursi*), broom crowberry (*Corema conradii*), and false heather (*Hudsonia ericoides*). Most regeneration is from sprouts on older root crowns.

Oak/Pine Forest (O). In the oak/pine forest, stems of tree-form oaks are far more numerous, though often smaller, than the pines. Pitch pine is almost always present; shortleaf pine also occurs, often mixed with pitch pine. Black oak is the most abundant oak; chestnut, white, scarlet, post, and southern red oaks also are widespread, although locally their distribution may be patchy. The shrubs are predominantly lowbush blueberry and black huckleberry, with some mountain laurel and very scattered stems of other upland shrub species. In many stands there are few herbaceous plants away from openings, but there are patches of mosses and lichens. Oak/pine forests are most extensive at the fringes of the Pine Barrens, but they are not restricted to these areas. Small forests of chestnut oak and black oak often occur on hilltops and in small configurations. Oak/pine forests also occur adjacent to some lowlands in the central Pine Barrens.

3.1.2. Lowland Forest Types

Cedar Swamp (C). The cedar swamps are characterized by dense, even-aged stands of narrow-crowned Atlantic white cedar (*Chamaecyparis thyoides*). While cedar predominates in the canopy, pitch pine also is often present. Trident red maple (*Acer rubrum* var. *trilobum*), blackgum (*Nyssa sylvatica*), and sweetbay (*Magnolia virginiana*) are common in the understory, with dangleberry (*Gaylussacia frondosa*), highbush blueberry, swamp azalea, fetterbush (*Leucothoe racemosa*), sweet pepperbush, and

bayberry (*Myrica pensylvanica*) likely to occur in the shrub layer. The understories of typically dense stands contain only scattered hardwoods and shrubs, which are far more numerous and can form a dense layer at the edges of stands or under stands that have been partially cut. While herbaceous growth is rarely very dense, there is a wide variety of species present, commonly including pitcher plant (*Sarracenia purpurea*), sundew (*Drosera* spp.), and chain fern (*Woodwardia* spp.). A rich carpet of peat mosses covers the ground. Cedar swamps are found in narrow bands running along many of the smaller stream courses and in larger configurations in the broader valleys.

Hardwood Swamp (H). The hardwood swamp forest is predominantly trident red maple in the canopy, commonly associated with blackgum and sweetbay; sassafras (*Sassafras albidum*) and gray birch (*Betula populifolia*) also occur frequently. Although nearly pure stands of broadleaved hardwoods are common, in some areas pitch pine and white cedar occur in the canopy, often numerically as abundant as the maple, blackgum, and sweetbay. The number of woody-plant species and their variability in stand compositions are greatest in the hardwood swamps. The shrubs which occur in the cedar swamps are also present in the hardwood swamps, often forming a very dense understory. The hardwood swamp occurs along both major and minor stream courses and in poorly drained areas. The hardwood swamp type also extends beyond the boundaries of the Pinelands and into the inner Coastal Plain; near the coast, holly (*Ilex opaca*) is a major component.

Pitch-Pine Lowland Forest (L). The pitch-pine lowland forest is characterized by a dense canopy almost solely of pitch pine. The understory is often dense, supporting maple and blackgum as well as a variety of lowland shrubs, especially sheep laurel; black huckleberry, dangleberry, and staggerbush also are common. The shrub layer varies in height, from relatively low shrubs such as sand myrtle (*Leiophyllum buxifolium*) and sheep laurel in drier areas to tall stems of such species as highbush blueberry, sweet pepperbush, and azalea near the swamps; in areas of frequent inundation, leatherleaf may form dense low thickets. In the drier areas a well-developed herbaceous layer occurs, composed of such species as bracken fern, turkeybeard (*Xerophyllum asphodeloides*), sedges and grasses, and teaberry; bracken in particular may appear to dominate in the understory just after a fire. The pitch-pine lowland forest is a transitional type, on the gradient between upland forest types and the cedar and hardwood swamps. The boundaries of pitch-pine lowland forests may be rather abrupt or very gradual, often grading into upland forest and extending onto drier soils. Small patches of upland forest may occur within the overall fabric of lowland forest. Pitch-pine lowlands often occur in a narrow band fringing the swamps along stream courses, with dense undergrowth but rather sparse herbaceous cover. In areas of low relief or circular depressions and other poorly drained areas, the pitch-pine lowland forest can be quite broad.

Fig. 1. Pine/Oak Forest. A few oaks and small, uneven crowns of pitch pine make an open canopy above a scattered shrub layer of lowbush blueberry and black huckleberry. The leathery scrub oaks and the epicormic and basal shoots on the pines are reminders of a history of fire.

Fig. 2. The Plains. Dwarfed and twisted pitch pines form a canopy barely taller than the blackjack and scrub oaks and lowbush blueberry and black huckleberry of the shrub layer. Bearberry forms trailing mats on the ground, dotted with other very low shrubs such as broom crowberry. The rare pyxie moss is usually abundant. The pygmy forest is the most extreme adaptation to fire found in the Pine Barrens, and is the direct result of the most severe extreme in fire history.

Fig. 3. Oak/Pine Forest. Scattered stems of pitch and/or shortleaf pines occur, often older and larger than the far more numerous stems of black, chestnut, white, scarlet, post, and sometimes southern red oaks. Twiggy, knee-high lowbush blueberry and black huckleberry are common shrubs. A 'jail house' chestnut oak is formed by basal sprouting after cutting or fire.

Fig. 4. Cedar Swamp. Closely spaced bare trunks of cedar stand on hummocks, rising above the tea-colored water of the swamp. Thin light filters through the closed canopy above, falling on sundews, pitcher plants, and orchids in the spongy carpet of sphagnum.

Fig. 5. Hardwood Swamp. The tangled stems of a thick undergrowth of lowland shrubs and small trees often reach to the strikingly deciduous canopy, dominated by red maple, with occasional blackgum and magnolia. Lush ferns, mosses, and lichens are found on the forest floor.

Fig. 6. Pitch-Pine Lowland Forest. The crooked, dense trunks of a canopy of small pitch pines stand out above an almost continuous band of shrubs, which in some areas display 15 or more species. In openings near the ground, clumps of turkeybeard can be found in mats of teaberry.

3.2. Forest Vegetation Patterns in the Pine Barrens

For the individual working with the vegetation maps, the complexity of what is shown can be confusing. Beyond the simple location of particular forest types, the maps should also convey a sense of the relationship between vegetation types and the patterns of vegetation that are characteristic of a given area.

It is well known that individual plants are remarkably sensitive indicators of environmental conditions. But plant communities, with the variations in occurrence and distribution of species within them, have a considerably greater capacity to reflect physical conditions, and the study of the relationships *between communities* can yield yet another, immeasurably greater capacity to distinguish subtle influences on the environment. The patterns illustrated in Appendix A -- showing typical relationships between forest types in the Pine Barrens -- can be seen as diagrams of the natural processes operative in the environment. Though some of the patterns -- or some aspects of them -- can be fairly confidently linked to known physical processes, others may represent relationships not yet documented or understood; it is conceivable that just as the meandering of a river was eventually shown to be predictable, to follow mathematical laws, these patterns too may ultimately be seen in similar terms, adding greatly to our understanding of how the involved systems operate. Therefore, although not as specifically understood or definable as the forest vegetation types, the typical patterns of Pine Barrens vegetation should be considered at least as important as the types themselves.

These patterns of vegetation are part of the *essential character* of the Pinelands and are important to preserve. The issue at hand is not merely the saving of all the most fragile places or some remnant of every major forest type, but the survival of a whole system. To save a narrow band of cedar accomplishes far less than preserving the lowland system within which it occurs (and at least a portion of the adjacent uplands). Similarly, to completely protect all lowlands while sacrificing all uplands would fracture the entire system.

Assuming that it will be necessary to identify discrete areas for protection, the boundaries of a watershed offer a means to identifying such areas that will tend to respect the integral patterns of the landscape. At another scale -- or considering other planning and management issues -- recognition of the patterns of the forest landscape will foster uses of the forest that maintain the integrity of the relationships between forest types.

4. CURRENT TRENDS AND IMPACTS IN THE FOREST VEGETATION OF THE PINE BARRENS

A vegetation map not only provides information on what vegetation types occur where, but also permits large-scale examination of the mosaic of vegetation in the landscape. In the case of the Pine Barrens, this mosaic of natural vegetation is largely intact, rather than relegated to isolated pockets of forest in a disturbed system, as is the case for much of the Middle Atlantic Seaboard region; and, while development has occurred and many streams have been impounded, the drainage network and surface topography, which determine much of the distribution of plant communities, have not been substantially altered.

Long-term changes in the landscape of the Pine Barrens have been reasonably well documented. But the availability of the 1973 vegetation mapping of the Pine Barrens proved very important, when that data was compared with the present data, in permitting a review here of current trends and impacts over the past decade of development and short-term environmental change; reviewing this landscape 'from the air' for a second time was indeed a remarkable journey, with more short-term change apparent than was anticipated.

In the first section of this chapter, the general trends and impacts will be reviewed; in the second section, critical concerns will be summarized. (Trends and impacts within each of the major watersheds of the Pine Barrens are summarized in Appendix B.)

4.1. General Trends and Impacts

4.1.1. The current maps show an increase in the extent of pitch-pine lowland forest when compared with the previous mapping.

In the central portions of the Pine Barrens, a rather substantial increase in the extent of pitch-pine lowland forest was recorded. However, the question arises as to how much of this change is attributable to mapping error and differences in interpretation and how much reflects an actual increase in the extent of wetlands. It is

probable that a combination of factors are responsible for the apparent changes.

Several of these newly mapped lowlands which were examined in the field were transitional in character, supporting both lowland and upland species; even in the field, precise delineations were difficult to draw, especially when the lowlands were adjacent to forests of pitch pine. The aerial photography permits examination of only the canopy layer, and in these transitional environments often the shrub and understory layers are more conclusive in determining forest type. It is probable that, in places, future field investigations may disagree with the typing on the current maps. It is also probable that there have been some significant differences in interpretation between the 1973 mapping (using black-and-white photography) and the current mapping; and no doubt some areas of pitch-pine lowland forest were too small to be picked up by the previous, more generalized mapping.

At the same time, it is unlikely that all of the recorded increase of pitch-pine lowland can be accounted for by mapping errors and differences in interpretation. Many of these newly recorded lowlands are located in the headwaters of larger streams (i.e., in the upper reaches of the watersheds) and along smaller, tributary streams, where watertable fluctuations are likely to be most pronounced. Some were observed adjacent to new cranberry reservoirs and new residential development and can probably be attributed to attendant alterations in stream regimen; in other cases, disturbances at a considerable distance from them may have accounted for changes in groundwater elevations. It is possible, then, that at least locally there have been appreciable rises in groundwater levels, although there is insufficient data available to either validate or deny this.

Ten years is of course a short period for this kind of pronounced change in forest composition. However, the actual interval of time involved is closer to 25 years, as most of the photography used to determine the boundaries of vegetation types in the previous mapping dated from 1956.

No firm conclusion about changes in groundwater conditions can be drawn from the two sets of maps. Indeed, more questions are posed than answered, and further study and field work is required. However, it is apparent that alterations in stream regimen from development activities do exert a direct influence on vegetation communities, and this influence may extend much further than can be accurately documented at the present time.

4.1.2. The current maps show an increase of hardwood swamp in areas previously mapped as upland forest.

The extension of the hardwood swamp forest into areas previously mapped as upland forest was less widespread than the newly mapped areas of lowland forest, and was generally confined to the upper reaches of watersheds. At the same time, some inland migration of the broad band of hardwood swamp fringing the coastal marshes was observed, although not in a uniform pattern.

Red maple was the most prominent tree of the extended hardwood swamp, rising above a relic canopy of oak and pine. In places adjacent to expanded hardwood areas, widely scattered red maple was observed in predominantly upland forest, suggesting that several areas currently typed as oak/pine or pine/oak may be in the early stages of transition to hardwood swamp.

Again, there is the question as to how much of this change can be accounted for by differences in interpretation between the 1973 and 1979 maps. Because many of the sites involved support both upland and lowland species, the boundary lines between upland and lowland types are of necessity judgmental. The true-color photography available for the current mapping permitted identification of individual red maples which may have been overlooked in the black-and-white photography used for the 1973 mapping; so it is likely that a measure of the recorded increase in the occurrence of hardwood swamp is attributable to the use of color photography. At the same time, it is unlikely that all of it can be so accounted for. Many areas of newly recorded hardwood swamp occur adjacent to newly recorded pitch-pine lowland forest. In some places along the coast, broad bands of red maple were observed which are not likely to have been overlooked in the black-and-white photography and which could have attained canopy height in the period since 1956. While no firm conclusions can be drawn, the likelihood of local changes in groundwater elevations should not be discounted.

4.1.3. Despite an overall reduction in the occurrence of cedar swamps, good cedar reproduction was observed in some areas.

Young cedar swamps were observed in some abandoned cranberry bogs, in some areas of burned swamp, in some cut-over cedar swamps, and in some shallow drainage channels in broad lowland areas, especially pitch-pine lowlands with shallow undulating relief. With careful management and/or protection, current distribution of cedar swamp can probably be maintained and even enhanced.

4.1.4. No substantial alteration in the distribution of pine/oak and oak/pine forests was observed.

While fire plays an important role in forest composition in the Pine Barrens, the impact of recent fire history has not produced any major changes in the distribution of oak/pine and pine/oak forests. Some boundaries in the mapping have shifted slightly, but this is likely due to clearer images in the color photography used for the current mapping; often, too, the transition is a gradual one, and no sharp boundary can be determined. Some patches previously typed pine/oak are now oak/pine and vice versa; however, these are scattered and local in occurrence, and several of these patches are too small to have been picked up in the previous mapping.

4.1.5. The landscape mosaic of the Pine Barrens is becoming increasingly fine-grained.

While no major forest vegetation type in the Pine Barrens is currently threatened with elimination, the grain of the landscape mosaic is becoming finer. Scattered development throughout the area and local disturbance to vegetation have produced smaller-scale patterns of vegetation-type distribution, as well as more variability within each vegetation type. (It is unlikely that this perceived change is merely a result of the more detailed mapping permitted by the larger-scale, color photography available for the present study.) The long-range impact of the present spot disturbances to forest cover is not likely to be significant. However, where this finer grain is due to development, it represents a more or less permanent disruption of the continuity of the forests of the Pine Barrens.

4.1.6. Large-scale development is getting larger.

Increasingly larger areas are being disturbed by single developments. These large residential developments are generally confined to upland forest, except east of the Garden State Parkway, where marsh and adjacent swamps have been impacted. These developments generally have no open-space systems, and natural drainage patterns are left as small, pinched swales or completely replaced by storm-drainage pipe networks. A few residential lakes have been created recently, and this is a trend that can be expected to increase. In many new developments, far less clearing of the forest than in the past was apparent, and most of the lots could be described as wooded; however, understory, shrub, and ground-layer vegetation was usually at least partially removed and replaced with lawn. The road networks serving these developments were substantially wider than in older developments, probably reflecting new zoning ordinances and street-design standards.

For the most part, these developments represent a permanent preemption of the native forest. Extensive grading, paving, and construction and the dramatic alteration of natural drainage patterns have produced an environment that no longer can support more than remnant bits of the native landscape. The specific impacts of recent development patterns are further reviewed in Appendix B.

4.1.7. The most extensive development in the Pinelands area is concentrated east of the Garden State Parkway.

Generally speaking, development patterns in the Pine Barrens have not yet sufficiently coalesced to have disrupted large local areas. The major exception is in the area east of the Garden State Parkway, where there has been substantial expansion from the shore resorts. Existing town centers have also increased in size. Lagoon-type development in the marshes often extends into the hardwood-swamp band running parallel to the marshes.

In much of the development in this area, one can see the spectre of the destruction of the essential character of the Pine Barrens that

inspired state and federal action to preserve the Pinelands. The forest and marsh environments are virtually permanently removed, and natural drainage patterns dramatically altered.

4.1.8. Scattered small-scale development has also increased markedly.

There is probably no other area so wild in character with as extensive a road network as the Pine Barrens of New Jersey. While this has been a boon to adventurous hikers and naturalists, and useful in fire management, it has also meant that virtually no area has been immune to scattered development. At the present time, the impact of scattered development is not too severe. Large tracts still remain undisturbed, and no substantial breaks in forest continuity have been created. The main problems with scattered development are related to the scale at which it occurs. If such development is uncontrolled, the wilderness quality of the Pine Barrens will rapidly diminish. Adequate fire protection will become almost impossible. And small-lot development is less likely to be confined to upland areas, as even the most fragile wetland environments are generally accessible (it was observed, for example, that one small cedar bog has been replaced with tennis courts).

4.1.9. Sites of surface excavation have increased dramatically.

Most borrow pits and surface-excavation sites have been greatly expanded, and several new ones have been started. While many of these sites can be reclaimed over time, in some areas very large expanses of forest are being impacted. Vast tracts have been subjected to extensive grading and excavation to subsoil, making reclamation more difficult than with small, isolated borrow pits. Like those of scattered development, the problems here are related to scale; while the smaller borrow areas provide valuable habitat diversity, the more extensive excavations, especially when concentrated in one locality, amount to major disturbance.

4.1.10. Recent logging has seriously reduced the extent of cedar.

While the days of massive cedar-harvesting are long gone, the scale of logging is still sufficient to seriously impact upon the extent of cedar. The cedar swamp was once the most extensive swamp forest type in the Pine Barrens, and it is still today a critical natural resource and unique habitat in the Pinelands. Since the previous mapping, the extent and distribution of cedar swamp have been reduced substantially by logging. Several large cedar stands were recently clearcut (these may largely return to cedar), and numerous small cedar patches as well.

It is difficult to predict exactly what the long-term impact on the extent of cedar will be, except to say that cedar will undoubtedly be reduced if current trends continue. The logging of small stands of cedar often favors natural succession to hardwood, as too small an opening is left to encourage the development of the shade-intolerant cedar. And as the overall distribution of cedar is limited, seed sources are also becoming locally more limited. Clearcut areas in the larger cedar swamps may return to cedar if only limited hardwoods are

present on the site and if slash remains are not too deep, or if inappropriate management is undertaken.

4.1.11. Recent agricultural activities in the Pine Barrens have not markedly altered the patterns of vegetation.

Many smaller cranberry bogs have been abandoned, but the large bogs have generally become larger. Upstream of the cranberry reservoirs are numerous small flooded swamps now supporting bog vegetation (many too small to have been mapped in the 1973 study), which provide increased habitat diversity.

The extent of other agricultural uses, including blueberry cultivation, has increased somewhat; but there has also been some abandonment of formerly cultivated areas, and some residential development on former farmland. Agricultural development is still fairly locally concentrated and has not significantly impacted the pattern of forest and field.

4.1.12. Scattered areas of other kinds of disturbance occur throughout the Pine Barrens.

Numerous auto junkyards and waste-disposal sites were observed, and several large areas where forest was cleared or disturbed for no apparent reason. The use of off-trail vehicles, especially near routes 70 and 72, has produced visible patterns of disturbance on the ground, with large patches and tracks of bare sand sometimes visible. Military uses have also reduced forest cover locally. The severity of impact of these activities is varied, but all require control in the future to ensure preservation of the Pine Barrens environment.

4.2. Overview and Critical Concerns

The recent past has been a time of great activity in the region, and the vegetation of the Pine Barrens has been subjected to many pressures, from encroaching development and often changes in use. At the same time, two aspects of the native vegetation stand out overall in relation to these pressures: (1) this vegetation can be very responsive to the changing conditions brought about by man's activity; and (2) when not overly disturbed, the landscape is essentially self-maintaining. An overview of the landscape shows that despite much abuse the Pine Barrens is still a vast and continuous wilderness area, unique in many respects. It has retained its character as a rich, diverse native forest, with a rich mosaic of streams and wetlands and abundant wildlife, while simultaneously accommodating a measure of continuous use and inhabitation by man.

However, though still not penetrating the vast bulk of the Pine Barrens, the increasing recent development activity threatens to radically change this relatively happy situation. Much of the new development breaks with the traditional patterns of human uses here and seriously threatens the existing character of the landscape.

A review of the traditional use-patterns and the way in which they have both impacted and preserved the landscape will show how much they contrast with the recent development techniques. This contrast should be instructive, for knowledge of the past successful adaptations to living in the area can be a key factor in successfully regulating new development.

The early settlers developed an economy that was based on the indigenous resources of the region. Though the changes they made were often sweeping ones -- vast and repeated clearcutting of the forest, for example -- they did not destroy the ability of the landscape to recover, and an equilibrium developed between the user and the land. This can be illustrated in many ways.

Swampland supports valuable cedar, and although cedar was cut, the swamps were not subjected to filling and dumping, but were left to grow new cedars. Only minor disruption of the aquatic systems was needed to grow cranberries. Actual removal of forest for tillage agriculture was confined to areas where the soils were less sandy, and fields were surrounded by extensive and continuous forest. Impacts on water quality were confined to the watersheds in agricultural areas, leaving streams elsewhere in the Pine Barrens still pristine in character.

Though erosion must have been greatly accelerated in the vast clearcut areas, and severe fires probably burned deep into the soil, no major changes in grade were undertaken and, for the most part, root stocks were left undisturbed, permitting sprouting and rapid regeneration of the vegetation. The cycle of fire was certainly modified, but fire nevertheless remained an integral factor of the landscape. Except for minor impoundments and excavations, the natural pattern of drainage was left substantially intact, thus maintaining the distribution of upland and lowland vegetation types and avoiding severe impacts on the balance of runoff to infiltration.

Such were the patterns of historical development here and their legacy. Recent development trends, however, tell a very different story. Most new building here has little to do with the intrinsic nature of the landscape; it is occurring largely as an expansion of the development in surrounding areas into the Pine Barrens, and has shown little inclination to alter its customary patterns in this quite unique environment. Many of the newly built projects bring to the Pine Barrens a technology that was developed for less fragile environments. Storm drainage systems, for example, are commonly built, preempting the natural drainage network and converting infiltration to runoff. Large paved areas further aggravate this problem. Large-scale removal of natural vegetation also occurs, and the natural vegetation is often replaced with lawns. These lawns must be maintained by heavy liming and fertilization and often require the importation of topsoil; this changes soil chemistry and has a severe impact on water quality by raising pH and adding nutrients that stimulate eutrophication. Where surface excavations were in the past often only small borrow pits,

easily reclaimed by the native vegetation, today there are excavations of much greater scale, where the soil has been scraped clean of all vegetation and the entire soil-horizon structure destroyed, severely inhibiting the ability of the native landscape to recover while at the same time opening the land to invasion by non-native species.

Much of the new building does not address itself to the fact that fire is an integral part of the Pine Barrens landscape. The response has usually been to attempt the suppression of natural fires. Unfortunately, this approach only increases the danger of much more severe fires at a later date with probable loss of life and property. Moreover, the scattered development pattern precludes prescribed burning, which has been the most successful method developed for both maintaining the natural forest and preventing destructive hot fires.

Traditional use-patterns, in the main, preserved the basic elements of the environment. The natural drainage pattern, though sometimes modified, remained. The ability of the vegetation to regenerate was preserved by leaving stumps and root mats to sprout again after cutting and by leaving the soil structure undisturbed. The continuous, connected nature of the forest was preserved, notwithstanding the widespread and continuous uses prevailing in it.

Preserving, revitalizing, and borrowing from these traditional use-patterns so well adapted to the Pine Barrens should be one of the key factors in preserving the character of the region. Ensuring that new development follows similar adaptive principles should be the main goal in regulating new development where it is to be permitted.

5. RECOMMENDATIONS

A number of designated boundaries are involved in the current Pine Barrens area planning, including those of the Pinelands National Reserve, the Pinelands Protection Area, the Pinelands Preservation Area, the Pinelands Area, the Critical Area, and Federal Project Review Area. However, it is clearly the intent of the Pinelands Protection Act to create two basic management areas: (1) a preservation area, where the Pine Barrens environment will be maintained in as natural a state as possible; and (2) a protection area, where development-related growth and change will be permitted to occur, but where the overall existing character of the landscape will not be essentially altered.

To achieve the full intent of the act with respect to the native vegetation, this basic two-part framework needs, in our judgment, to be strengthened with certain general principles and certain sets of area-specific regulations. This section will first outline the recommended general principles -- principles to follow in defining the boundaries of the management areas -- and second, present a series of detailed recommendations for each area on which regulations could be based. Finally, a recommended educational component for the management plan will be described.

5.1. General Principles

The preservation area as defined in the act permits certain indigenous uses and as such will not be entirely natural. But there are compelling reasons for having an area that is as close to true wilderness as possible (these will be discussed in 5.2). Therefore within the preservation area there should be an extensive *core-preserve* of 'untouched' forest, off-limits to all but the most passive uses, such as limited recreation, educational uses, and scientific study. Surrounding this core 'educational and scientific' area, in the *remainder of the preservation area*, certain indigenous uses can be permitted as allowed for in the act; the uses permitted here should essentially be those that do not require extensive modification of the natural environment, e.g., forestry and cranberry and blueberry culture.

Within the *protection area*, which surrounds the preservation area, the Pinelands Protection Act permits new development plus a range of indigenous and other uses. The intent of the act is that new development should be compatible with the area and that the essential character of the landscape is to remain. The primary tool for protecting the character of the native vegetation should be the maintenance of the entire natural drainage pattern; while other regulations must also be adopted, to protect upland forest areas for example, this natural drainage pattern must be the basic framework for all permitted uses.

It is a basic characteristic of the Pinelands area that a 'wildness gradient' exist -- that is, the intensity of use drops off gradually as the heart of the region is approached. Development gives way to farmland, which in turn yields to forested areas. Contraventions of this gradient would not only appear incongruous and out of character in the area, but also likely juxtapose incompatible uses. Wherever possible, therefore, this gradient should be maintained throughout the entire Pinelands. Confirming new development primarily to extensions of existing communities, as suggested in the Pinelands Protection Act, is in keeping with this wildness gradient principle.

5.2. Core-Preserve of the Preservation Area

The purpose of establishing an 'educational and scientific' core-preserve within the preservation area is to ensure the existence of an area (or areas) where all the vegetation types typical of the Pine Barrens can be preserved in a natural and undisturbed state. Besides being an invaluable resource for educational and scientific use, such an area will aid in the preservation of the gene pool of Pine Barrens plants and provide an essential base-line study-area against which the other Pine Barrens areas can be measured.

Since there are more Pine Barrens vegetation types than those recorded with the mapping categories used in the present study, the areas for inclusion in the core-preserve should be determined following recommendations by a working-group of naturalists and scientists familiar with Pine Barrens vegetation. But some preliminary recommendations are possible. Upland vegetation types that should be represented include at least the following: pine-blackjack oak-heath, pine-blackjack oak-scrub oak, pine-post oak-scrub oak, pine-black oak-heath, pine-black oak-scrub oak, oak-pine-heath, oak-pine-scrub oak, scarlet oak-shortleaf pine-heath, and chestnut oak with a unique undergrowth (McCormick, 1979).

Consistent with the principle of including representative areas of all Pine Barrens vegetation types, the core-preserve should include all of the plains or pygmy forest area, and a large segment of coastal marsh and hardwood swamp. It may not be possible to have the latter area contiguous with the rest of the core-preserve; however it might be contiguous with existing state holdings such as the Barnegat Wildlife Refuge.

Areas designated as critical areas by the other natural-resource consultants should be included in the core-preserve to as great an extent as possible; these may include, but should not necessarily be limited to, habitats for rare and endangered species, areas supporting the most diverse and typical Pine Barrens species, and cultural and agricultural sites. Cedar swamps, because of their present limited and scattered distribution, should be included in the core-preserve insofar as is feasible. The major tracts of forest already in state hands, primarily those of Lebanon State Forest and Wharton Tract, should likewise be included.

The core-preserve should be a single area of contiguous components insofar as possible. The forests of the Wharton Tract and Lebanon State Forest, for example, should obviously be joined. However this principle should not preclude core-preserve status for non-contiguous 'islands' if it is judged that they are important enough to justify strict preservation under this 'untouched' category.

5.2.1. Permitted Uses

1. Limited passive recreation compatible with wilderness-quality forest would be permitted, subject to specific regulations.
2. Access for scientific research and study and limited disturbance for scientific experiments would be permitted.

5.2.2. Management Guidelines

1. Insofar as possible the natural cycle of fire should be maintained.

   Some prescribed burning may, however, be necessary to reduce the hazard to areas outside the core-preserve and where extremely hazardous conditions occur. Also, prescribed burning may be necessary in the plains or pygmy forest area; a certain frequency of fire may be necessary to preserve this forest in its most typical condition (stems less than head-high).

2. Certain planned disturbance, consistent with the wilderness quality of this area, may be necessary to provide greater habitat diversity.

   Many species of plants and animals typical of the Pine Barrens, including a number of endangered species, require younger successional habitats than those that will be favored by maintaining the core-preserve as wilderness. Some clearing in lowlands to create bog habitats and some clearing in uplands to create grasslands and sandy areas may be advisable; these areas could if required be maintained by annual mowing and/or selective clearing.

3. A program of appropriate management techniques for rights-of-way is required.

   Herbicide management of rights-of-way should be prohibited. Two specific alternatives are mowing and the establishment of dense

shrub cover which would inhibit most tree development. The latter would require removal of trees and stumps in the right-of-way and additional planting of shrubs; selective clearing would probably be required until dense shrub cover is established, but only minimal further maintenance would likely be necessary.

4. The use of deicing salts on roads and other paved surfaces should be strictly controlled.

   The use of sand and grit should be encouraged in all but the most intractable situations; where further control is required in localized areas, as for steps and ramps, standard fertilizer can be used instead of the chloride-based deicing salts. This recommendation should pertain to roadways and paved surfaces throughout the whole of the preservation area, and in the protection area as well.

5. The use of off-trail vehicles for recreational use should be strictly prohibited, and other vehicular access strictly controlled.

   The use of off-trail vehicles can cause extensive damage to vegetation, especially in the shrub and ground layers, as well as disturbing wildlife; its prohibition should pertain to the whole of the preservation area. While vehicular access to the core-preserve should be provided for, uncontrolled use of the many sand roads would seriously impact upon the wilderness quality of the area.

6. No motorized boats of any kind for recreational use should be permitted, and canoe access should be limited.

   Motorized boats not only adversely affect water quality but also generate wave action which can disturb fragile aquatic habitats. Canoes should be limited to numbers compatible with a wilderness area.

5.3. Preservation Area Outside of the Core-Preserve

In this portion of the preservation area, while still maintaining the basic purpose of preserving the existing natural forest areas, the compatible indigenous uses as outlined in the Pinelands Protection Act could occur. The aspect of this area would be substantially similar to that of the core-preserve, except that here the forest would be occasionally interrupted by pockets of human activity in much the same way that the Pinelands has always been. However, the uses permitted should be ones that do not entail substantial modification of the natural environment, and they should be subject to review.

5.3.1. Permitted Uses

1. Agriculture that does not require or entail major changes in existing environmental conditions (e.g., liming, which would change soil chemistry) would be permitted in limited areas. Nurseries raising native plants, for example, would be an acceptable use, as would cranberry and blueberry culture. Existing areas of tillage agriculture would not be permitted to expand.

2. Minor infill within existing communities would be permitted, subject to special regulation.

3. Forestry operations would be permitted, within specific management guidelines.

4. A broader range of recreational activities than in the core-preserve would be permitted: those mentioned as examples in the Pinelands Protection Act (hunting, fishing, trapping) plus such activities as hiking, canoeing, picnicking, and camping -- in designated areas and subject to specific regulation.

5.3.2. Management Guidelines

1. A program to oversee agricultural operations is recommended.

The growing of cranberries and blueberries is one of the few land uses suitable in wetland environments. Where expansion of these indigenous industries has occurred, it has generally been into transitional habitats, minimizing direct impact on lowland forest systems. However, a review program, especially for expansion of agricultural activities, would serve to check possible disturbances of critical areas; the siting of a new cranberry reservoir, for example, should be reviewed for potential impacts on lowland habitats. At the same time, it is important to recognize the many problems faced by today's growers of cranberries and blueberries. Other state programs may be required to foster these industries which are so compatible with preserving the character of the Pine Barrens.

2. A program to oversee logging activities and to promote the reestablishment of cedar is recommended.

Forestry is an industry which could expand substantially in this area without adversely impacting upon the essential character of the Pine Barrens if appropriate forest management practices are followed. The New Jersey Bureau of Forest Management has provided recommendations for proper forest management in the Pinelands area (New Jersey Bureau of Forest Management, 1980). Among practices that should be discouraged is the use of herbicides, pesticides, and fertilizers to maintain stands.

Dr. Silas Little (personal communication) suggested these requirements for cedar reproduction after clearcutting:

a. Adequate slash disposal is necessary; herbaceous cover and at least the fine branches should be burned when the swamp floor is wet.
b. Swamp hardwoods should be cut and the slash disposed of.
c. Deer browsing should be controlled.
d. Control of competition from tall shrubs and understory hardwoods is required, especially in partially cut stands.

Dr. Little also recommended the reestablishment of cedar in the hardwood swamps which are unaffected by sediment deposits and wide enough so that edge effects would not extend over much of their area.

3. A program of prescribed burning should be established for the whole of the preservation area.

   Prescribed burning is required both to maintain native vegetation and to reduce the hazard of severe fire. Prescribed burning would also increase available nutrients and control shrub and understory growth in areas used for forestry. (See also 5.2.2., recommendation 1.)

4. Facilities for accommodating increased recreational uses are needed.

   Unnecessary damage to the native landscape will occur unless adequate facilities for recreation are provided; these may include, but are not limited to, canoe landing sites along streams, picnic and camping areas, and restroom facilities.

5. Where development occurs within existing communities, the management guidelines and controls for development in the protection area should be observed.

   (See 5.4.2.)

5.4. Protection Area

The protection area is the remaining area of the Pinelands, surrounding the preservation area. The intent of management here is to maintain the basic character of the Pinelands while not unduly limiting activities and growth appropriate to the area.

5.4.1. Permitted Uses

The Pinelands Protection Act describes the permitted uses in the protection area as "the continuation and expansion of agricultural and horticultural uses" and "appropriate patterns of compatible residential, commercial, and industrial development." Appropriate development would be unlikely to include facilities for the handling or disposal of toxic or hazardous materials, acknowledged sources of pollution (e.g., jetports, power plants, refineries, and smelters), or other uses incompatible with the protection, preservation, and enhancement of the Pinelands environment.

5.4.2. Management Guidelines

1. The natural patterns of drainage in the Pinelands should determine the drainage patterns in areas subject to development.

   Concern for the maintenance of water quality and protection of lowland habitats is integral to the Pinelands Protection Act. Minimal disturbance of natural drainage patterns is required in order to protect lowland habitats, which would be substantially impacted upon by even moderate changes in the elevation of the seasonal high watertable and the duration and elevation of standing water.

   The use of a 'natural drainage system' would entail adapting water management to the natural drainage patterns of the area. Lowlands would remain essentially unaltered and provide the major

corridors of the drainage system. Stormwater would be dealt with at as small a scale as possible and would be retained over naturally vegetated land, permitting some biological purification as well as more gradual infiltration. The use of networks of storm-drainage pipes and excavated retention basins would be prohibited, as these methods encourage concentration of runoff, reduce local infiltration, preempt native vegetation, and usually bring contaminated water in direct contact with the most porous layers of the soil.

There would be at least four major public benefits deriving from a natural drainage system. First, a continuous and natural open-space network is provided by the drainage network, permitting passive recreational use, wildlife movement, and the maintenance of forested corridors linking major open-space areas.

Second, substantial improvement in water quality, compared with the results of conventional stormwater drainage, can be realized. The native vegetation maintained in the drainage network will take up nutrients as well as retarding flow rates and trapping sediment.

Third, an effective natural drainage system will require both minimal clearing of forest and restrictions on the extent of lawn and impermeable cover, which will further protect native vegetation. The clearance restrictions will also minimize the area subject to the conventional horticultural practices used to maintain ornamental plantings; these practices include liming, fertilizing, herbiciding, and pesticiding, all of which can have adverse impacts on water quality and native plant communities.

The Woodlands, a 15,000-acre new-town outside Houston, Texas, located on the Coastal Plain, has been using a natural drainage system for about six years; it has proven to be remarkably effective (Juneja and Veltman, 1979). Despite relatively stringent restrictions, the developments are quite successful and have attracted local builders. Perhaps even more important for the long run, a distinctive community style is developing and has fostered the participation of local residents in meeting the goals of the initial master planning. Indeed, a kind of indigenous style of landscape design has evolved, in which houses are almost completely obscured by dense forest vegetation and individual lots are distinguished by a diverse array of small bridges over shallow swales with ornamental plantings of native species.

Fourth, initial site-development costs, as well as long-term maintenance costs, are reduced, and the system is less likely to suffer from poor maintenance practices.

Specific and complete design standards for a natural drainage system in the Pinelands have yet to be determined. However, with regard to reducing impacts on the natural vegetation, several criteria can be suggested:

a. The main drainage corridors should include all hardwood swamps, all cedar swamps, all pitch-pine lowland forests which occur on C-type and D-type soils, as well as all other wetland types, including marsh, inland marsh, bog, and water. This corridor should also obtain in areas where new agricultural development is to occur.
b. A buffer is required paralleling the drainage corridor. This buffer should be no less than 50 feet wide on either side of

the corridor, to prevent disturbance to the vegetation within the corridor from the impacts of development (including filling, clearing, stockpiling, and grading). Where the width of the drainage corridor exceeds 50 feet, the buffer on either side should be as wide as the corridor, up to a maximum buffer width of 300 feet. Thus, the buffer increases in size in relation to the size of the drainage corridor, and where the corridor is widest upland forest can be preserved within this open-space network; the width-dimension of 300 feet* is a presumed threshold at which areas of upland-forest buffer would be large enough to be reasonably self-sustaining (assuming that the impacts of clearing at the edge of the buffer do not extend too deeply into it). No clearing of vegetation should be permitted in the drainage corridors or buffers.

c. The remaining area on a site may be considered 'buildable area'. In order to reduce impacts on the vegetation of the whole site, both within the 'buildable area' and within the drainage network, it is necessary to maintain insofar as possible the water regimen characteristic of the site in its undeveloped state. The retention of all stormwater generated by the 10-year storm within the 'buildable area' is recommended. Some of the methods that could contribute to accomplishing this can be listed.
   (1) The use of porous paving for all paved surfaces is recommended; curbs should be used where necessary to retain the required volume of water over the porous surface.
   (2) Strict restrictions on the amount of clearing on a single lot or site will provide areas of forested upland over which stormwater can be retained; some slight berming may be needed to control runoff, although the layout of roads and other site construction could also be used.
   (3) Soak pits and perforated pipes leading to forested retention areas or porous-paving retention areas can be used.
   (4) Roof-top retention should be permitted.
   (5) Drainage swales may be required to direct flows and to provide further retention; where swales are used, a buffer of at least 25 feet wide should be maintained on either side of the swale to permit the establishment of native forest vegetation (including canopy, understory, shrub, and ground layers) within this swale-and-buffer area.

   It is possible that the stormwater retention provided within the 'buildable areas' in combination with the retention capacity of the forested natural drainage corridors and buffers would be sufficient to accommodate stormwater flows in excess of the 10-year storm; however further investigation is required to develop specific and complete design standards.

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* No documented studies were available to confirm the appropriateness of this dimension; it is based on field observation and consultation with scientists familiar with the Pine Barrens.

2. The maintenance of native plant communities within the fabric of development should be encouraged at all levels.

Restrictions should be established which prohibit clearances of native vegetation in developments except where necessary for construction. Earth-moving should be restricted, not only to prevent losses of forest but also to limit the creation of made land, a principal vehicle for the establishment and distribution of exotic disturbance-plants, which can eventually compete with indigenous plants.

The natural drainage system, including the drainage corridors, the upland buffers, and the local forested stormwater-retention areas, will provide for substantial protection of forest resources within the protection area. But where the total amount of land to be left in forest on a given site as determined by the natural drainage corridor and buffer is less than 50% of the site, additional undisturbed forest should be retained; a minimum of 50% of the site should be left in open space maintained in native vegetation. This requirement would help maintain forest continuity in the landscape, keeping a substantial area of upland forest in its natural state.

Restrictions on the clearing of vegetation should pertain to canopy, understory, and ground layers.

3. Local zoning standards should be revised to favor cluster development and more efficient land use.

Conventional zoning, in part responding to excessive crowding in developments in the early 1900s, has tended to prescribe minimum dimensions in design standards (for setbacks, parking configurations, road widths, and the like) on the generous side. This has been a factor in development sprawl. A reasonable revision of these standards could lead to a significant increase in the amount of site area that could be left undisturbed.

Beyond revisions of such design standards, provisions for true clustering of development and provisions for communal open space are required to preserve the landscape to the greatest degree; the issue of maintenance of community open space is less problematic here than elsewhere, as the open space would be largely undisturbed forest requiring only minimal intervention. Furthermore, clustering of development would permit prescribed burning as a management practice, reducing the hazard of fire while maintaining a native process integral to the native vegetation; with both scattered and large-lot development, prescribed burning is inappropriate and fire suppression is favored, ultimately increasing the likelihood of severe fires (see recommendation 5). The patterns of cluster development, interspersed with generous open space, would also contribute to a far better blending of old and new community patterns. The village communities of colonial and Victorian times which remain in the Pine Barrens today are aesthetically appealing and are suggestive of new patterns of development.

4. The use of indigenous species in habitat plantings should be encouraged at all levels.

The picturesque quality of the Pine Barrens is largely a matter of the native vegetation; it can be maintained in developed areas if native plants are used for landscape purposes in ways that replicate their lives in the wild. At the same time, the potential dispersal of non-native plants, and the adverse impacts on water quality and native plant communities from the conventional horticultural practices used to maintain them, will be avoided. It is unlikely that the use of non-native plants can be prohibited on private land. But a major commitment from federal, state, and municipal agencies to use native-habitat landscaping on all land under their jurisdictions (including rights-of-way, easements, smaller parks, and around office buildings) would provide a large-scale pilot program to both experiment with alternative landscaping solutions and to display these solutions for aesthetic consideration.

The popularization of native plants for ornamental use has often resulted in widespread collecting from the wild by individuals and nurseries, which has had serious adverse impacts on natural habitats, even to the point of further threatening some endangered species. The problem would be substantially alleviated if native plant stocks were widely available at a reasonable cost (they are not at present). Therefore, specific programs should be established to foster the propagation of native plants by local nurseries.

This would be especially important with regard to providing acceptable alternatives to the use of lawn, given its relative impermeability and dependence on liming and fertilizing. Fire sedge (*Carex pensylvanica*) for example is a grasslike native plant, averaging only 4 inches in height, which could probably be used widely to provide a surface similar to lawn, though less even in texture. However, propagation methods applicable to widespread use of this plant are not available -- neither is the seed. In any case, restrictions on the use of lawn should be established, favoring maintenance of native vegetation in developed areas.

The most serious objection to the use of native plants in landscaping seems to be the issue of their flammability; this will be dealt with in the following recommendation.

5. A comprehensive program of prescribed burning should be established for the whole of the protection area.

In the simplest terms, a wide swath of lawn around a house undoubtedly provides a measure of firebreak which would not be provided by native forest. However, this view is restricted to the scale of one house, and even at this scale the price for such protection -- the devastation of a large piece of the natural landscape around the house -- seems excessive. The technique certainly does not find support in the very evident trend in recent development to maintain trees, providing wooded lots.

Prescribed burning is the most successful means of controlling the hazard of fire in the Pine Barrens. A concerted effort to set up prescribed-burning programs related to development becomes more

important as development pressures increase. Configurations of houses and streets which allow for prescribed burning should be determined; even a firebreak around a cluster of single-family homes is far less destructive to the native forest than wide lawns, and would provide a break beyond which prescribed burning could take place, thus reducing the larger-scale fire hazard.

The aim of the following recommendations is to achieve acceptable fuel reduction in developments without widespread clearing of native vegetation and replacement planting of non-native species.

a. Prior to development, the entire site should be prescribed-burned to reduce available fuel on site.
b. A major break around the entire development should be established; specific dimensions based on fire-hazard ratings of various vegetation types can be provided by the New Jersey Bureau of Forest Fire Management (Cummins, J.A., and Hughes, J., 1980). In order to minimize disturbance to the forest, it is recommended that this firebreak also serve as a major road corridor. Canopy trees should be cleared from the entire width of the firebreak, except for an occasional specimen, to inhibit the spread of canopy fire. Native shrub- and ground-layer vegetation should be maintained in the area cleared of canopy.
c. Development patterns permitting at least partial prescribed burning within the development should be determined and tested. Forested tracts used as retention areas could probably be managed with fire, for example.
d. Immediately around structures, dead fuels and accumulations of leaves should be removed annually; foundation plantings should be discouraged, and native vegetation should be selectively thinned to reduce living fuels. The ground-layer vegetation should be left undisturbed.

6. <u>The use of off-trail vehicles for recreational purposes should be strictly controlled.</u>

This is a thorny issue that must be dealt with effectively. Severe disturbance was noted in several areas of the Pinelands, and the longer wanton use is permitted, the more difficult it will be to curtail.

7. <u>Controls on the extent of surface excavations should be established, and reclamation standards as well.</u>

The impact of sand and gravel operations and other excavations is not uniform throughout the Pine Barrens; however some areas, particularly in the vicinity of Toms River, have seen substantial loss of forest, and expansion of current operations is likely. Both the size of any one excavation area and the total area under excavation at any one time in any one watershed should probably be limited. The impacts of these borrows, however, could be substantially reduced if a reclamation program were implemented. While eventual reforestation is desirable, it is probable that

with the use of native grasses and shrub rootstocks, adequate cover could be established. These shrubs and grasses would provide some habitat diversity of value to wildlife, and over time natural succession to forest vegetation types would occur. At the present time, however, neither the grasses nor the rootstocks are available commercially, and specific reclamation procedures require further testing. Both the propagation of suitable plant materials and pilot reclamation programs are needed before reclamation costs will be low enough to be reasonably borne by land owners.

5.5. The Coastal Hardwood Swamps and Marshes

The coastal hardwood swamps and marshes should be preserved intact. The coastal wetlands are of acknowledged ecological value, and are intimately linked with and supported by the streams of the Pine Barrens. Development should be prohibited, as should dredging and filling. Salt hay could be harvested from existing stands, but no further ditching to favor the establishment of salt hay or to control mosquitoes should be allowed. Recreation would be permitted, provided no significant habitat alterations are entailed.

5.6. Educational Program

Integral to the comprehensive management plan for the Pinelands National Reserve, as described in section 502 of the National Parks and Recreation Act of 1978, is a "public use component including, among other items, a detailed program to educate the public concerning appropriate uses of the area". In line with this provision, two guides for public use are recommended.

5.6.1. A Development Design Guide should be prepared.

The success of the management plan that is ultimately developed will in large measure depend upon how smoothly a transition can be made from conventional development patterns; it will clearly involve the participation of a broad spectrum of interested parties. Good design guidelines on how to meet the standards adopted would be very useful in assisting local officials, planners, and developers to more fully understand and use the Pinelands management plan, and in giving coherent direction and information to local residents. A similar guide was prepared for the Woodlands new-town in Texas (Wallace, McHarg, Roberts, and Todd, 1973); while initial responses to the regulations from several local developers were negative, the guide proved very useful in overcoming early opposition, and development for the most part has proceeded in accordance with the regulations.

5.6.2. A Landscape Design Guide should be prepared.

The use of native plants for landscaping is certainly an idea whose time has come. However, its application has been hampered by several stubborn problems: (1) the general public, designers, and nurserymen have very little understanding of native plants and their habitat requirements; (2) current horticultural practices tend to view each

plant as an individual rather than as a member of a plant community intimately related to habitat conditions; (3) the general horticultural practice is to fit the site to the desired plant rather than fitting plants to the site -- hence we see widespread use of topsoil, lime, fertilizers, herbicides, and pesticides to maintain plants essentially unsuited to local environmental conditions; and (4) native plant material is not widely available, and many native plants, especially herbaceous species and early successional species, are completely unavailable in the marketplace.

A Landscape Design Guide for the Pinelands could address at least the first three of these problems, and to some extent even the fourth. It should cover major topics, including:

1. A review of the Pine Barrens vegetation in a readable and comprehensive fashion for the layman.
2. Planting methods and maintenance practices suited to the Pine Barrens.
3. Good examples of how to use native plants to achieve desired design goals, especially at the scale of the residential lot.
4. A review of recommended management practices for large-scale landscapes, including rights-of-way, easements, and roadsides.
5. A review of reclamation techniques for disturbed sites, such as borrow pits and surface excavations.
6. A review of available native plant material and acceptable alternatives.
7. Specific alternatives to the use of lawn.

6. DATA GAPS AND ISSUES REQUIRING FURTHER STUDY

The Pine Barrens of New Jersey has long been an area studied by naturalists and scientists. But it has often been the case that the more one learns about the Pine Barrens, the more one sees how much is not yet understood. A list of issues requiring further study could be very long indeed. Here, however, particular issues and data gaps especially important to the Pinelands Commission in carrying out its mandate are identified:

1. Some additional forest vegetation mapping is required.

   Replacement photography for the three missing flight lines noted in chapter 2 is expected to be available shortly, and the updating of the affected portions of the current maps should be undertaken as soon as possible.

   The boundaries of the Plains for planning purposes should be determined and transferred either to the current maps or to the 1:125,000-scale base maps of the Pinelands presently being prepared. Because the boundaries of the Plains have changed over time and in places grade into pine/blackjack oak forest with no distinct boundary, and because some recent fires have obscured boundaries, no accurate assessment of the extent of Plains vegetation could be made on the basis of a single set of aerial photographs. Partial mapping of the Plains does exist, including the Plains within Bass River Township (approximately 3,000 acres) and the Spring Hill Plains (about 300 acres), for which there has been good field verification; analysis of these boundaries against several years' worth of aerial photography should permit reasonably accurate aerial interpretation of the boundaries for the remaining areas of Plains.

2. A survey of cedar reproduction would assist in better defining management techniques and sites where cedar development might be encouraged.

   The occurrence of cedar is largely relegated to widely scattered islands, limiting available seed sources. At the same time, natural succession favors hardwood swamp, which is already widely

distributed. However, the maintenance of cedar-swamp habitat over time might be facilitated by a fairly comprehensive field survey of the range of conditions under which cedar becomes established; this could lead to some useful management techniques and the designation of appropriate sites. (See 5.3.2, recommendation 2.)

3. Propagation and distribution of native plant species is an important issue, recommended for further study.

   As suggested in section 5.4.2, recommendation 4, the issue of a coordinated program of state and commercial nurseries for the propagation and distribution of presently unobtainable native plants, especially herbaceous and early successional species, is important and worth further study.

4. Reclamation procedures and standards for surface excavations need further study.

   As noted in section 5.4.2, recommendation 7, native grasses and shrub rootstocks are not available commercially, and specific reclamation procedures require further testing. Both the propagation of suitable plant materials and reclamation programs are needed before costs will be low enough to be reasonably borne by the land owner.

5. The development of a large-scale pilot program to use native-habitat landscaping on all land under the jurisdiction of federal, state, and municipal agencies is recommended for consideration.

   As suggested in section 5.4.2, recommendation 4, such a program along with the testing of appropriate vegetation management techniques (such as prescribed burning related to development) would be well worth considering.

6. Standards for the development of a natural drainage and open space system should be formulated.

   This critical issue is discussed in section 5.4.2, recommendation 1; a coordinated and thorough synthesis of the findings and recommendations of all the natural-resource consultants would form a basis for further work on it.

APPENDIX A

FOREST VEGETATION PATTERNS IN THE PINE BARRENS

The following patterns (all drawn to the scale of 1:24,000 or 1"=2,000') were taken directly from the current forest vegetation maps, although they have been somewhat simplified and modified for illustrative purposes.

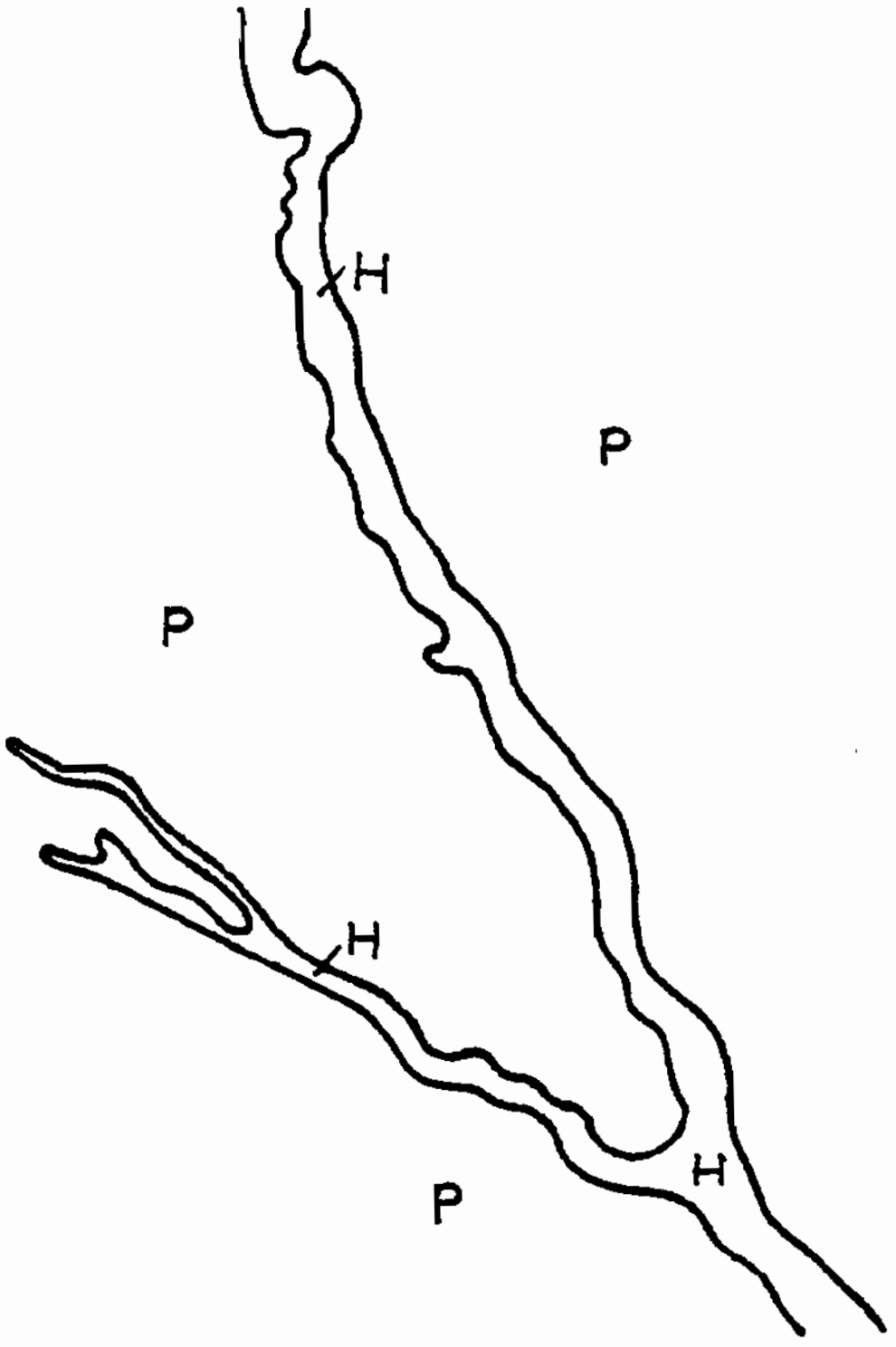

Fig. A. In areas of higher relief and at the fringes of the Pine Barrens, discrete ribbons of hardwood swamp (H) often follow narrow drainage courses, many of which probably supported cedar swamp in the past.

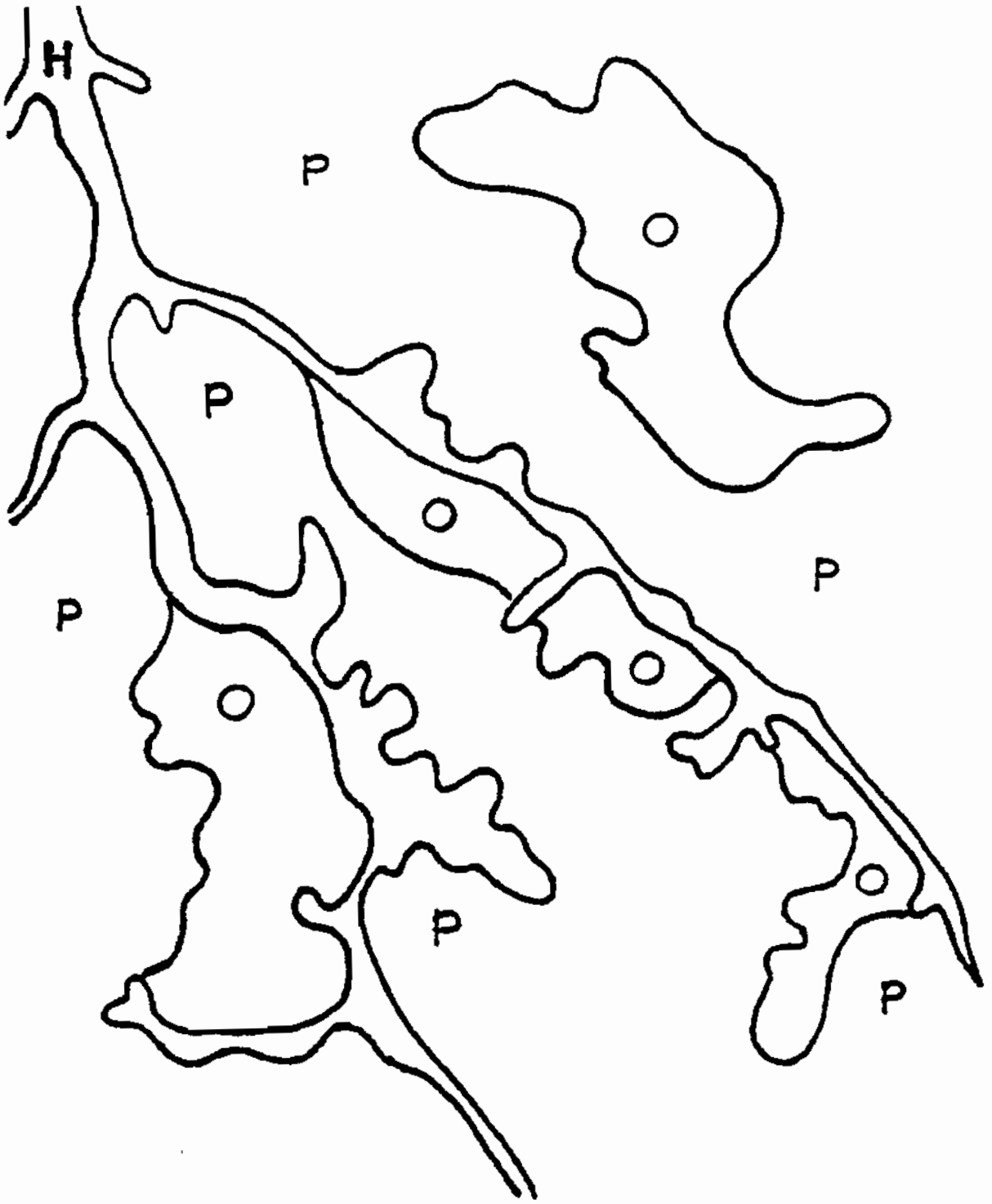

Fig. B. In the central portions of the Pine Barrens, the oak/pine forest (O) is often confined to pockets bordering discrete stream channels and small hilltop areas.

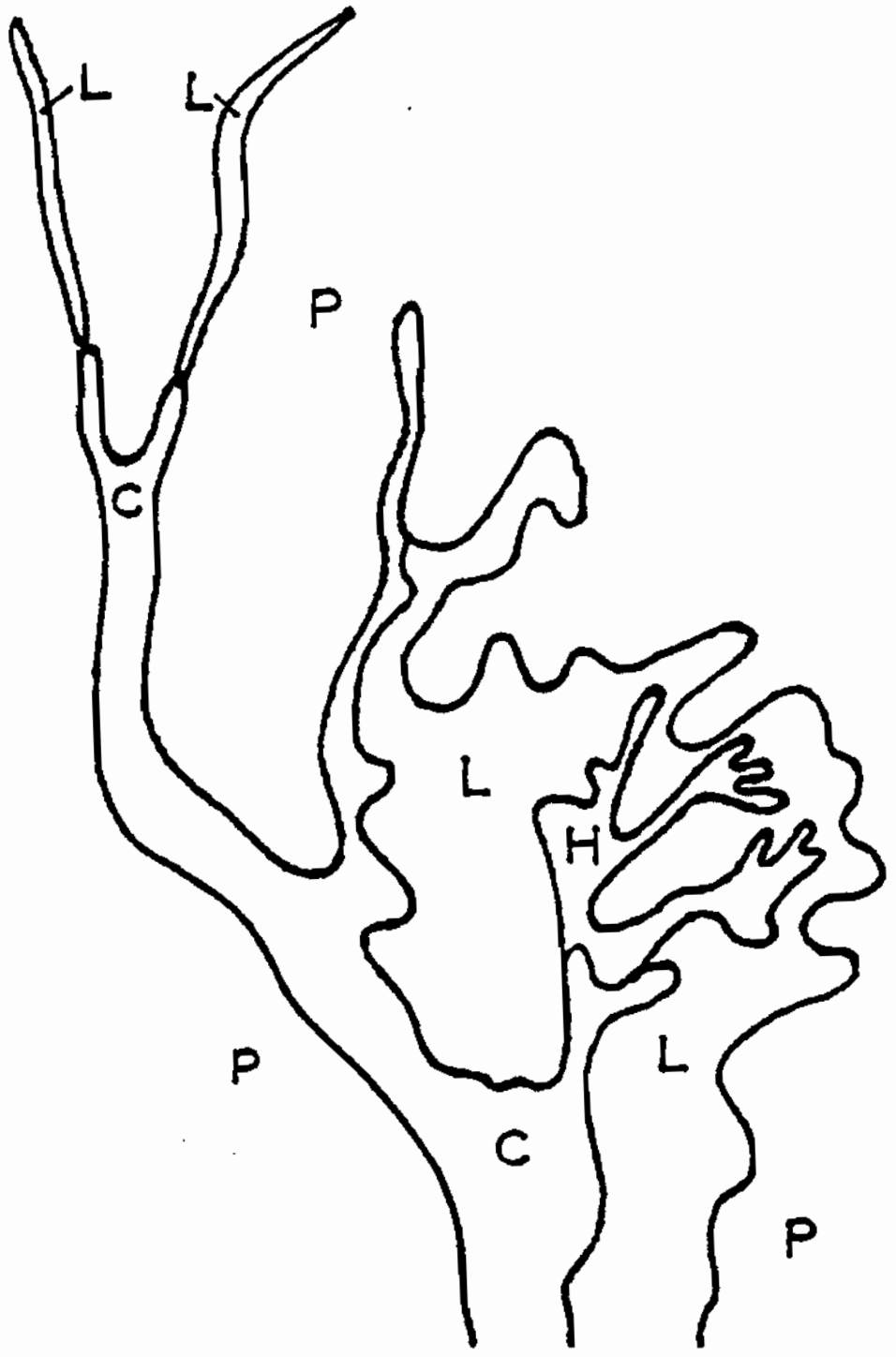

Fig. C. Where cedar (C) has not been replaced by hardwood swamp (H), pure stands can be found along stream courses, often bordered by pitch-pine lowland forests (L) on adjacent poorly drained soil and at the headwater areas. Many of these pitch-pine lowland forests may have recently increased in size.

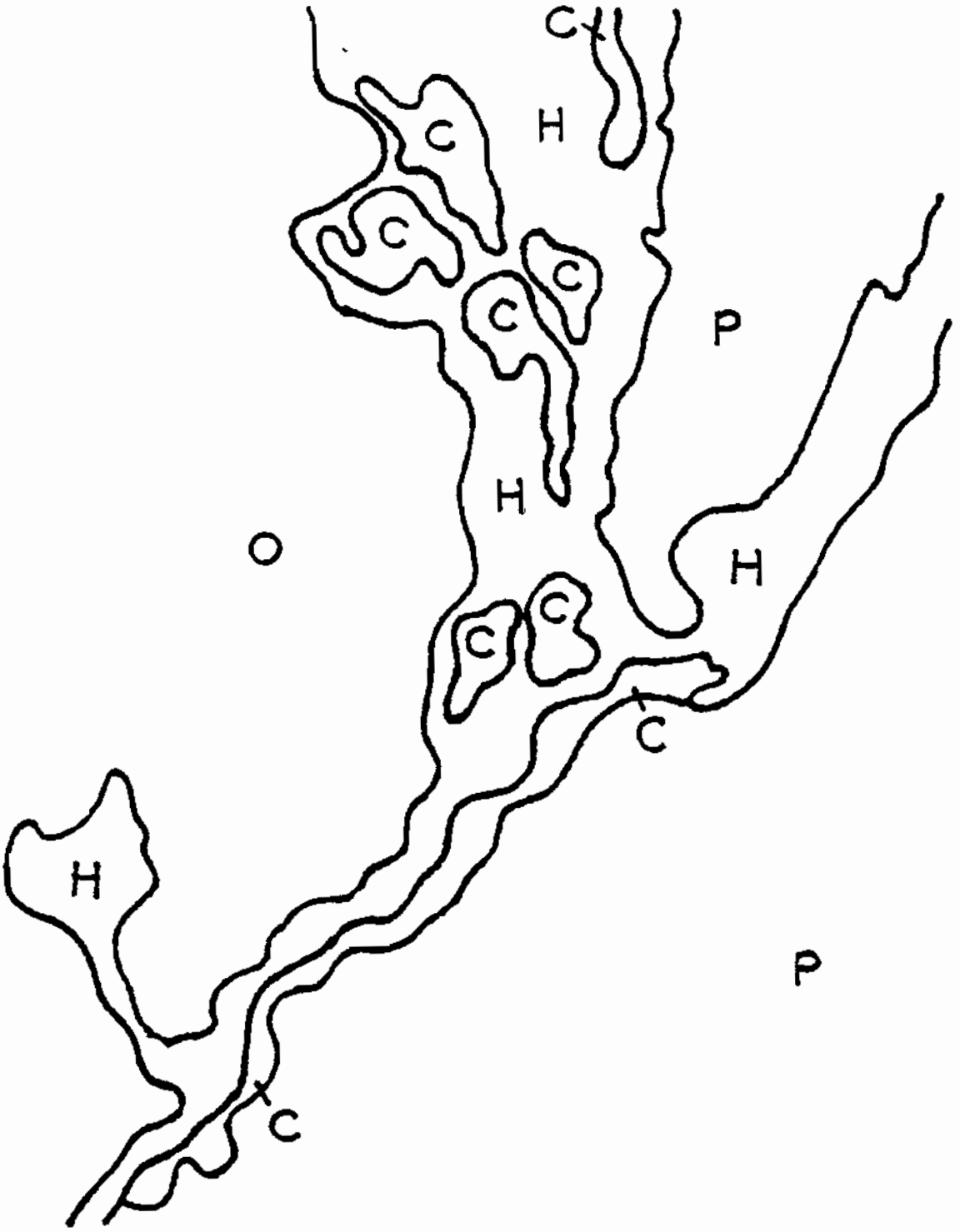

Fig. D. Many of the larger drainage channels still support patches of the once extensive cedar swamp forest. Cedar swamps (C) today are generally confined to scattered islands along a stream or to a narrow fringe at the edge of these lowlands.

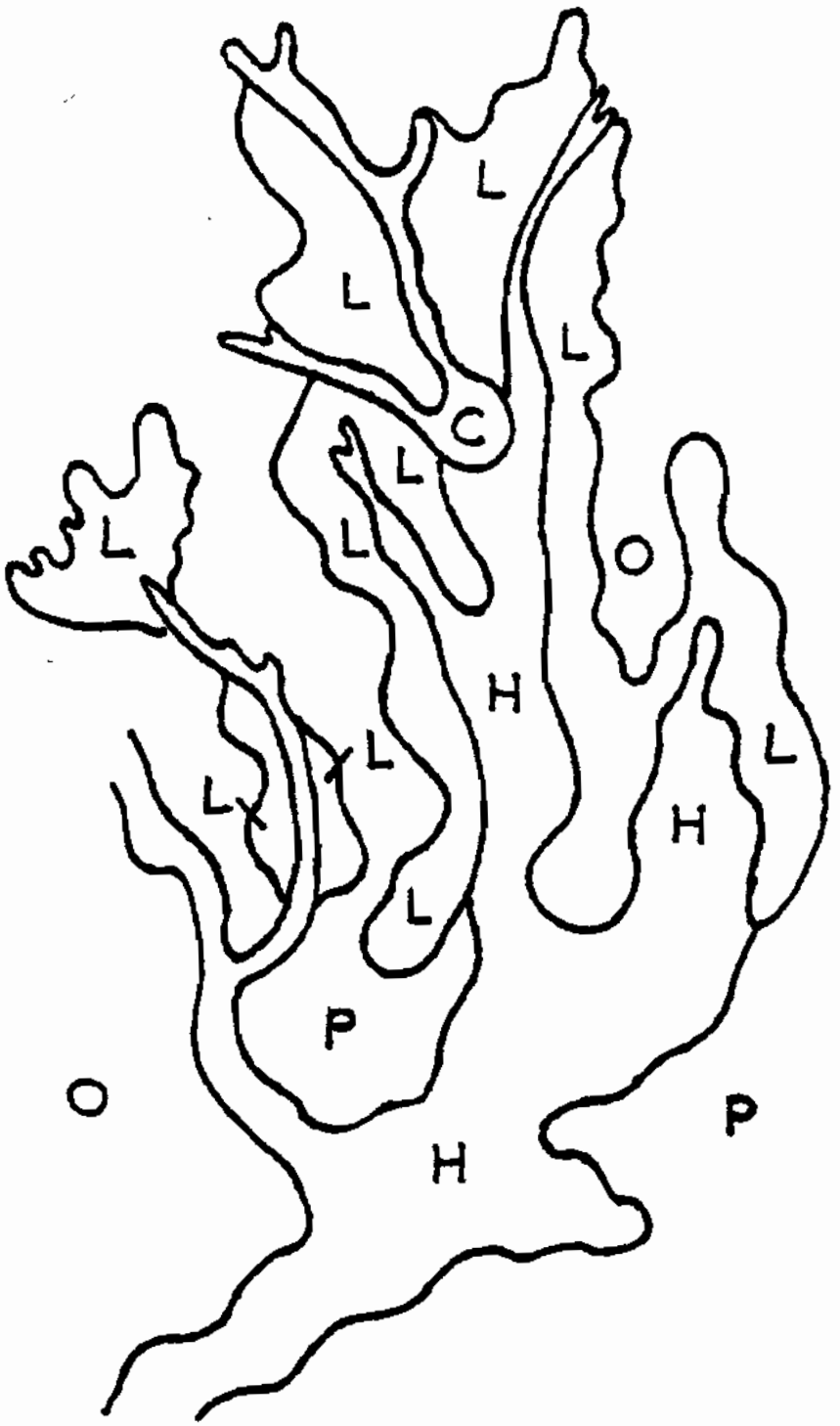

Fig. E. On many tributary channels in the central portions of the Pine Barrens, extensive development of pitch-pine lowland forests (L) has occurred between smaller drainage courses, at headwater areas, and fringing the ribbon of swamp along the stream.

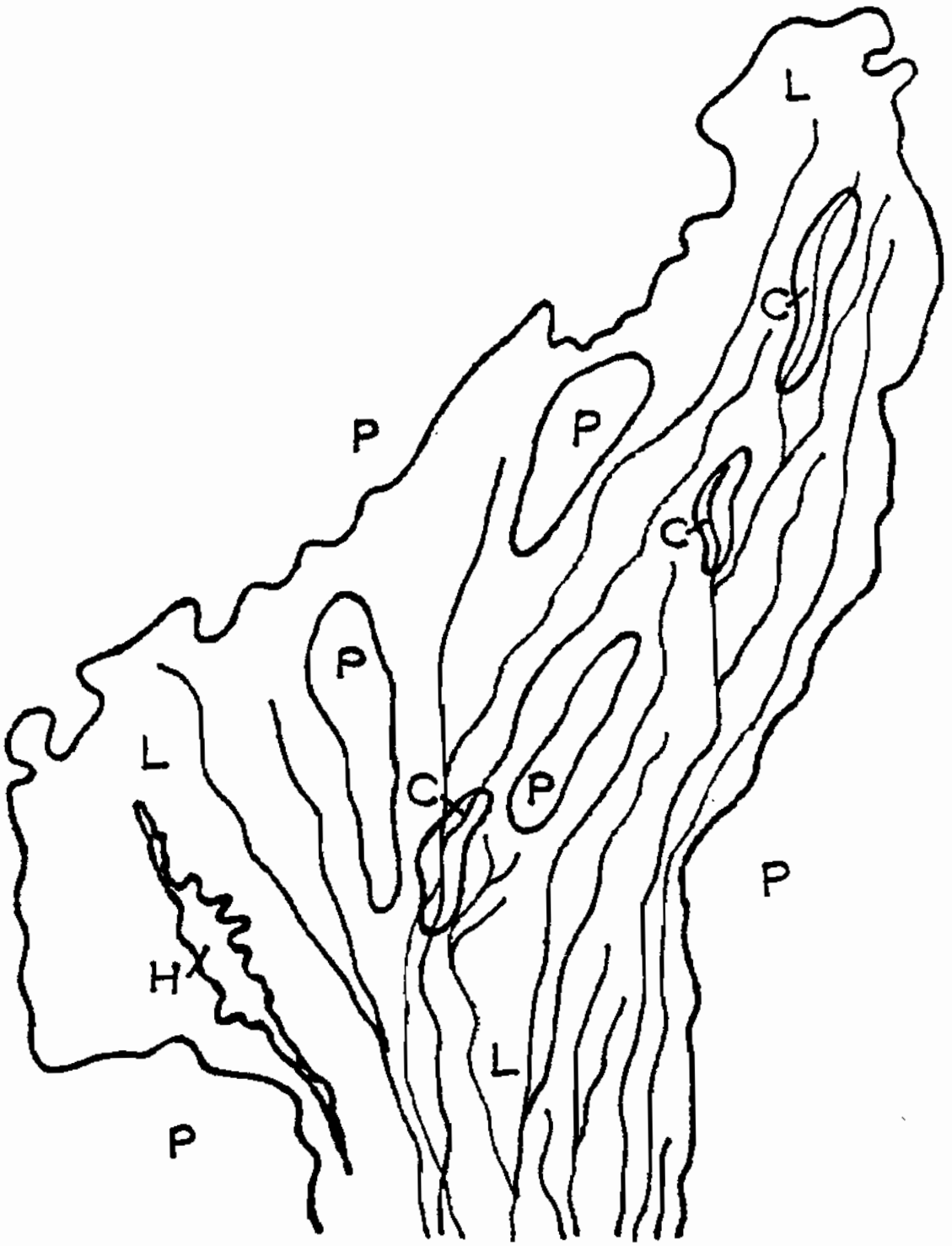

Fig. F. The broad, expansive pitch-pine lowland forest (L) is typically found where the ground is low and gently undulating. Islands of upland forest (P) may occur between the many small drainage channels which often support young stands of cedar (C).

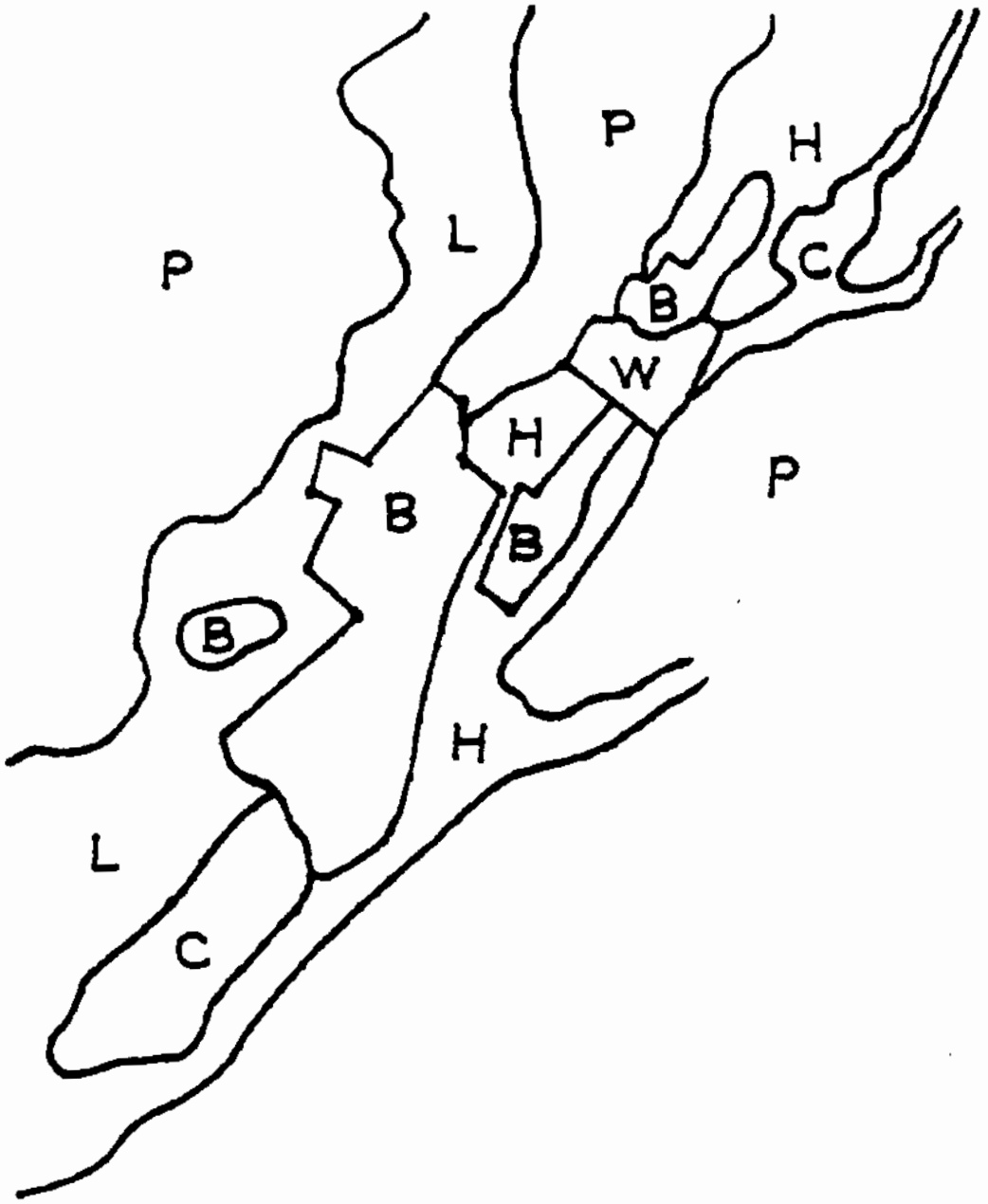

Fig. H. Many lowland systems support extensive development of cranberry bogs (B). The reservoir (W) as well as smaller and older bogs usually occur on the main stream channel, but expansion of many bogs has recently occurred on lowland areas adjacent to the channel. Abandoned bogs often support inland-marsh or shrub vegetation typical of natural bogs; older, abandoned bogs have forest stands, with cedar or red maple or a mixture of the two being the common compositions.

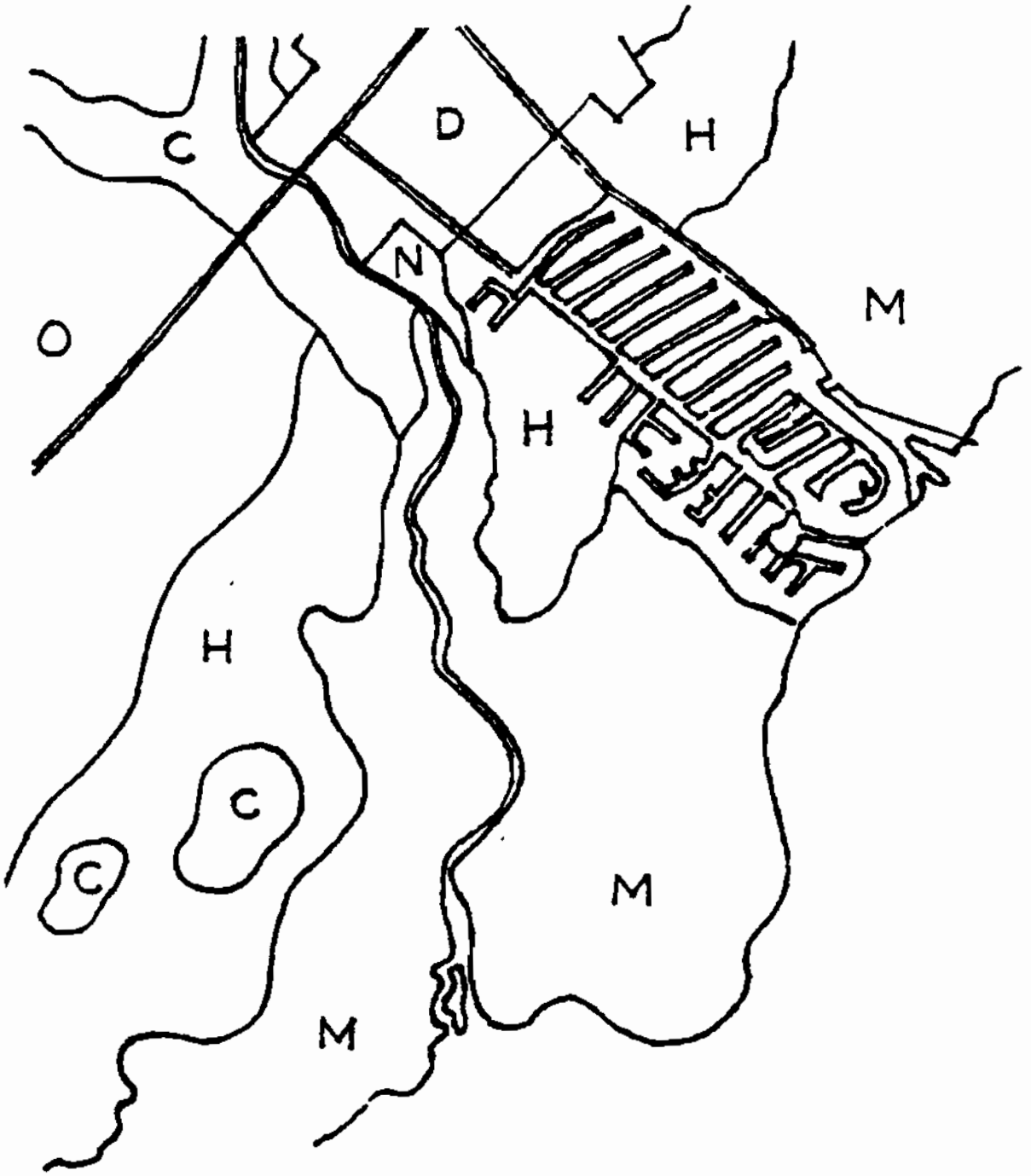

Fig. I. In the coastal zone, a band of swamp, often quite broad, runs adjacent to the marshes, which often extend well upstream on the larger rivers. Smaller stream channels still support cedar (C); however, hardwood swamp (H) has replaced the once extensive cedar swamps in most of the coastal zone. (The lagoon-type development is one of the most destructive land uses observed, preempting most native plant communities as well as disrupting aquatic systems.)

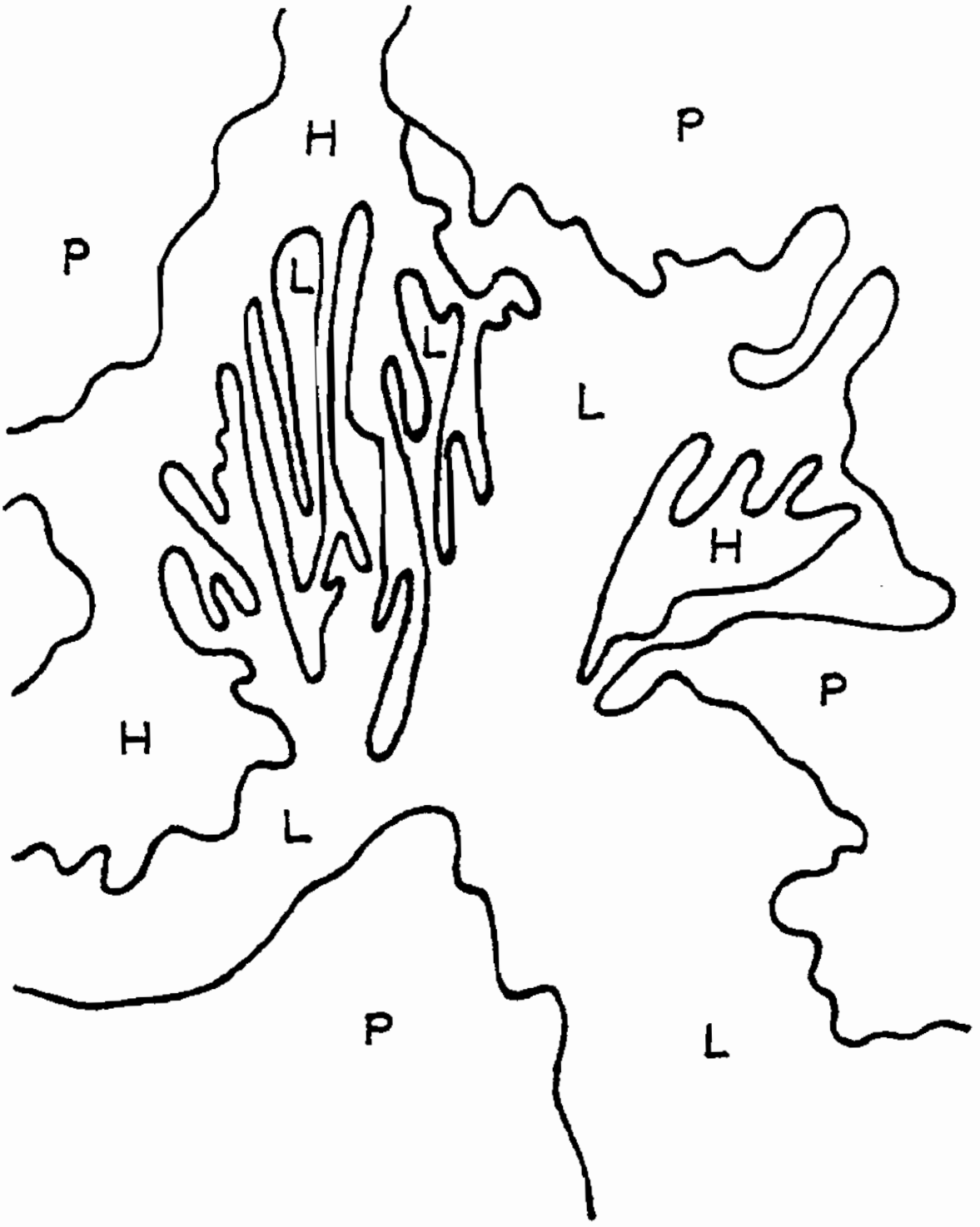

Fig. G. In more extensive lowland areas of the central Pine Barrens, the gradient between pitch-pine lowland forest (L) and hardwood swamp (H) or cedar swamp is often expressed as a network of fingers, which probably shift subtly over time, reflecting changes in water regimen.

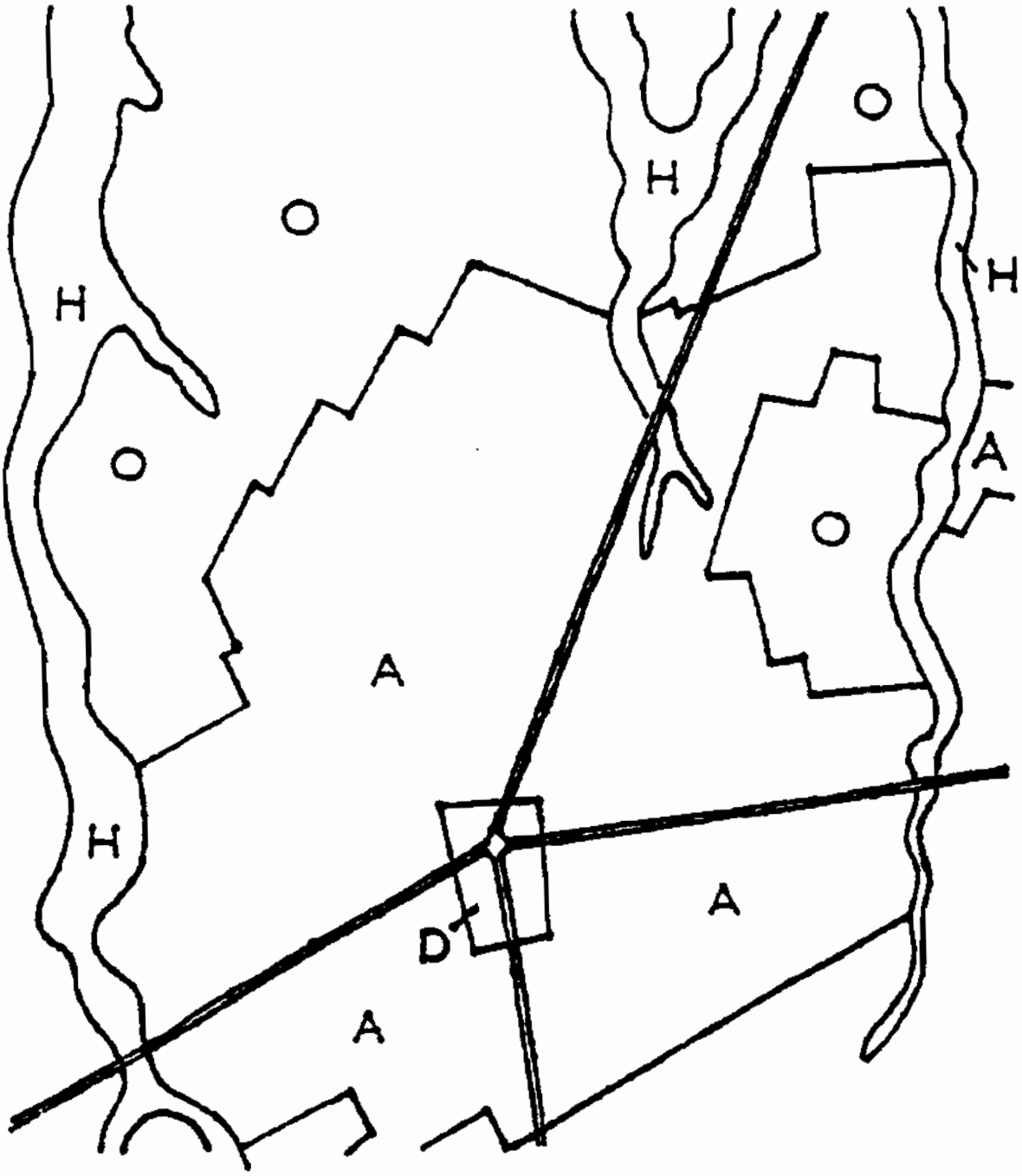

Fig. J. A typical pattern found in agricultural areas is a village (D) at the crossroads, surrounded by a geometric mosaic of fields (A) traversed by narrow ribbons of hardwood swamp (H); these small drainage channels probably once supported cedar. Such agricultural development is generally more responsive to the character of the site than other development types.

APPENDIX B

TRENDS AND IMPACTS IN THE VARIOUS WATERSHEDS

The Pinelands area is basically a slightly domed plain located between the Atlantic Ocean and the Delaware River. Within the boundaries of the Pinelands area, the major central and eastern portions include complete river systems than drain into the Atlantic Ocean, and the northern and western portions include parts of river systems that drain to the Delaware River and the Delaware Bay.

B.1. Toms River Basin

The Toms River Basin watershed drains into Barnegat Bay; the mouth of Toms River is not within the Pinelands area. The major tributaries of the Toms River system are Ridgeway Branch, Wrangle Brook, Davenport Branch, and Jakes Branch.

In the northern part of the watershed, ribbons of hardwood swamp follow stream channels. This pattern has remained essentially unchanged since the previous mapping; the apparent increase in the complexity of the landscape mosaic is primarily due to the increased detail of the current mapping. In the southern part of the watershed, the previous mapping showed primarily broad ribbons of cedar swamp and pitch-pine lowland forest along stream channels with some hardwood swamp. There is currently a complex mosaic of hardwood and cedar swamp, pitch-pine lowland forest, and bogs and impoundments along the drainage channels. The cedar is much reduced, although still present along smaller streams.

The pattern of upland forest types is pine/oak in the southern portions of the basin and oak/pine in the northern portions; despite minor shifts in forest types, this distribution is basically unchanged. Toms River Basin, however, shows the most pronounced disturbance of upland forests of any watershed within the Pinelands area. The large Lakehurst and Plumstead military reservations are located within the watershed, and both show further clearing and expansion of facilities since the previous mapping. There is also major disturbance of upland

forests due to dramatic expansion of surface excavations and borrow pits, and impacts from many scattered small residential developments and several large ones. A major exception to this trend is in the headwaters area of the basin, which is largely unchanged in pattern and intact; part of this area is protected by the New Jersey Wildlife and Game Refuge.

B.2. Cedar Creek

Cedar Creek drains into Barnegat Bay. The entire watershed is within the Preservation Area and a small portion of the basin is within the Double Trouble State Forest.

Trends in this watershed are typified by Factory Branch, a tributary of Cedar Creek. Previously mapped as a ribbon of cedar swamp and pitch-pine lowland forest, it is now a complex mosaic of cedar and hardwood swamps, pitch-pine lowland forest, and bogs, with cedar much reduced by logging and a number of small new cranberry bogs. Urbanization has been most pronounced in the coastal areas, where large lagoon developments and intensive building along major roads have disrupted the marshes and the broad band of predominantly hardwood swamp adjacent to them, resulting in the loss of a major stand of cedar at the mouth of the creek.

Upland forest types are for the most part intact and unchanged in pattern, with oak/pine in the eastern portions of the watershed and pine/oak in the western portions.

B.3. Forked River Basin

There are four major streams in the Forked River watershed -- Forked River, Oyster Creek, Mill Creek, and Westecunk Creek -- with numerous smaller streams flowing into Little Egg Harbor Bay, Manahawkin Bay, and Barnegat Bay.

Coastal areas are characterized by broad marshes and broad bands of hardwood swamp; these bands are narrower at the mouths of Forked River and Oyster Creek. Development in this watershed is confined for the most part to the coastal areas, particularly near the mouths of streams. In the area of the Manahawkin Hunting and Fishing Grounds and the larger Barnegat National Wildlife Refuge, the marsh and hardwood swamp band is very wide and almost completely intact, except for the huge lagoon development at Beach Haven West and the reduction of a large stand of cedar within the hardwood swamp band to small pieces. At the mouths of the Tuckerton and Westecunk creeks, the marsh band is broad and largely undisturbed, while the hardwood swamp band is narrow and heavily developed.

Development in the uplands is also concentrated in the coastal area, especially east of the Garden State Parkway. Previously mapped patterns of oak/pine and pine/oak forests are now often replaced by patterns switched in type and less contiguous in occurrence. Development west of the Garden State Parkway is predominantly that of

agriculture and surface and borrow-pit excavations; large portions of the upland forests are generally unchanged.

Trends in the lowland portions of this watershed which lie outside the coastal areas are typified by the North Branch of Forked River. Replacing the previously mapped long ribbon of cedar swamp adjacent to the stream channel, with hardwood swamp or pitch-pine lowland forest lining the streams in the headwater areas, current forest types bordering the stream channels are a mosaic of cedar, hardwood swamp, pitch-pine lowland forest, and bogs. In the headwaters of Forked River and Oyster Creek, there is some expansion of hardwood swamp and pitch-pine lowland forest into areas previously mapped as upland forest.

B.4. Mullica River Basin

The Mullica River Basin is the largest and most extensive watershed within the Pinelands area. The watershed of the Mullica River Basin occupies the heart of the Pine Barrens, and the bulk of it falls within the Preservation Area as well as within the boundaries of a number of state forests -- Wharton, Penn, Bass River, and Green Bank. For the purposes of description, this watershed is divided into four sections: (1) Bass River; (2) Lower Mullica, including Nacote, Landing, and Hammonton creeks; (3) Wading River, including the Oswego River; and (4) Upper Mullica, including Batsto River, the upper reaches of the Mullica, and Nescochaque Creek.

B.4.1. Bass River. The Bass River flows due south into the Lower Mullica. Almost half of this watershed lies within the many tracts of the Bass River State Forest and is reasonably intact. The most serious disturbance is logging of major cedar areas not on state-forest land. Development for the most part is confined to coastal areas, where it has substantially impacted the mouth of the river and the adjacent hardwood swamps, although the marshes are still intact.

Along drainage channels of the Bass River, a thin ribbon of cedar swamp is still the predominant forest type, although some cedar has been lost and replaced by a complex mosaic of lowland forest types.

The uplands are predominantly pine/oak and have remained largely unchanged since the previous mapping, except in the headwater areas which lie within the Warren Grove Target Area of the United States Naval Reservation, where upland forests have been disturbed by military activities.

B.4.2. Lower Mullica, including Nacote, Landing, and Hammonton creeks. The Lower Mullica is a broad, meandering river which flows into Great Bay. In coastal areas, the forest pattern is characterized by a broad band of hardwood swamp adjacent to a broad band of marsh; small stands of cedar lie within the hardwood band. For the most part this coastal system is still intact, except for lagoon development near the mouth of the river and logging, which has severely reduced the larger cedar stands previously mapped. Further inland, the Lower Mullica is joined

by several small tributaries -- Nacote, Landing, and Hammonton creeks.

The lowland forests are generally hardwood swamps running in a ribbon adjacent to the stream channels, sometimes fringed with pitch-pine lowland forests, with some expansion of pitch-pine lowland forest into areas previously mapped as upland forest. The uplands, formerly entirely oak/pine, are now pine/oak in the central portions of the watershed, with oak/pine confined to coastal areas and drainage divides. About half of the watershed is used for agricultural activities, but there has been some urbanization of previously agricultural areas, particularly along major roads and near Egg Harbor City. There has also been some expansion of agriculture in the southern portions of this watershed.

B.4.3. Wading River, including the Oswego River. The Wading River is the largest tributary of the Mullica River and has two extensive and distinct branches -- the West Branch and the East Branch (the latter becomes the Oswego River). The West Branch lies largely within the Wharton State Forest, and the East Branch runs through the West Plains and the Warren Grove Target Area of the United States Naval Reservation.

In the watersheds of both branches, the lowlands typically have extensive pitch-pine lowland forests and hardwood swamps occurring in broad areas of low relief. Often there is little or no upland between branches of a stream, as numerous tiny rivulets occur between the major channels. These large lowland forests are extremely rich in pattern, showing frequently a braided mixture of hardwood swamp, pitch-pine lowland forest, and small areas of cedar swamp. The area of cedar on private land has been much reduced by logging; however, some cedar reproduction does appear to be taking place, especially adjacent to larger stands of existing cedar where land has been cleared of canopy trees by burning, flooding, or clearcutting. The finer grain observed in these lowland forest patterns is due not only to the greater detail in the current mapping, but also to the effects of the logging of large cedar stands, the spread of new cranberry bogs and the abondonment of others, and severe burns.

In the watersheds of both branches, the uplands are essentially unchanged in pattern. Predominantly pine/oak, with oak/pine confined mainly to the higher elevations and sloped areas adjacent to streams, the upland forests show little disturbance, except for the Plains area where extensive bombing and clearing has resulted in large non-forested areas and considerable scarring in the remaining forested areas. A further change in pattern was an increase in the area mapped as extent of lowland forest, particularly in the headwater areas of streams and along the Wading River; these extensions show predominantly pitch-pine lowland forest with some increase in hardwood swamp. Numerous small bogs and ponds dot the ground.

B.4.4. Upper Mullica, including Batsto River, the upper reaches of the Mullica, and Nescochaque Creek. The main drainage channels of the Batsto and Mullica rivers support long ribbons of hardwood swamp. In

contrast, the drainage channels of Sleeper Branch, Albertson Brook, and Nescochaque Creek are more complex, supporting mosaics of lowland forest types which tend to merge into broad, extensive lowland vegetation on the land of shallow relief between stream channels. These lowland forests have a very rich fabric and are interwoven with hardwood and cedar swamps, with islands of pine/oak occurring at higher elevations. Some of these areas are very lush and mature, although there have been recent severe burns in other areas. The current mapping has picked up greater detail in these lowland areas than the previous mapping, but the finer grain here is also due to logging of larger cedar stands, agricultural expansion, and the occurrence of bogs in some burned areas.

At the headwaters of Sleeper Branch, Albertson Brook, and Nescochaque Creek, no extensive lowlands occur; narrow ribbons of hardwood swamp occur along stream channels which flow through large tracts of agricultural land, only slightly changed in pattern from what was recorded in the previous mapping.

In the central portions of the watershed, the upland forest type is predominantly pine/oak, except for the area near the northern and western drainage divides which supports predominantly oak/pine forest; this pattern has remained essentially unchanged since the previous mapping.

On the Batsto River, upstream from the large pitch-pine lowland forest areas, there has been an extension of lowland types -- predominantly pitch-pine lowland forest -- into areas previously mapped as upland forest.

B.5. Doughty Creek

Doughty Creek, a small stream in the Atlantic Drainage Basin flowing into Reed's Bay, is the only stream in this watershed which lies within the Pinelands area. At the mouth of Doughty Creek, the coastal area is characterized by broad marshes and a narrow band of hardwoods bordering the upland oak/pine forest. There has been very little development in the hardwood swamp and oak/pine forest, and the marshes are completely intact and protected by the Brigantine National Wildlife Refuge.

B.6. Great Egg Harbor River Basin

The watershed of the Great Egg Harbor River is the second largest within the Pine Barrens. The river flows into Great Egg Harbor Bay where it is joined by the Tuckahoe River. The headwaters of the Great Egg Harbor River do not lie within the Pinelands area. For the purpose of description, this basin is divided into two sections: (1) Lower Great Egg Harbor River, below May's Landing; and (2) Upper Great Egg Harbor River, above May's Landing.

B.6.1. Lower Great Egg Harbor River, below May's Landing. In the coastal area, the river flows through an extensive, broad band of marshes. These marshes are generally undeveloped, and a portion of them falls within the Corbin City Hunting and Fishing Grounds. Adjacent to these marshes, a hardwood swamp band narrows somewhat in the northeastern portion of the watershed and is disrupted by agricultural use and developments extending from the adjacent uplands; only a small amount of this disturbance has occurred since the previous mapping.

In the central portions of this watershed, the tributary streams typically support ribbons of hardwood swamp (sometimes quite broad ribbons) fringed by pitch-pine lowland forest.

The uplands are predominantly oak/pine; however, there are substantial tracts of agricultural land in the western half of the watershed. The upland forest patterns have not changed significantly since the previous mapping.

B.6.2. Upper Great Egg Harbor River, above May's Landing. Above May's Landing, the river is a wide, meandering stream bordered by a broad band of hardwood swamp. Islands of pine/oak upland forest and pitch-pine lowland forest occur within this hardwood swamp band, and the hardwood swamp band is often fringed by a band of pitch-pine lowland forest, which is generally wider in the current mapping than in the previous mapping. There has been, since the previous mapping, a noticeable extension of pitch-pine lowland forest into areas previously mapped as upland forests and hardwood swamp.

In the central portions of the watershed, there are several broad hardwood swamps in low-lying areas between tributaries; several have been severely burned, forming a complex mosaic with large boggy areas. Cedar is substantially reduced where it occurred in large stands within these broad hardwood swamps, and there is a substantial increase in pitch-pine lowland forest at the fringes of the swamps.

The uplands are almost entirely oak/pine forest, with the upper portion of Upper Great Egg Harbor River watershed supporting a substantial amount of agriculture. South of the town of Hammonton, there is considerable development and throughout the watershed there has been an increase in small- and medium-scale development which tends to concentrate along the main channel of the river and along roads. There is also a noticeable increase in pitch-pine lowland forest into previously mapped oak/pine areas. But, in contrast to other watersheds within the Pinelands area, there is also substantial occurrence of pitch-pine lowland forest within areas previously mapped as hardwood swamp, which may be attributable to the finer grain of the current mapping.

B.7. Tuckahoe River

The Tuckahoe River flows into Great Egg Harbor where it joins Great Egg Harbor River. In the coastal areas, the vegetation is characterized

by parallel bands of marsh and hardwood swamp. The marshes, protected by the Tuckahoe State Hunting and Fishing Grounds, are unchanged in pattern and intact. In the northern portion of the coastal zone, the hardwoods and oak/pine uplands are largely undisturbed; but in the southern portions there has been new small-scale development, an expansion of agriculture, and some forest clearing. There is extensive small-scale development along the main body of the Tuckahoe River where it joins the coastal marshes.

In the central and upper portions of the watershed, the stream and its tributaries generally support a broad ribbon of hardwood swamp. Since the previous mapping there has been an increase in pitch-pine lowland forest at the fringes of these hardwood bands and also a marked increase in hardwood swamp.

The coastal marshes extend well up to the mouth of the Tuckahoe River, with development and agriculture confined to a border directly adjacent to the stream channel. Throughout the Tuckahoe basin, the tributary stream channels generally support ribbons of hardwood or cedar swamp, fringed by pitch-pine lowland forest, a pattern unchanged since the previous mapping. But in the central portions of the watershed, between the branches of small tributaries, large hardwood swamps occur in broad, shallow low-lying areas. One of these hardwood swamps falls within the Tuckahoe State Hunting and Fishing Grounds and is extremely rich and undisturbed. Oak/pine forest occurs in the uplands, with scattered areas of pine/oak forest which did not appear on the previous mapping.

B.8. Rancocas River

The Rancocas River flows into the Delaware River. Only the upper reaches of the North and South branches of the Rancocas fall within the Pinelands area. At the fringes of the Pine Barrens, slightly beyond the mouth of the river, lowland areas show primarily ribbons of hardwood swamp bordering stream courses, with no extensive development of lowland forest systems. The uplands support extensive agricultural areas, traversed by the narrow stream channels. The major forest type of the uplands is non-Pine-Barrens forest, which occurs in small leftover pieces between fields and adjacent to lowland areas of hardwood swamp. In the central portion of the watershed, lowland vegetation is primarily hardwood swamp, often mixed with cedar swamp and pitch-pine lowland forest. Several streams are impounded to form large reservoirs as well as a number of new and previously existing cranberry bogs. The uplands here support primarily oak/pine forest; there are several large new suburban developments, two of which have retained the forest landscape, and a major increase in wetland vegetation occurs adjacent to these new developments. In the upper reaches of the Rancocas and in the headwater areas of the North and South branches, the lowlands along stream channels often support mosaics of hardwood and cedar swamp and pitch-pine lowland forest; broad lowland systems occur in the shallow, poorly drained valleys between stream branches. Both oak/pine and pine/oak occur in the uplands, and there has been some extension of both hardwood swamp and pitch-pine lowland forest into areas previously mapped as upland forest.

B.9. Crosswicks Creek

Crosswicks Creek flows into the Delaware River. Only the small streams of the headwater areas are included within the Pinelands area. This portion of the Crosswicks Creek watershed lies almost entirely within the Fort Dix Military Reservation, and the southern tributaries of North Run have been obscured by facilities at the MacGuire Air Force Base. Jumping Brook, the only other tributary of Crosswicks Creek within the Pinelands area, supports a mosaic of forest types -- primarily hardwood and cedar swamp and pitch-pine lowland forest -- along the drainage channel. At the headwaters of the main channel of Crosswicks Creek is a very large lowland area which forms a complex mosaic of hardwood swamp, bog, inland marsh, and pitch-pine lowland forest. The uplands support pine/oak; several newly cleared areas were noted. There has also been a small extension of pitch-pine lowland forest into areas previously mapped as upland forest.

B.10. Maurice River

The Maurice River flows into Delaware Bay. Only a very small portion of the eastern half of this watershed is included within the Pinelands area. This portion includes two major tributaries of the Maurice River: the Manumuskin River and Muskee Creek. Both these streams, as well as the smaller tributaries, support ribbons of hardwood swamp, often bordered by pitch-pine lowland forest at their headwaters. The Delaware Bay marshes extend well up the mouth of the Maurice River and are often fringed by narrow hardwood swamps. The upland forest was previously almost pure oak/pine, but this pattern is now broken by scattered development and expanded agricultural areas as well as scattered areas of pine/oak forest.

B.11. Dennis Creek

West Creek and Dennis Creek are the only major streams of this watershed included within the Pinelands area. The marshes of Delaware Bay extend well up the mouths of both creeks and several smaller channels, and are bordered by narrow bands of hardwood swamp which have reached farther inland since the previous mapping. The uplands adjacent to this swamp fringe support extensive agricultural areas; there are widely scattered oak/pine forests, which become larger farther inland where there is less land under cultivation.

The upper reaches of West Creek and the East Branch of Dennis Creek support broad bands of hardwood swamp, portions of which lie within Belleplain State Forest. One very broad area of hardwood swamp in the headwaters of Dennis Creek, named Great Cedar Swamp, obviously supported extensive stands of cedar in the past. By the time of the previous mapping, the cedar had been reduced to large isolated stands, and these stands have been substantially reduced by recent logging. Bordering this swamp are pitch-pine lowland forests which may reflect higher watertable elevations in this area.

APPENDIX C

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