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The Effects of Geology, Topography, and Disturbance on the Soils and Vegetation of the Middlesex Fells, Massachusetts

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Trip B-7

THE EFFECTS OF GEOLOGY, TOPOGRAPHY, AND DISTURBANCE ON THE SOILS AND VEGETATION OF THE MIDDLESEX FELLS, MASSACHUSETTS

by

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Introduction

The Middlesex Fells became a reservation in 1896, when it was acquired by the Metropolitan Park Commission. Prior to that time the area had a long history of abuse. Its timber resources were used for a variety of domestic, industrial, and even military purposes. Parts had been cleared for agriculture. All of it was regularly used for foraging livestock. Its bedrock, particularly the Medford Diabase, was quarried for building the road materials. Fires were frequent.

The present landscape still shows the effects of the earlier abuse. Quarries and road cuts gave a sometimes incongruous roughness to a landscape generally smoothed by glaciation. The vegetation mosaic is now different in character to that at the time of settlement. The present structural and compositional variations are difficult to interpret, but appear to reflect man-induced disturbance.

Geology and Geomorphology

Little space is devoted here to geology and geomorphology. For details, you should consult Skehan's (1975) excellent little field guide.

Much of the surface of the Fells is covered by a thin veneer of glacial drift. Bedrock is generally exposed on ridges, and in road cuts and quarries (see the I-93 cut at Pine Hill). Three bedrock types are common in the Fells. The Precambrian basement complex is represented by the Dedham Granodiorite, a light-colored plutonic rock. Two sets of volcanics have cut through the basement materials. The Middle Paleozoic Lynn Volcanics are fine-grained, generally buff-colored. Intruding through the Lynn Volcanics and the Dedham Granodiorite are many Triassic dikes. The dark rock is common throughout the Fells. Its intrusive character is best illustrated in the I-93 road cut on the east side of Pine Hill (seen on the way from Bellevue Pond to the Spot Pond Area.)

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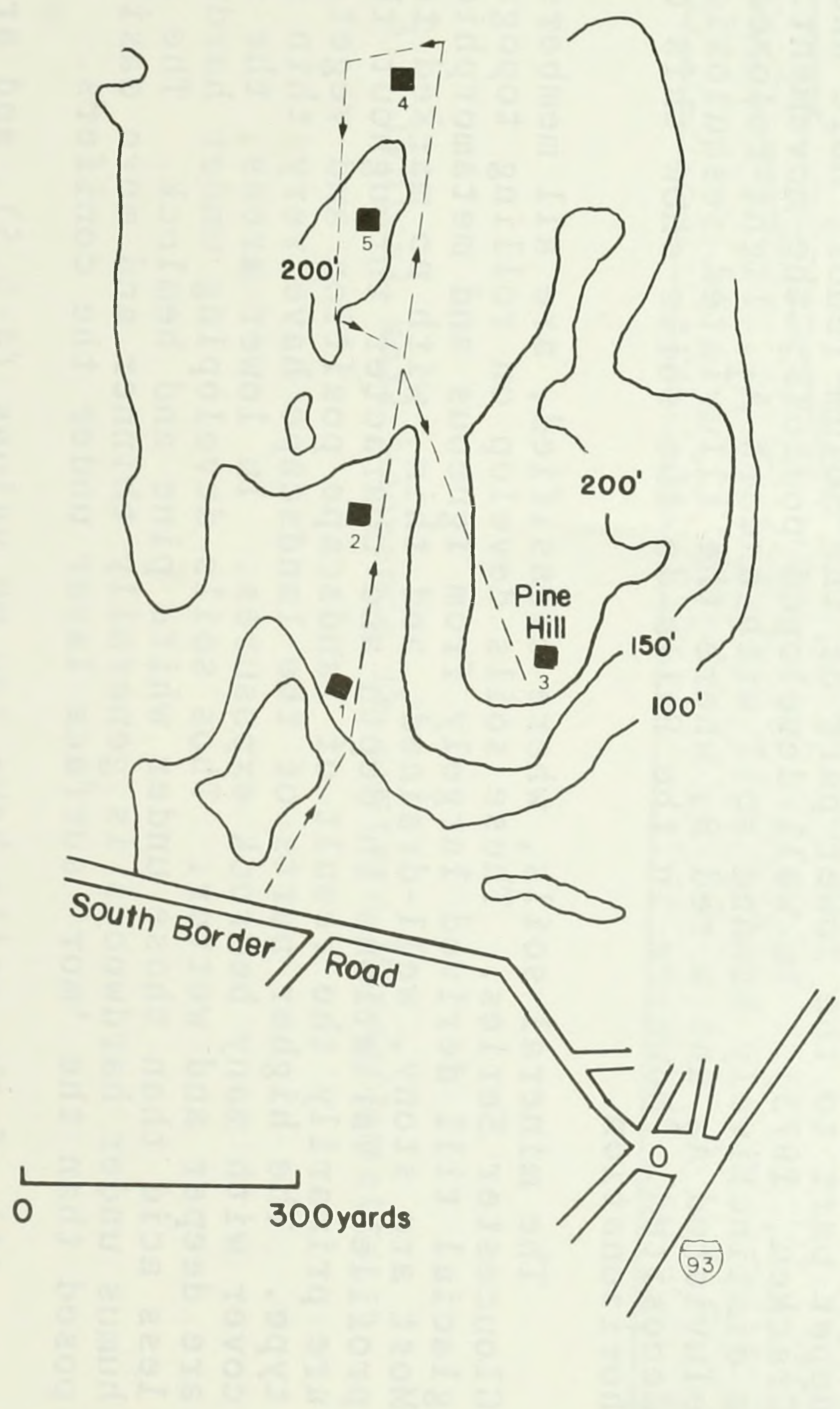
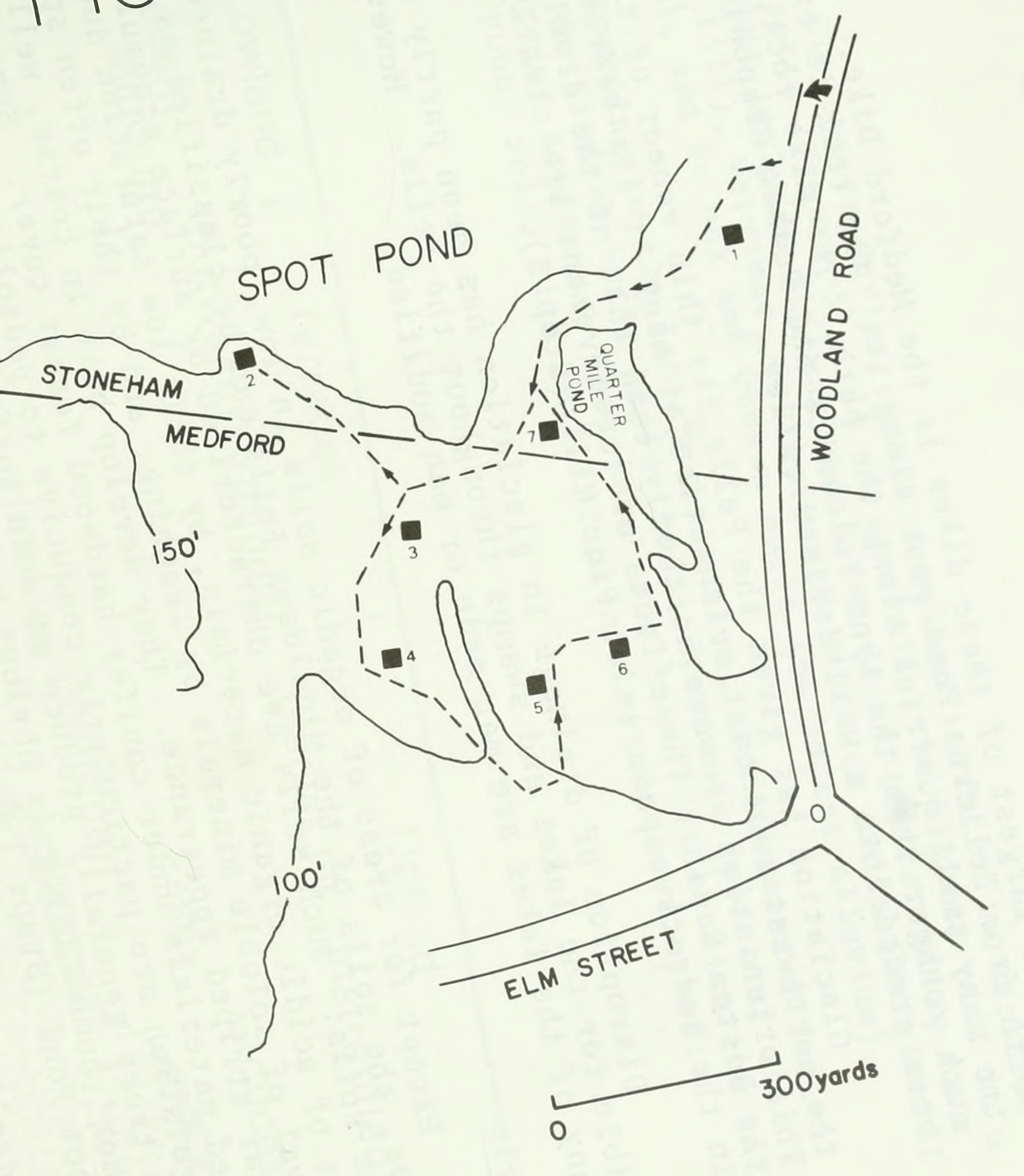
FIGURE I



4
5
200'
200'
2
Pine
Hill
3
150'
100'
1
South Border
Road
0
0
300yards
93

FIGURE 2


SPOT POND
STONEHAM
MEDFORD
QUARTER MILE POND
WOODLAND ROAD
ELM STREET
150'
100'
1
2
3
4
5
6
7
0
0
300yards

The largest of these dikes is the Medford Dike. The path north from Bellevue Pond runs along it. The rock is exposed in the many small quarries along the path. The dike rock, although much younger than the Lynn Volcanics and Dedham Granodiorite, has been eroded into a well-defined valley.

Glaciation has given the Fells its thin veneer of till and the northwest-southeast orientation of many of its bedrock ridges. This orientation is more northerly than that of the drumlins in the Boston Basin. The effects of ice movement are clearly seen in the bedrock exposures at Pine Hill (Stop 3).

Disruption of drainage in glaciation has been partly responsible for the lakes and swamps throughout the Fells. However, many of the lakes are man-made or man-modified.

Soils

Except for areas of organic soils in low, poorly drained sites, the soils of the Middlesex Fells can be classified as podzolic soils. Such soils are characterized by surface accumulations of acidic organic materials, by their low saturation due to removal of soluble minerals by leaching, and by their often spectacular striped appearance. They develop best in coarse, well-drained materials under conifer-hardwood forest cover. Some kinds of vegetation are particularly conducive to podzolization. Coniferous trees generally produce an acid surface organic layer. This 'mor' humus layer is obvious under the hemlock and pine areas near Spot Pond (Stops 1 & 5).

Podzolization is a combination of processes that involves translocation of organic matter, and iron and aluminium for the upper part to the lower part of the solum (Buol, Hole and McCracken, 1973). In well-developed podzols, the movement produces a distinctively banded soil with a dark A_1, light-colored, eluviated A_2 and a red B, where the illuviated sesquioxides are deposited. Nowhere in the Fells do the soils show this clear horizonation.

The mineral soils, where classified, are all members of the Gloucester Series. These soils develop on rolling topography in glacial till derived largely from igneous and metamorphic rocks. Most are stony, well-drained, and thin, with no marked textural profile. Variations in depth and character throughout the Fells are primarily the result of landscape position and vegetation type. The higher parts of the landscape have very thin soil cover with many bedrock exposures. In lower areas, the soils are deeper and wetter. Thos soils developing under hardwoods are less acid than those under white pine and hemlock. The surface humus under hardwoods is generally thinner and more easily decomposed than the 'mor' surface layer under the conifers.

All of the soils have low pH values (4-5.5), and are deficient in potash, nitrogen and phosphorus.

The Gloucester Series occupied upland surfaces in eastern Massachusetts (Figure 3). It is generally the highest soil in a catena that includes Whitman and Essex Soils (wetter sites on glacial till), Merrimac, Scarboro and Hinckley soils (an glacial outwash), and Po unk and Ondawa soils (on recent alluvium).

According to the 7th Approximation, the Gloucester Series are classified as Entic Haplorthods; Spodosols (podzols) that lack distinctive horizons. They have some similarities with the Entisols, young soils with only incipient horizon development.

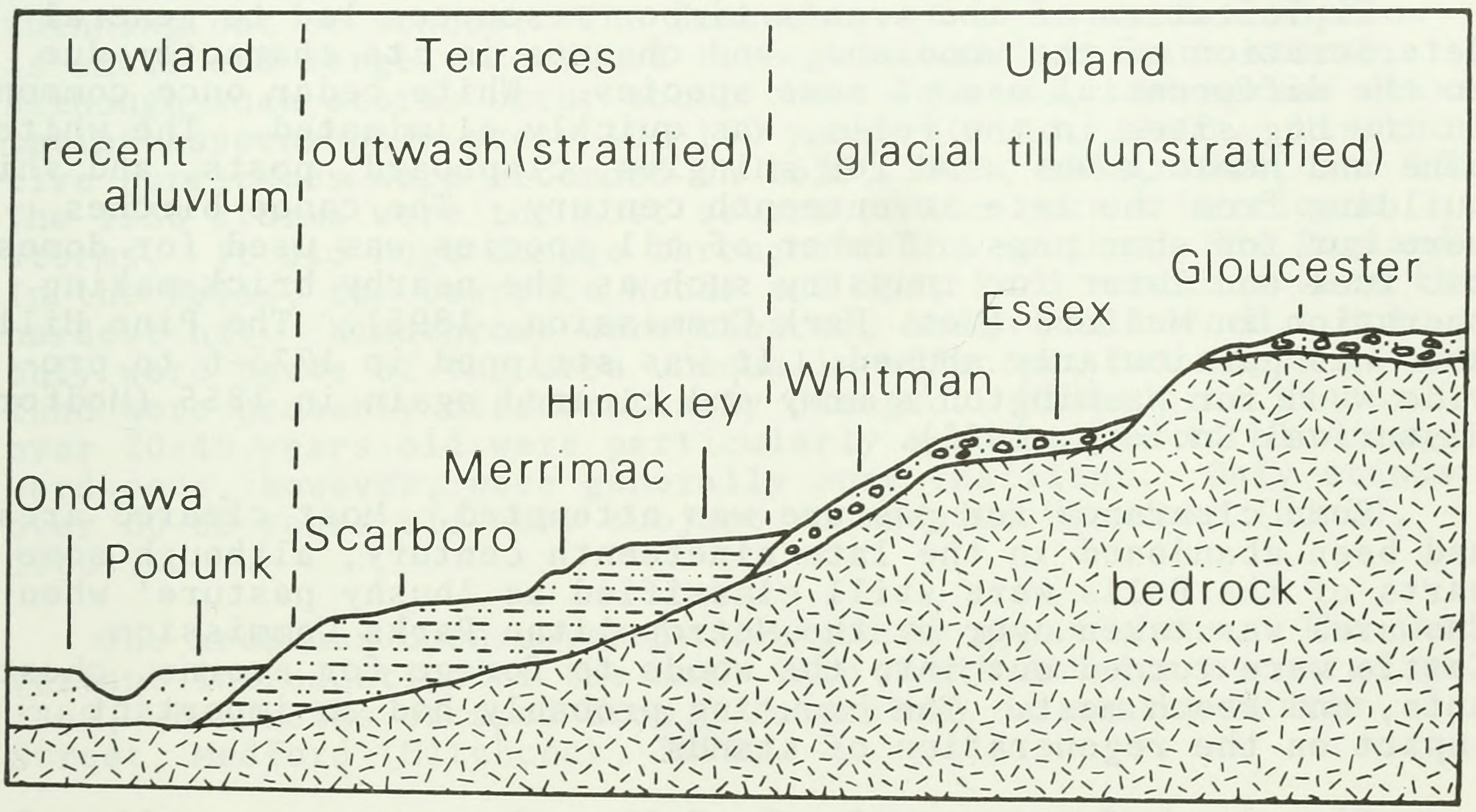


Figure 3. Typical soil sequence in eastern Massachusetts.

Vegetation

The vegetation of the Middlesex Fells is a composite of communities that vary with landscape position and with the frequency and nature of disturbance.

The vegetation at the time of settlement was a mosaic dominated by white pine and hemlock. Hills and ridges were often covered with cedar, oak and hickory with admixtures pine. Canoe birches fringed swampy areas where red maple, grey birch and white cedar dominated. In 1632, Winthrop observed that the Spot Pond area was thick with pine and beech. The change to the present hardwood dominated woodlands can be attributed to man-induced destruction and disturbance rather than to successional changes.

Exploitation of the area's timber resources led to general deterioration of the woodland, and changes in its character due to the differential use of some species. White cedar, once common in the bog sites in the Fells, was quickly eliminated. The white pine and hemlock was used for shingles, clapboard, posts, and shipbuilding from the late seventeenth century. The canoe birches were cut for shoe pegs. Timber of all species was used for domestic fuel and later for industry such as the nearby brick-making operation in Medford (Met. Park Commission, 1895). The Pine Hill area was particularly abused. It was stripped in 1775-6 to provide wood for Washington's army and cleared again in 1855 (Medford Historical Society, 1935).

Some clearance for pasture was attempted. Most cleared areas had been abandoned in the late nineteenth century, although some parts of the Fells were still classified as 'bushy pasture' when the area was taken over by the Metropolitan Parks Commission. Cattle were turned out into the woods to forage for acorns, chestnuts, and beech mast. The browsing probably had an important impact on the regeneration of stands.

Fires were frequent. In the Fells, there were generally of small extent, but common. Winchester recorded eleven fires in fourteen years, Stoneham seven fires in seven years in the early part of last century. By 1880, much of the area was classified as brush (Wright, 1893). Frequent burning may have been responsible for the limited regeneration of hemlocks, and for the importance of oaks in the present forest communities. Although the frequency of fires decreased after 1894, occasional fires have continued to modify community structure and composition. The area south of Spot Pond was badly burned in 1894 and in 1955. A small section was burned in 1974 (Stop 3).

The impact of burning on the present distribution and character of vegetation is difficult to assess. The openness of much of the woodland south of Spot Pond may be attributable to fire, as may be the dominance of red oak in that area. However, the failure of seedling generation in the white pine stand at Stop 5 may be the product of infrequent burning and the consequent accumulation of raw surface organic material.

Studies of unmanaged Connecticut woodlands indicate that disruption by fire may be only temporary. The forest in a burned area returned to its original character within 40 years of a major fire (Stephens and Waggoner, 1970).

The natural frequency of fires in the conifer hardwood forest of New England is probably low. In conifer forests in Minnesota, distinctive fires occur about every 100 years, although species are differentially affected (Heinselman, 1973).

Windthrow by storms is a natural hazard in the woodlands of southern New England. The storms do substantial damage, but may also have an important role in the removal of old trees and the thinning out of stands. The frequency of widespread windthrow is small and largely confined to occasional hurricane storms. Although such storms occur about once a decade, widespread devastation happens only every 100-150 years (Gould, 1960). Destructive hurricanes were recorded in 1635, 1815, 1938, 1944, and 1954. The 1938 storms were the most severe of the recent hurricane storms. It did huge damage throughout the southern New England In the Fells, the Lawrence Woods and Spot Pond sections were the hardest hit. Windthrows were cleared, brush was burned. Not only were parts of the area unequally affected, but types of woodland were probably differentially damaged. White pine stands over 20-40 years old were particularly susceptible to blowdown. Hardwoods, however, were generally more resilient. Only stands over 60-80 years old were subject to massive blowdown (Gould, 1960).

The area has been severely damaged by gypsy moths. The inadvertant introduction of the moth into North America occurred in 1869, when moths escaped from a laboratory in nearby Myrtle Street, Medford (Hitchcock, 1971).

Chestnut, once an important component of most hardwood communities in southern New England, was eliminated in the early years of this century by chestnut blight disease.

Since 1894, and the creation of the reservation, many trees have been planted. Only a few general locations of the plantings are known. Some of the white pine and hemlock stands may have originated in this way. Their even age may be indicative of such an origin, although even-aged stands are very common in New England forests, and may be associated with fire, disease, windthrow, or lumbering.

Each of the forest communities in the Fells is composed of a small number of interrelated species that appear to reflect landscape position as well as the effects of the disturbances indicated above. Soil depth and soil moisture availability are critical variables. In the Fells, thin soils and dry soils are generally coincident. Aspect is locally important. South-facing slopes tend to be drier than those facing north. Compositional variety (number of species) delines from moist, but well-drained sites to dry sites with thin soils and poorly-drained organics.

In the Pine Hill area, the lower, well-drained slopes have a diverse hardwood community dominated by red maple and red oak. The drier, thinly-covered ridges, have an open woodland of white pine and red oak . Red maple increases in importance in the wet locations.

In the Spot Pond section, the open area near Stops 2, 3, and 4 is dominated by red oak, but has a well-developed ground cover that includes blueberry, dogwood and sassafras.

The present woodlands are dominated by deciduous hardwoods, particularly red oak and red maple. The hardwoods have replaced the once-dominant conifers because of the ability to recover rapidly from disturbance. Red oak and red maple are particularly prolific root-sprouters. The conifers do not have this means of rapid regeneration.

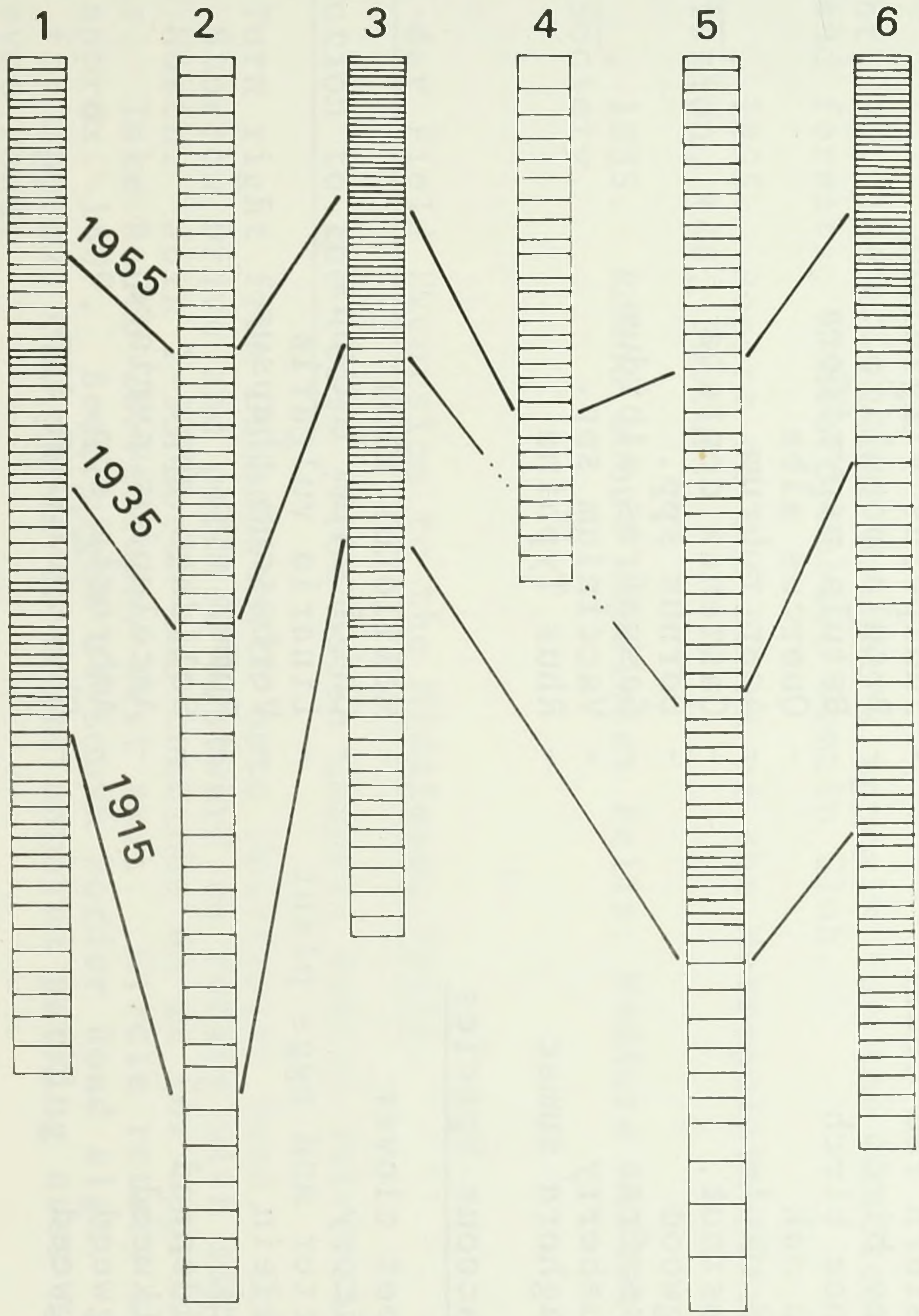
Tree Rings

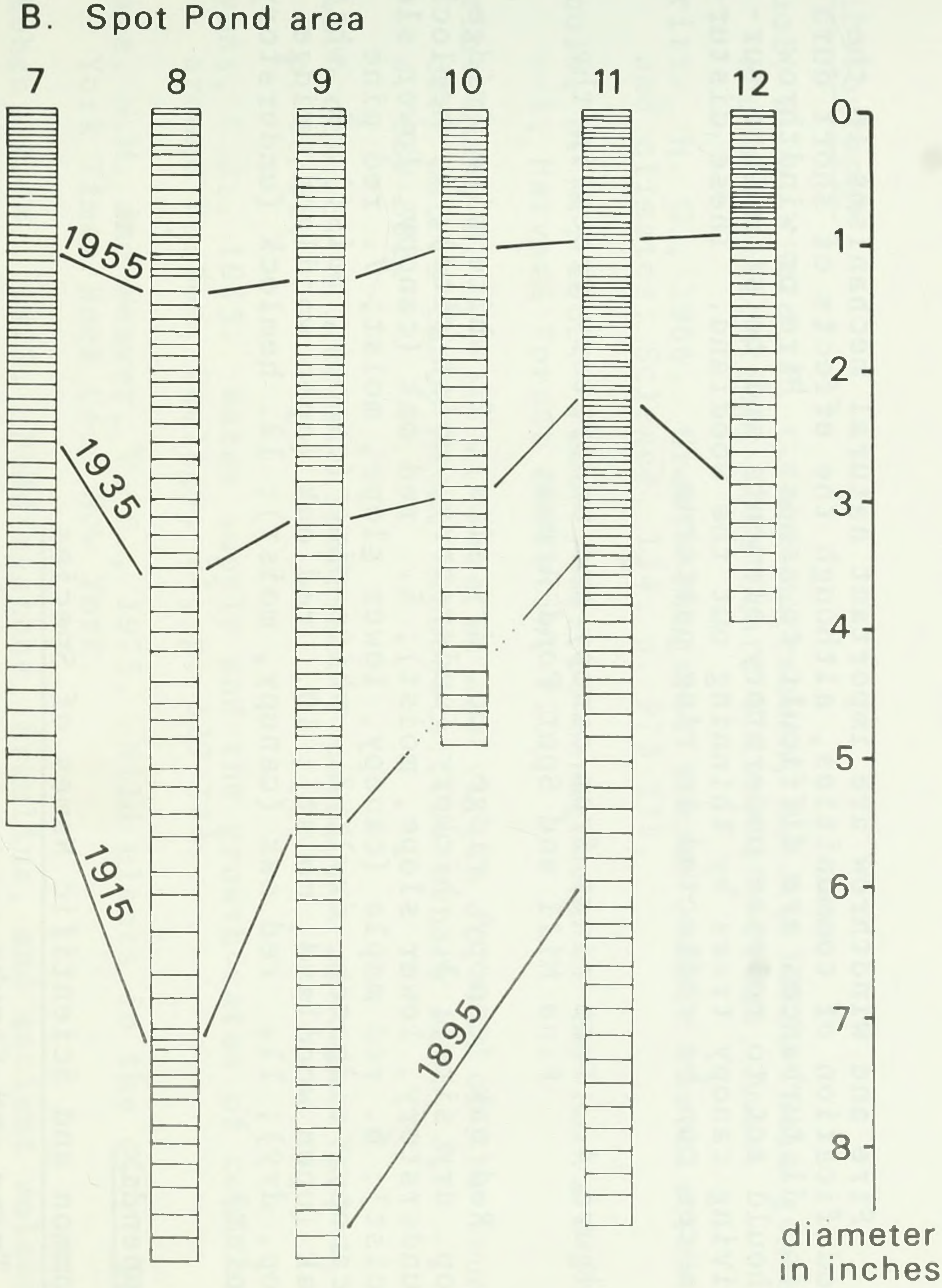
Tree ring data are useful in establishing age-size, and community structure-age relationships. Where trees are responsive to climatic variations, tree rings may be used in the reconstruction of past climates. An annual ring comprises a sequence from large diameter, thin-walled xylem cells produced in early spring and summer, to progressively smaller diameter cells with thicker walls produced in autumn. The abrupt change to the next year's early wood marks the ring boundary. Cell formation is dependent on the supply of photosynthate which is influenced by environmental conditions (Fritts, 1967). Sensitivity to climate is greatest where trees are in the open, and where stressful environmental conditions occur.

Tree rings from the Middlesex Fells area appear to be 'complacent' i.e., variation in ring width is conditioned by community structure rather than climate. A few examples are presented in Figure 4. No general trends are evident in the sample, except for the general outward narrowing of the rings, a function of age. Even trees of the same species share few similarities.

The patterns here probably represent variations in the supply of photosynthate that have been controlled by changes in community structure and composition. The tightly-packed rings of the hemlock (Fig. 4, #12) are probably due to intraspecific competition and to suppression as an understory component. However, the hemlock in the Pine Hill area are also understory, but show rapid growth in recent years (#4). Tree rings of hemlocks in New England purportedly show some coordination with summer rainfall (Lyons, 1943). Those in the study area show no common response.

A. Pine Hill area




B. Spot Pond area
7
8
9
10
11
12
1955
1935
1915
1895
0
1
2
3
4
5
6
7
8
diameter in inches

Fire and windthrow are important natural mechanisms in the modification of communities, although the effects of short duration disturbances are difficult to assess. Fire or windthrow should act to release understory elements and to stimulate surviving canopy trees by thinning out the woodland. These disturbances can be reflected in ring patterns.

Figure 4. Tree rings from canopy and understory trees in the Pine Hill and Spot Pond Areas.

1. Red oak (canopy, ridge top, dry site); 2. white pine (ridge top, dry site); 3. hickory (understory, moist site); 4. hemlock (understory, lower slope, moist); 5. red oak (canopy, lower slope moist); 6. red maple (canopy, lower slope, moist; 7. red pine (canopy, ridgetop, dry); 8. white pine (canopy, moist); 9. white oak (open woodland, moist); 10. red oak (open woodland, ridge top, dry); 11. red oak (canopy, moist); 12. hemlock (understory, moist).

Appendix

Common and Scientific Names of Species

Trees and Shrubs

white pine	- Pinus strobus
red pine	- Pinus resinosa
hemlock	- Tsuga canadensis
southern white cedar	- Chamaecyparis thyoides
eastern red cedar	- Juniperus virginiana
grey birch	- Betula populifolia
canoe birch	- Betula papyrifera
red oak	- Quercus alba
red maple	- Acer rubrum
chestnut	- Castenea dentata
dogwood	- Cornus spp.
sassafras	- Sassafras albidum
blueberry	- Vaccinium spp.
staghorn sumac	- Rhus Typhina

Herbaceous Species

sweet clover	- Melilotus alba
chicory	- Chichorium intybus
butter and eggs plant	- Linaria vulgaris
mullein	- Verbascum thapsus
dock	- Rumex spp.
goldenrod	- Solidago spp.
milkweed	- Ascelepius syriaca
ragweed	- Ambrosia spp.
pigweed	- Chenopoldium spp.

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Half-day Field Excursion to the Middlesex Fells.

Direction to the Fells (From Marsh Chapel, Boston University)

Turn right from Commonwealth onto University Road. Continue onto Storrow Drive and proceed eastward to rotary with signs for I-93 North. Join I-93 North and continue on it for approx. 5 miles. Take Route 28-Fellsway West exit. Circle rotary at exit for approx. 180°. Bear right at South Border Road sign. Follow road for approx. 350 yards to small unpaved parking area at Bellevue Pond.

Pine Hill Area:

Walk along path on east side of Bellevue Pond.

Mileage
0.15 mile. Stop 1. Northeast side of Bellevue Pond.

The woodlands here contain the largest number of tree and shrub species in the Fells. Red oak and red maple dominate the canopy trees. Hickory, cherry, basswood and hemlock are important understory elements. The diversity is partly a function of soil moisture and aspect. The moist lower and middle slopes have the greatest diversity. The upper slopes and ridge tops have fewer species. Red oak and white pine dominate. Red maple increases in importance in the wetter sites. The development of ground plants and shrubs is largely dependent on the character of the canopy layer. Where the canopy is closed, light intensities at ground level may be small, sometimes less than 1% of above the canopy. Closed canopy woodlands tend to have few ground plants or contain species that bloom and set seed prior to the leafing of the canopy trees.

Continue along path to:

0.20 mile. Stop 2. Soil Profiles.

Soil exposures on both sides of the path. On the east side, a thin soil appears to have developed from the underlying granodiorite boulders. Note the granular disintegration. The soil exposed on the west side is typical of much of the Fells. The thin stony soil is developed in glacial till. Stones occur throughout the profile which shows little variation in texture and no distinctive horizonation. The Gloucester Series are acid soils, partly because of the lack of bases in the parent material and partly due to the removal of soluble minerals by percolating water. Most of the nutrients in a forest ecosystem are being constantly recycled within the biomass. Trees such as red oak and red maple produce a litter layer that is quite acid and generally low in potential nutrients.

Contrast and surface humus mat developed under deciduous hardwoods at this site with that developed under conifers at Stops 1 and 5 in the Spot Pond area. Part of the difference can be attributed to the character of the litter, but the greater accumulation of litter under conifers results largely from the deficiency of decomposer organisms and mixers.

Continue northward along path until its intersection with path to Pine Hill (entering from right). Take Pine Hill path to summit.

0.45 miles. Stop 3. Pine Hill.

The limited vegetation cover over the upper parts of Pine Hill is related to the thin, dry soil, and extensive bedrock exposures, to disturbance caused by visitors to the site, and to occasional lightning strikes that cause localized burning.

Pine Hill Ridge is composed of light-colored Lynn Volcanics (Paleozoic) intruded by dark Triassic dikes. Note the effects of glacial scouring on the exposed bedrock at the summit. Some aligned grooves and striations indicate the direction of ice movement. Look around for erratics.

From the tower one can see the whole Boston Basin. The faultline scarp of the Northern Boundary Fault is still obvious to the east and west of the tower. Drumlins are prominent landforms throughout the city and as islands in the bay.

For further details of the geology of this area see Skehan, (1975)

Return down path to junction with main path continue north to clearing with rock piles to left of path.

0.80 miles. <u>Stop 4</u>. <u>Disturbed Area</u>.

The rock piles were dumped here during the widening of the off ramp from I-93 to Medford Square in 1971. The site has many weedy, 'disturbance' species that are well-adapted to the colonization of open spaces with little or no soil cover. They are typical of the early stages of plant succession, but are seldom found in the later stages because of their intolerance of shade and their inability to compete with perennial, woody plants.

The pioneer plants are mostly annuals and biennials. They grow rapidly and produce very large numbers of easily dispersed seeds. A large proportion of them have been naturalized from Europe. These exotics thrive in disturbed environments but seldom become community components in later stages of the succession. Herbaceous species at this site include sweet clover, chicory, butter and eggs plant, mullein and dock -- all exotics. Native species include goldenrods, and milkweed. Two of the most common disturbance plants ragweed and pigweed are not well-represented here.

Invasion by pioneer shrubs and trees are started. Staghorn sumac is prominent around the margins of the disturbed site. A few yound birch and poplar trees are noticeable.

Page and Weaver's "Wild Plants in the City" (see bibliography for full citation) is a well-illustrated guide to the vegetation of disturbed areas in Boston.

Walk west through the disturbed area. Turn south on path that climbs onto a ridge to Lynn Volcanics.

0.90 miles. Stop 5. Thin Soil and Open Woodland.

Ridgetops tend to have thin soil cover and many bedrock exposures. The thin, dry soils generally do not support the same variety and biomass as the wetter, deeper soils on middle and lower slopes. Red oak and white pine dominate. In such locations, closed canopy woodland seldom develops. The open character of the ridge top woodlands is conducive to the development of an often varied and continuous ground cover. Here that cover includes blueberry.

A similar situation is evident at Stops 3 and 6 in the Spot Pond area.

Return to the car park at Bellevue Pond. Approx. 1.25 miles.

Return to rotary. Follow signs for Route 28 North (Fellsway West). Note dikes in I-93 roadcut in side of Pine Hill. Turn right at intersection with Elm Street. Continue along Elm Street to rotary. Circle rotary (approx. 270°) to Woodland Road. Follow Woodland Road for approx. 1/2 mile. Make turn at third left cutoff. Park in small parking area on west side of Woodland Road. (Figure 2).

Spot Pond Area

0.05 miles. Stop 1. Hemlock stand on south side of path.

This evenaged stand of hemlock shows considerable variation in size, possibly related to soil moisture variations, but probably a function of community structure. The small hemlocks have an oak overstory. These trees date from the 1920's, when many hemlock seedlings were planted in the Fells. Note the thick, raw humus mat, and the charcoal fragments just below the surface. Note the lack of seedlings from either the hemlock or the red oak.

Continue along the main path to intersection with short path to edge of Spot Pond.

0.4 miles. Stop 2. Spot Pond.

Spot Pond is one of several lakes in the area that originate in hollows produced from ice scouring. It was enlarged last century to accomodate ice houses, and later to increase its capacity as a reservoir.

Contrast the development of shrubs and ground plants in the open woodland west of the path with the closed canopy pine stands to the east. Sassafras and dogwood become important understory shrubs in moist areas with an open canopy.

Return to the main path follow it for approx. 100 yards. Branch left from path towards the low ridge to the south of the park.

o.5 miles. Stop 3. Burned area.

This area was burned over in the summer of 1974. The ground cover was burned back, but mature trees were unaffected. Root sprouts on red oak and red maple trees were burned, but sprouting resumed the following year (1975). The importance of fire in natural ecosystems is now being generally appreciated. Fire is part of a natural recycling process that maintains maximum vigor and diversity in most communities.

Continue south along the ridge to large, perched boulder.

0.55 miles. Stop 4. Glacial erratic (?).

This large boulder has obviously been moved from its original position. It may be considered as a large erratic. It is of the same rock type as the underlying bedrock, and is unlikely to have been transported very far.

Descend to valley on the south side of the boulder. Walk northeast (left) along gully. Climb up right side to a white pine stand.

0.60 miles. Stop 5. White pine stand.

White pine, like most pine species, appears to be fire-dependent. Fire is necessary to remove excess surface litter and to prepare the seedbed. Even pine seeds will not germinate in thick acidic litter. Note the lack of seedlings in the stand. White pine and hemlock were important elements in the regional woodland at the time of settlement. Their demise can be partly attributed to their removal for lumber, and is partly the result of their inability to regenerate by root sprouting as do the oaks and maples that largely replaced them.

Note the thick, fire-resistant bark on the pines and the lack of undergrowth. The soil is thin and acidic.

Continue through stand to open woodland on ridge above the stand (south-east).

0.62 miles. Stop 6. Open, ridge-top woodland.

This area is similar to that at Stops 3 and 4, and that of Stop 5 (Pine Hill area). The open woodland is dominated by red oak. Red oak and red maple sprouts are common. White pine seedlings, probably from the nearby stand. The litter here is thinner and less acid than under the pines. Moss can provide a good seedbed for pine.

Drop eastwards from the ridge to Quarter Mile Pond. Follow shoreline northward.

0.75 miles. <u>Stop 7</u>. Contact between Precambrian granodiorite and Triassic dike rock.

Note the textural differences and the baked contact.

Continue north to main path. Turn right. Return to Woodland Road parking lot.