THE VEGETATION OF CONNECTICUT NATURAL AREAS

No. 3

The Natural Areas of the McLean Game Refuge

FRANK E. EGLER and WILLIAM A. NIERING

STATE GEOLOGICAL AND NATURAL HISTORY SURVEY
OF CONNECTICUT

A DIVISION OF THE DEPARTMENT OF AGRICULTURE
AND NATURAL RESOURCES

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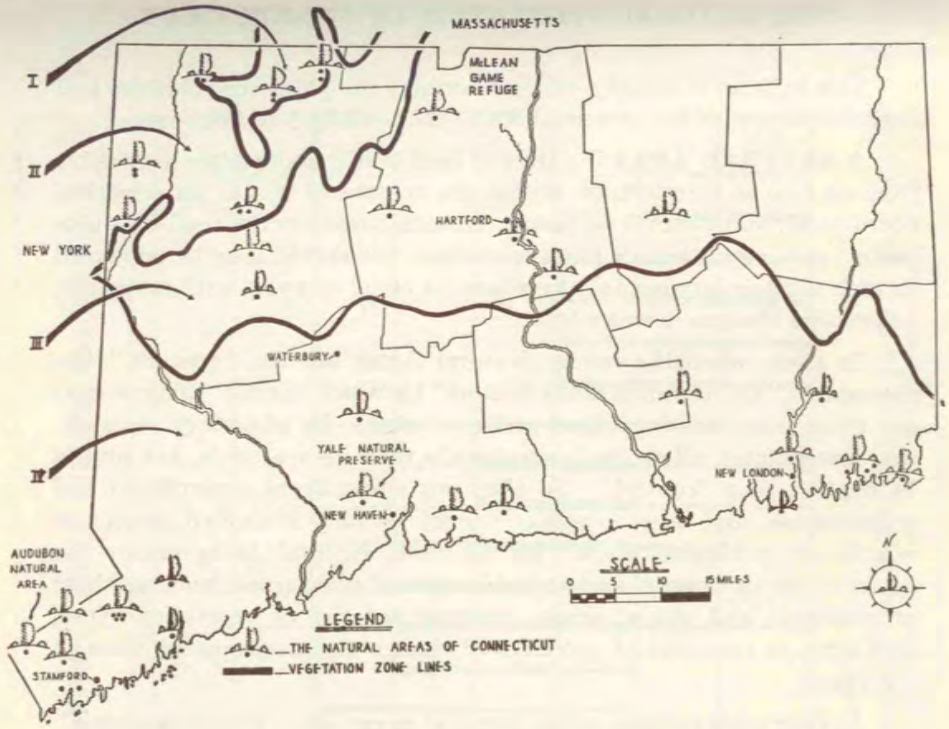


Map of Connecticut showing the Natural Areas and the Vegetation Zones. A Natural Area is a tract of land formally reserved—as free as possible from all human interference except pedestrian trails—for scientific, educational and cultural purposes. The Natural Areas are located but not named, except for the Yale Natural Preserve and the Natural Area of the Audubon Center of Greenwich, described Reports No. 1 and No. 2, respectively, and the Natural Areas of the McLean Game Refuge, presented in this third publication in the Series. There are four Vegetation Zones in Connecticut characterized by differences in the plant communities. They are correlated roughly with temperature factors in the environment, and even more roughly with altitude. For example, Zone I does not occur in the extreme northwest corner of the state, even though the elevations seem to be suitable. The lines separating the Vegetation Zones are at the approximate midpoints of transitional belts, with minor irregularities smoothed for purposes of mapping. The line separating Zones I and II has been mapped with considerable precision (Egler, 1940), for it marks the upper limits of oaks (except red oak), hickories, tulip tree, sassafras, pitch pine, black gum and others. The line separating Zones II and III approximates the 1,000-ft contour line. The line separating Zones III and IV is marked by the lower limit of old-field stands of white pine.

This bulletin is one of a series describing the plant communities and vegetation types of the preserved **NATURAL AREAS** of Connecticut.

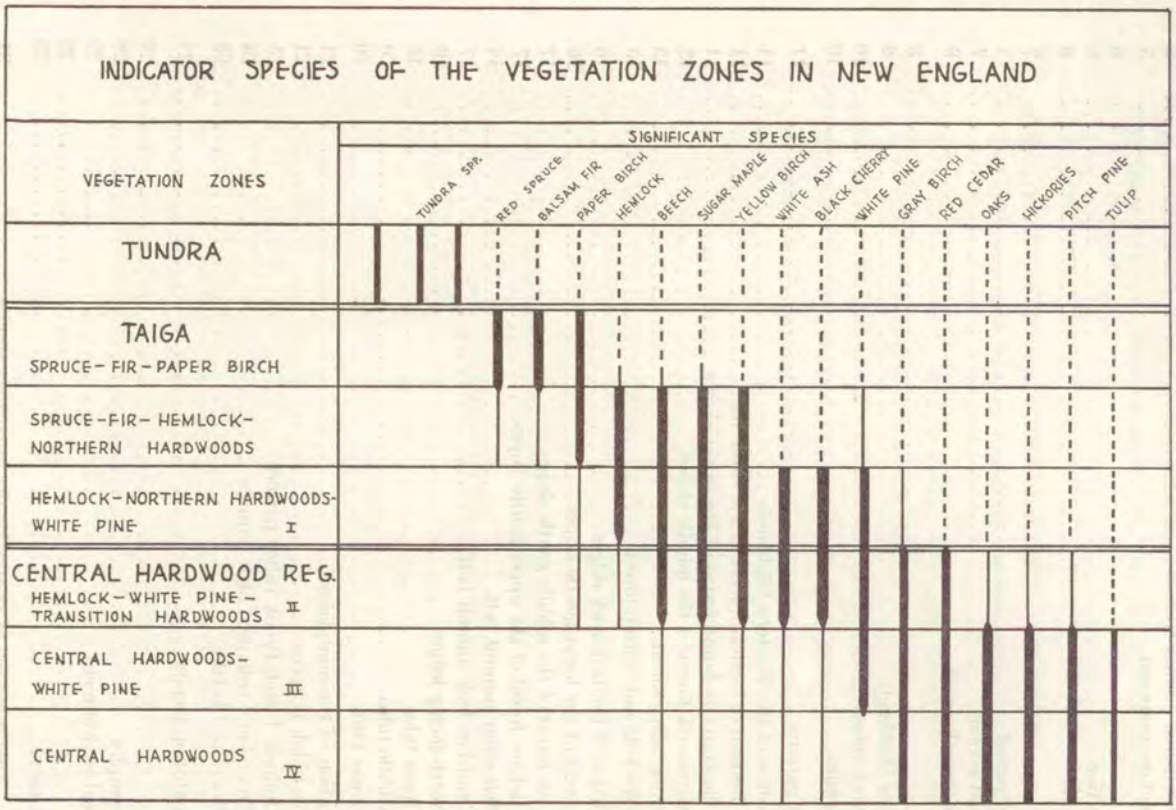
A **NATURAL AREA** is a tract of land that is kept as free as possible from all human interference, within the context of its use for scientific, educational, and cultural purposes. Natural areas are not used for lumbering, public hunting, or mass recreation, nor should they be subjected to such total environmental alterations as aerial spraying with pesticides, or artificial changes in water tables.

In their **scientific** values, Natural Areas are the "controls," the "standards," or "common denominators" by which various land-management programs can be judged and evaluated. In laboratory research, one manipulates, alters, and experiments with his materials, but always in relation to a "control." So also, our silvicultural, agricultural, soil conservation, and other practices cannot be fully evaluated, except in relation to a Natural Area. Furthermore, Natural Areas ensure the preservation of unusual and valuable natural phenomena, such as those of geological and glacial origin, preserve samples of vegetation types, and serve as examples of processes of change and development through the years.

In their **educational** values, Natural Areas are "outdoor museums," preeminent for the exhibition of the plant, animal, and mineral world about us. They should be treated with the same care and consideration as are historical monuments or exhibits in the halls of our museums, some of which are under the guidance and care of trained leaders. Explanatory literature—as exemplified by this bulletin—facilitates the communication of these educational values.

In their **cultural** values, Natural Areas are assuming more and more worth in a crowded world where space and privacy are becoming rare and cherished commodities, and where the contemplative in spirit can gain renewed strength in their intellectual awareness of the natural—so as to continue their lives in the artificial haunts of man. The study and enjoyment of Natural History is one of the humanities, one of the graces of our age, a tenth Muse of our civilization. Natural History is largely a product of Natural Areas.

This series of bulletins on the vegetation of Connecticut Natural Areas is designed as a contribution to the public, to improve their awareness and enjoyment of the scientific, educational and cultural values of Natural Areas, owned and preserved both by the State of Connecticut and by private non-profit organizations operating in the public interest.



Indicator Species of the Vegetation Zones in New Fngland

The signfficant species found within the three Vegetation Zones in New England—Tundra, Taiga, and Central Hardwood Region—are shown by the relative thickness of the vertical bars. The floristic relationships of the four major Vegetation Zones in Connecticut are also shown. Broken lines are irrelevant except as guide lines.

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ILLUSTRATIONS

The authors wish to acknowledge the helpful comments of Kathleen A. Dilzer Bernice Wheeler, Greely Sturdivant, Joe Webb Peoples, and James A. Slater in the preparation of this manuscript.

We are indebted to Harry E. Van Deusen for the illustrations.

The cover was especially designed for this series by Louis Darling to whom we express our sincere thanks.

The price of this Natural Area Report is 25 cents. Additional copies may be ordered from the State Librarian, Hartford, Connecticut 06115 (postpaid; Connecticut residents must add 3½ percent sales tax). Like all publications of the Connecticut Geological and Natural History Survey, one copy is available, free of charge, to public officials, exchange libraries, scientists, and teachers, who indicate to the State Librarian, under their official letterhead, that it is required for professional work. A List of Publications of the State Survey is also available from the State Librarian on request.

The Natural Areas of the McLean Game Refuge

by

Frank E. Egler and William A. Niering

ABSTRACT

The geologic and vegetational pattern of the McLean Game Refuge is unusually diverse. Maintained in its present natural condition, it offers unlimited opportunities for education and research. Within its two Natural Areas, comprising about half of the 3,400-acre Refuge, are three distinct geologic terrains, the Paleozoic metamorphic rocks of the Western Highlands, the Triassic diabase hills (trap-rock ridges), and the more recently deposited sandy terraces (sand plains) of glacial origin. A chestnut-oak forest covers the upper slopes and summits (in the Western Highlands). On the midslopes an oak forest prevails, replaced by an oak and northern-hardwood community on the lower slopes; red-maple swamp forests occupy the poorly drained sites. On the major trap-rock ridge in the Refuge (the eastern Barndoor Hill), a lower, gentle, southeastward-facing slope leads up to the crest and then to a steep, northwestward-sloping talus accumulation. On the lower southerly slope a red-oak and hickory forest is replaced upslope by a less diverse oak type. On the gentle upper slopes is a smaller, more open hickory forest, and along the summit red cedar and a belt of dead hemlock are found—a pattern favored by the openness of the site as well as by droughts. Scattered northern hardwoods dominate the northward-facing ledges. On the upper and lower edges of the extensive open talus slope is a limited forest development but there is no evidence of forest encroachment on the relatively stable lichen community which covers the talus. On the sand plains, flat and eroded terraces, undrained kettles, and the drained valley of Bissell Brook comprise the major site types. On the flat, sandy terrace, formerly cropped and pastured, is a mixed oak forest with scattered pines and hemlock, correlated with recent fire protection. A similar forest pattern occurs on the dissected terraces, although the increase in shrub cover there suggests that pasturing rather than crop growing took place. Along Bissell Brook the trees are larger; they are oak and scattered northern hardwoods, joined by red maple on the lowest sites.

Changes are taking place within this complex mosaic of vegetation types. However, no overall change toward a single vegetation type—a "climax" type which would eventually cover the entire area—is discernible. In contrast, there are many relatively stable types fluctuating in a dynamic equilibrium, a pattern typical of such a Natural Area.

Ownership and administration

The McLean Game Refuge, a tract of land located within the towns of Granby, Simsbury, and Canton, was established in 1933 under the terms of the will of George P. McLean for the maintenance of its wild conditions and for use as a source of wilderness recreation (fig. 1). Totaling approximately 3,400 acres, the Refuge is maintained by an endowment from the McLean Estate and owned and administered by a self-perpetuating Board of Trustees, as called for in the will. The Hartford National Bank and Trust Company acts as agent for the Trustees, and further information concerning the Refuge is available from its Trust Department.

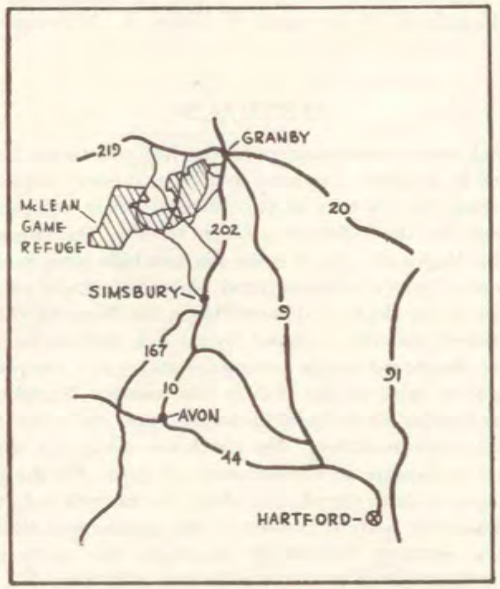

Fig. 1. Routes to the McLean Game Refuge, located approximately 12 mi. northwest of Hartford.

George P. McLean, former Governor of Connecticut and United States Senator, set forth in his will the purpose and function of the Refuge. The land and its appurtenances and the funds attached, he said, are to "be permanently devoted to" and "for the protection, preservation and propagation of wild birds, game and fish and for the protection and preservation of the forest and other natural vegetation and the springs and water courses thereon...and I direct said Trustees to permit the public to use and enjoy said property as a natural park for recreation, subject to such restrictions and provisions as said Trustees may in their discretion make for the preservation and protection of said property and the wild life thereon." Mr. McLean further stipulated:

> I want the Game Refuge to be a place where trees can grow unmolested by choppers and trout and birds and other animal life can exist unmolested by hunters and fishermen, a place where some of the things God made may be seen by those who love them and who may find in them the peace of mind and body that I have found. I want it to be a forest park with the exception of such land as it may be necessary or desirable to retain as open land. The cleared land and buildings thereon...may be leased for farming...If the dams give way or need rebuilding, the Trustees may expend such sums as may be necessary for such purpose. I authorize and empower said Trustees...to purchase other lands...But it is my hope that no land shall be sold unless it will be detrimental to the interests of the Game Refuge to keep it.

In practice, the McLean Game Refuge essentially fulfills the wishes of its founder in regard to the patrolling and preserving of its wild conditions and the recreational use of the wild land by the public within the context of wilderness recreation. The enormous potential of the tract for its scientific, educational, and cultural values is, however, only beginning to be realized.

In 1949 the Trustees, faced with a threat of increased taxation, sought the advice of various experts for possible solutions. On the basis of their recommendations, foresters cruised the area and marked the mature timber for cutting according to standard forestry practice. Before cutting was started, however, an ecologist visited the Refuge and brought to the attention of the Trustees the incompatibility of timber cutting with the terms and intent of the will of Senator McLean. Plans for lumbering were cancelled, and this threat has not recurred.

At the end of 1955 the McLean Subcommittee of the Natural Areas Committee of the Connecticut Forest and Park Association (which is now the Connecticut Chapter of The Nature Conservancy) became concerned about the potential irreconcilability of certain phases of Senator McLean's will. With increased experience in wildland management, it has become apparent to ecologists that total protection of the land, with the least possible interference by man, as instructed by the will, is not always compatible with the protection and management of wildlife—game, birds, and fish. Conditions for animals, for instance, are often improved by alterations in the vegetation. Furthermore, agricultural lands, picnic areas, and organized recreation are distinctly incompatible with the preservation of natural and semi-natural areas. The Natural Areas Subcommittee presented to the McLean Trustees a plan whereby these different interests would be reconciled specifically in different parts of the Refuge. As a result, the Trustees have adopted a commendable plan, indicated in their current map of the Refuge, whereby the major part of the acreage is designated as Natural Areas and Wildlife Areas (fig. 2). Smaller tracts are utilized as agricultural land and picnic areas in order to concentrate the intensive public use.

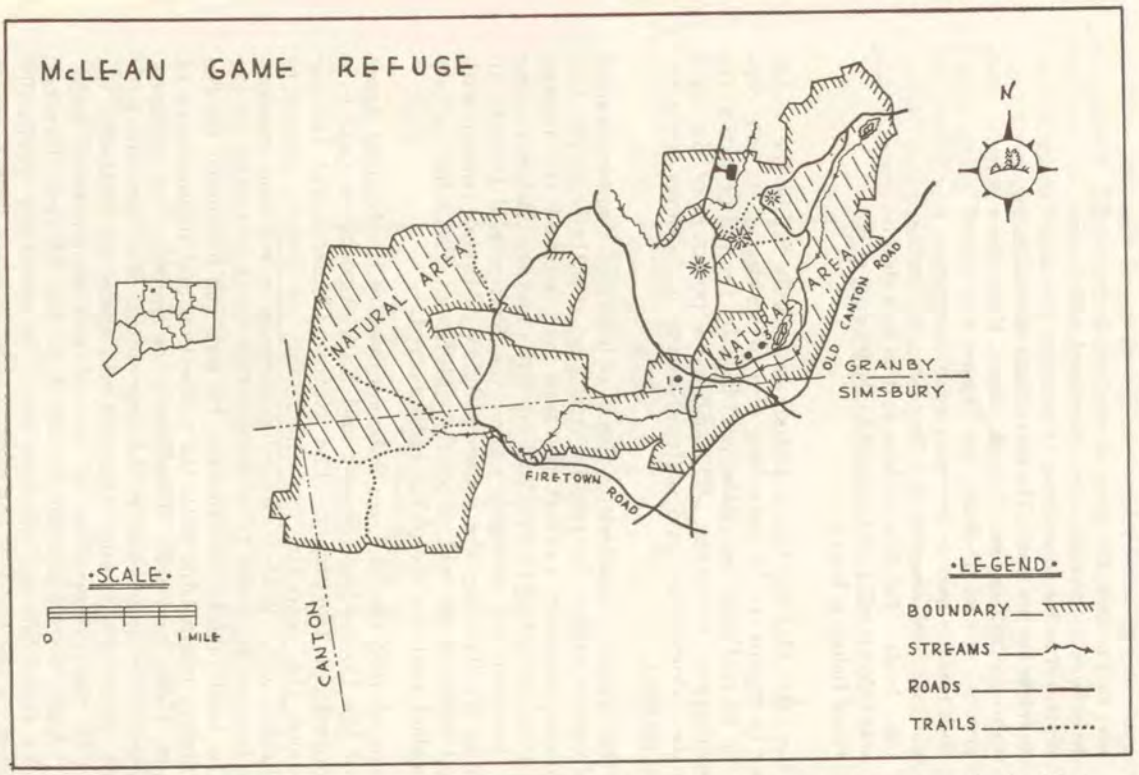

Fig. 2. Map of the McLean Game Refuge, showing locations of its two Natural Areas, one in the Western Highlands (left) and the other in the Connecticut River valley on the sand plains, with one of the diabase hills or trap-rock ridges (Barndoor Hills) shown in the northeastern part of the map by 3 star-like symbols. The remainder of the Refuge is designated as Wildlife Areas, where management of the vegetation is permitted in order to increase wildlife values. A limited area has been set aside for picnicing in the northern part of the Refuge. Three kettles are shown by 1, 2, and 3.

In 1962 aerial spraying for gypsy-moth control became an issue between entomologists and ecologists and conservationists of the state. Entomologists of the Connecticut Agricultural Experiment Station reported the presence of gypsy-moth infestations in the Refuge. Although numerous conservationists and conservation organizations in Connecticut made every attempt to inform the McLean Trustees of the greater dangers of such spraying to the total ecosystem, the Refuge was sprayed.

Physical environment

The topographic setting of the McLean Game Refuge is shown on the New Hartford and Tariffville quadrangle maps of the U. S. Geological Survey (see fig. 3). Although the greater part of the Refuge is in the western part of the Central Lowlands of Connecticut, a sizable part extends into the Western Highlands. As shown on the bedrock map of the Tariffville quadrangle (Schnabel and Eric, 1965), the Western Highlands here consist primarily of Paleozoic metamorphic rocks of the Hartland Formation (Rodgers and others, 1956, 1959), resistant schists with pegmatite intrusions. The bedrock east of the Highlands, tilted beds of the Triassic New Haven Arkose, is less resistant than these schists. It is cut by a sill-like intrusion of diabase, which dips eastward like the sandstones which enclose it. Along the relatively narrow, northeast-southwest-trending area underlain by diabase rise several conspicuous "trap-rock ridges," among them the Barndoor Hills. Around these hills and along Bissell Brook, sandy terraces—the sand plains—laid down by melting Pleistocene glacial waters overlie the eroded Triassic sandstones. Part of the terraces are relatively level, while other sections are highly dissected into irregular terrain; within them are several steep-sided kettles, probably formed where buried ice blocks melted.

Elevations in the valley range from about 200 ft along the streams which dissect the sandy terraces to 700 ft on one of the highest ridges, the Barndoor Hills. The highest elevations in the Refuge reach over 1,100 ft, in the Western Highlands.

The shallow soils of the Western Highlands, interrupted by many rock outcrops, are classed in the Gloucester series, which includes fine sandy loam and loam types with stony phases (Morgan, 1939). The diabase hills, such as the Barndoor Hills, are rocky with soil depth increasing downslope. The sandy valley-terrace soils are classified in the Manchester and Merrimac series (Morgan, 1939); both of these series exhibit a variety of textural types, ranging from loams to loamy sand and including gravelly phases.

There is considerable variation in climate within the Refuge from the lower valley elevations to the higher summits in the Western Highlands. The average annual precipitation recorded in a rural area near Canton, near the Refuge on the west, is 46.94 in.; the average annual temperature is 47° to 48°; mean annual snowfall ranges from 50 to 60 in., compared with 30 to 40 in. along the coast (Brumbach, 1965).

Flora

In general floristic relationships, the McLean Game Refuge is typical of much of Connecticut. It has none of the "southern" elements, such as red gum (*Liquidambar styraciflua*), American holly (*Ilex opaca*), or coast white cedar (*Chamaecyparis thyoides*). Neither does it contain any of the "northern" elements, such as upland red spruce (*Picea rubens*). The local topography is sufficiently variable, however, so that "northern" bog species are present, as well as "southern" summit species.

An annotated list of the vegetationally important species of the Refuge is included in the Appendix, where the nomenclature follows that of H. A. Gleason (1952). No complete list of the plants has yet been made. An authoritative collection of the flora, with authenticating herbarium specimens, would be a highly desirable project for a school or society of the region.

Vegetation

There are four vegetation zones recognized in Connecticut (see map, p. iii). The McLean Game Refuge lies in Zone III, the central hardwoods-white pine zone. This belt, commonly termed "Sprout Hardwoods with Pine," occupies much of the northern half of Connecticut except for higher portions to the northwest. The sprout hardwoods are mainly species of oak. To a lesser extent, hickories are common locally. The name "sprout hardwood" is derived from the fact that the present trees arose as stump sprouts from old root systems, following destruction of the original trees by fire or lumbering and of the younger sprouts by grazing. Native white pine (*Pinus strobus*) is found sporadically through the upland forests. Along with it, pitch pine (*Pinus rigida*) is common locally on the sand plains. The typical species of the northernmost zone (beech, yellow birch, sugar maple, and hemlock) are present especially in swamps, on swamp margins, in coves, and on lower slopes but they do not dominate the general uplands. The typical old-field type of the zone, which occurs on abandoned pastures, is dominated by white pine, although gray birch (*Betula populifolia*) and red cedar (*Juniperus virginiana*), the major old-field dominants of the southern part of the state, are common in places.

Studies concerned with the vegetation pattern in New England include those of Lutz (1928), Bromley (1935), and Westveld and his co-workers (1956); those of Nichols (1913a, 1913b, 1914, 1915, 1916, 1920a, 1920b) deal especially with Connecticut. Natural Area vegetation studies include those of the Yale Natural Preserve (Egler and Niering, 1965) and of the Natural Area of the Audubon Center of Greenwich (Niering and Egler, 1966).

Methods

Both authors have long been familiar with the McLean Game Refuge—the senior author since 1949, the junior author since 1953. Both have visited it and studied it on several occasions. Field notes made by the senior author during July, September, and October 1949 have been incorporated into the present investigation.

Following the policy adopted for this series of vegetation studies of Connecticut Natural Areas, both authors spent one 12-hour day in the field (on June 16, 1961), chiefly studying the eastern sand plains. Another 12-hour day was spent on September 22, 1961, covering the portion of the area within the trap-rock ridges and the Western Highlands. On these two days the area was criss-crossed, field notes were taken either continuously or at short intervals, and summary notes were made at longer intervals. Although data were collected primarily within those tracts designated as Natural Areas, the site and vegetation types presented in this report are typical of the major portions of the Refuge. The present study is intended only as a preliminary survey, to provide the framework upon which future, more detailed studies may be developed.

HISTORY OF VEGETATION

Indian period

The last glacial episode is believed to have ended about ten to twelve thousand years ago, with stagnation of the ice sheet. Although northern types of vegetation undoubtedly were present immediately preceding and following this glaciation, leaving records in the peat deposits of bogs, there is no obvious evidence of them in the present upland plant communities.

Indian populations probably moved into the area of the McLean Game Refuge as the ice disappeared. Fires, both intentional and accidental, undoubtedly swept repeatedly over the land, possibly as often as the vegetation would burn. Clearings for villages and for agriculture were perhaps a dominant factor on the flat sand-plains landscape, while trees may have been removed for timber from the slopes of the Western Highlands area. Under the repeated impact of fires, a type of equilibrium may have developed, perhaps involving open, grassy areas on the sand plains, interspersed with brush and patches of forest, especially where lakes and streams offered some protection from frequent fires. These fires would have swept up the rocky slopes of the Western Highlands and the Triassic hills, tending to limit the abundance of fire-sensitive species like beech and young hemlock. The higher rocky summits of the Western Highlands frequently became very dry, and fires would have been destructive there.

Colonial period

Settlement by European colonial peoples began in the early 1600s and Indians disappeared from the area in the late 1600s. Concomitant with this change, there was extensive clearing of the land for cropland agriculture on the sand plains, combined with pasturing on the rocky slopes. Upland farm sites were also developed on the Western Highlands; some of these continued to be farmed until early in the twentieth century. Rocky lands which were not farmed were probably lumbered.

Although the history of the tract has not been investigated in detail, it seems probable that the predominant species of the original vegatation of Indian times—itself certainly not "virgin" or "climax"—has been strikingly altered, perhaps several times.

Post-Colonial period

Lumbering, fire, pasturing, and cropping probably took place continuously, or at least repeatedly, throughout the nineteenth century. Agriculture was predominant on the sand plains, lumbering and pasturing dominated on the upland slopes. Abandonment of the farms on the rocky upland probably occurred during the closing decades of the nineteenth century.

During the twentieth century several episodes have markedly affected the vegetation. The chestnut blight, which entered the area in the 1920s radically altered many upland forests of central Connecticut but had little effect on the area of the McLean Refuge, where chestnut comprised less than 10 percent of the forests. The elimination of a limited number of chestnuts allowed the remaining tree species to fill the gaps in the forest with the same relative abundances. The almost complete disappearance of farming from this part of the Western Highlands has also affected the vegetation of the Refuge. On the sand plains of the Connecticut Valley farming is declining, although some areas still are actively cultivated, among them parts of the McLean Game Refuge. Other nearby lands owned by Senator McLean have been retired from farming and now bear post-agricultural vegetation types. Subdivision for home development is continuing to take over land in the vicinity and large acerages under single ownerships are being reduced.

SITE TYPES

The McLean Game Refuge is the only wildland tract in the three southern New England states that contains clear and typical exampies of three major types of geologic terraines: the Western Highlands of ancient crystalline rocks, the tilted Triassic intrusion now expressed as trap-rock ridges, and the terraced sand plains of the Central Lowlands, formed by the Pleistocene glaciation (fig. 4). The vegetation of each of these terraines will be considered separately. Each occupies a distinct geographic area and, although the elements of the flora are essentially the same throughout, with no striking differences in the dominant species of the plant communities (except for the restriction of pitch pine to the sand plains), there are some differences which are related to soil and rock outcrops.

Western Highlands

This area includes a variety of sites, expressed as a series of belts ranging from the dry, rocky summits to the moist and relatively deep-soiled lower slopes. The intermediate sites, the general upland type designated as midslopes, occupy the largest area. The deep-soiled, rela-

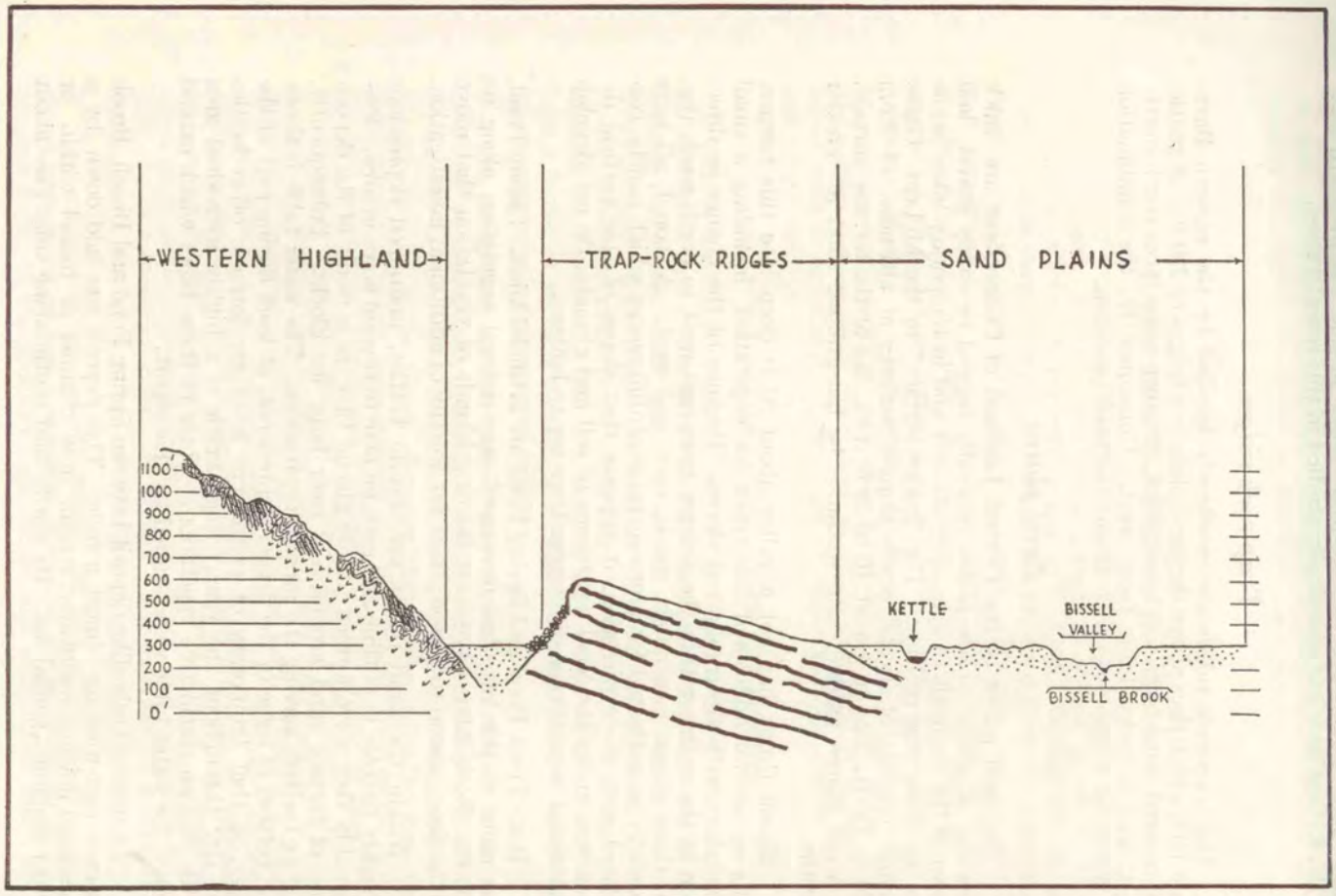

Fig. 4. Diagrammatic cross section of three major geologic features found within the Refuge from east to west (right to left). Trap-rock ridges are restricted to the north-central sector of the Refuge. Elevations are shown on the left in ft.

tively flat, abandoned agricultural lands in the southwestern part of the Refuge were not specifically studied in this investigation.

Trap-rock ridges

The trap-rock ridges are excellently typified by the eastern Barndoor Hill, which rises above the sand plain to a height of 250 ft. A gentle, soil-covered slope faces south-southeast, its steep slope faces north-northwest, and a rocky talus faces west. Consequently, the combination of site types is displayed with almost textbook precision.

Sand plains

The sand plains of the Central Lowland of Connecticut are thick deposits of coarse to fine sands, generally capped by sandy gravel, laid down in the channels of aggrading streams and in temporary lakes while the ice sheet was melting. The "major terrace" in the McLean Game Refuge consists of several gently sloping surfaces at altitudes of from 270 to 350 ft. Sandy gravel, 10 to 20 ft thick, lies at the terrace surface, in most places grading into medium- to fine-grained sand at greater depths.

Bissell Brook has cut a valley about 50 ft deep into this terrace, offering several additional site types for vegetation, including a small floodplain with steep adjacent slopes. Because of the change in direction of the valley within the Refuge from east-west to north-south (fig. 3), these slopes face north, south, east, and west. Although all were carefully investigated for any vegetational differences which can be correlated with slope direction, it appears that slopes of this vertical dimension, under the local conditions of soil and climate, do not develop significant vegetational differences from top to bottom.

Both Trout Pond and Spring Pond are artificial lakes. Spring Pond, the older of the two, has developed semi-natural vegetation along its shores. Both lakes have some floating islands of vegetation that move about from season to season; these are worthy of additional investigation.

Within the sand plains are several kettles, undrained depressions roughly circular in outline and each an acre to several acres in area. Presumably they were formed in late glacial time, as a result of the deposition of terrace sand around and over huge ice blocks. Subsequently, the ice melted, leaving the present depressions. The water table is above the bottom of some of the deeper depressions, at least during part of the year, so that temporary or permanent lakes are formed; other kettles are dry throughout the year. Each kettle is a highly individual area with its own distinctive vegetation. Three of these holes which extend below the water table were studied for this report.

An unusual eskerlike deposit between Spring Pond and Bissell Brook extends east-west for almost a mile. This deposit was laid down by a westward-flowing meltwater stream in a channel or tunnel within or under stagnant glacial ice. Its north- and south-facing sides rise about

50 ft above the base. Like the valley of Bissell Brook itself, these slopes are not sufficiently different environments to produce significant differences in the vegetation, nor are such differences present vertically.

VEGETATION PATTERN

Vegetation of the Western Highlands

This portion of the McLean Refuge is part of a highly irregular mountain mass. Rising from the Connecticut Valley at about 350-ft elevation, it reaches its highest summit at 1,122 ft. Within this terrain the surface is very irregular, with numerous brooks commonly entrenched in small, rocky ravines about 100 ft in depth. The resulting topography is a complex of minor crests, midslopes, and lower slopes, each bearing its own type of vegetation, regardless of the absolute altitude. The vegetation of this local topography is of four major types (fig. 5): 1) a summit type of chestnut oaks with an understory of low ericads, 2) an upper slope of chestnut oak with an understory of low, dense laurel, 3) an extensive midslope vegetation of mixed oaks, and 4) a lower slope forest with a considerable admixture of sugar maples, yellow birches, and tulip trees.

CHESTNUT OAK-ERICAD FOREST OF THE SUMMITS

This is the forest characteristic of the highest, driest summits. On no hilltops in this region were extensive exposed bedrock ledges or open shrubby or grassy communities observed. In places the land is relatively flat and soil covered. The forest is 99 percent chestnut oak (*Quercus prinus*); the trees are 6 to 10 in. in diameter and 30 to 40 ft high. Occasional dead pines and hemlock suggest that severe droughts may have been a factor in weeding out the trees which demand more moisture and which may invade during moist cycles.

The understory of this forest, very typically developed in an area of about ½ acre at the 1,122-ft summit, is a remarkably uniform and solid cover of three intermingled species of ericads. Huckleberry (*Gaylussacia baccata*) is the tallest, growing about knee high; the low sweet blueberry (*Vaccinium angustifolium*) is the lowest, over ankle height; the low blueberry (*Vaccinium vacillans*) is intermediate in height. In many places these species form a three-layered community. In a few spots, the dryland Pennsylvania sedge (*Carex pensylvanica*) is found, although it occupies less than 1 percent of the land. There is a remarkable absence of other shrubs, even those that are abundant elsewhere: mountain laurel (*Kalmia latifolia*), witch hazel (*Hamamelis virginiana*) and maple-leaved viburnum (*Viburnum acerifolium*). Transgressive trees, such as the overstory chestnut oak, which would indicate the nature of any succeeding forest, are absent. The community is essentially stable.

CHESTNUT OAK-LAUREL FOREST OF THE UPPER SLOPES

There is an abrupt transition from the ericad understory of the summit forest to the shoulder-high, dense, and continuous laurel under-

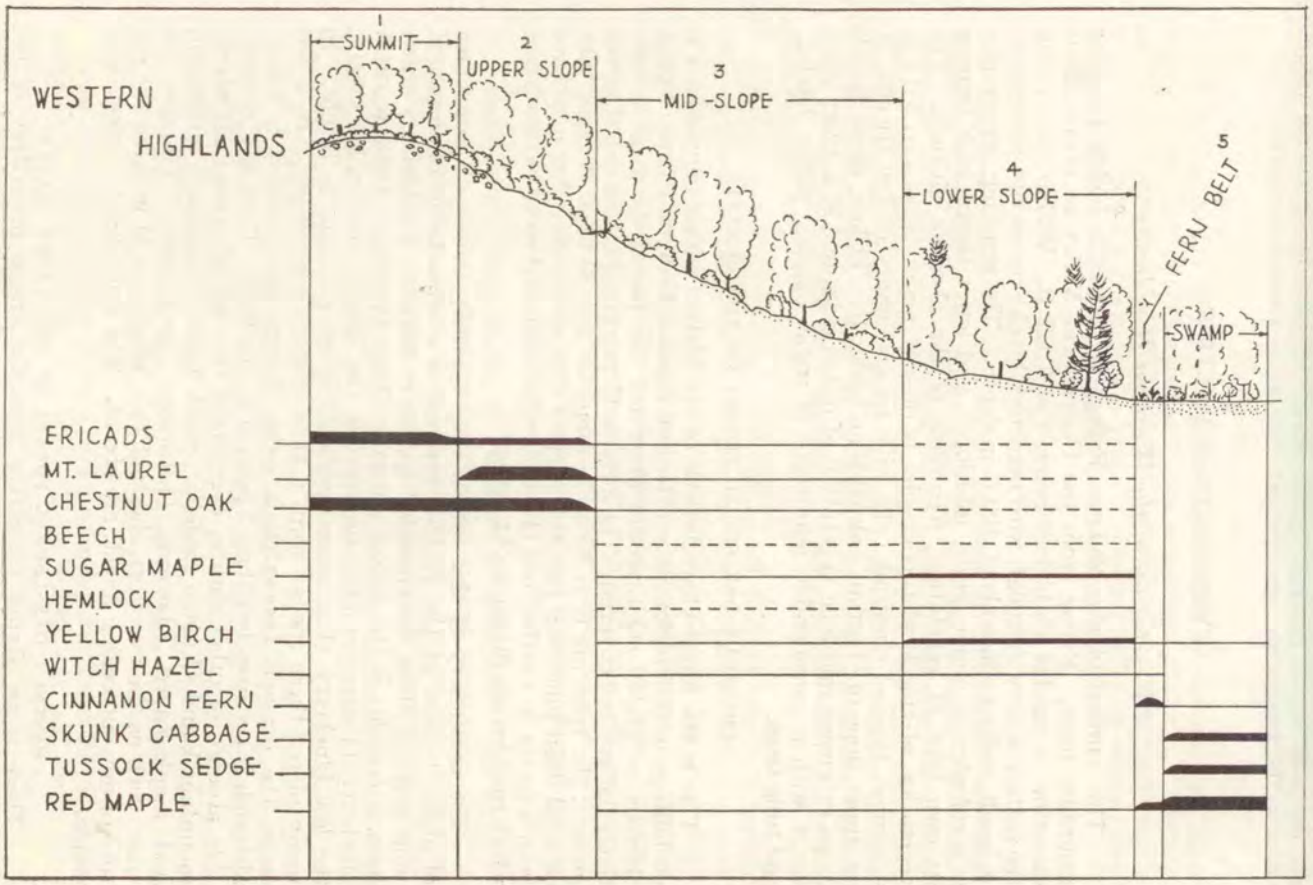

Fig. 5. Diagrammatic cross section of Western Highlands portion of the Refuge, illustrating major site types; relative abundances of the more important species in the various vegetation types are shown by the width of the solid lines.

story of the upper slope forest. In every direction the lower chestnut oak-laurel forest surrounds the hilltops in the chestnut oak-ericad forest. Although the three ericads are mingled with the laurel, it is clear that laurel dominates the understory, occupying 90 to 95 percent of the surface. Other plants, such as wintergreen (*Gaultheria procumbens*) and sheep laurel (*Kalmia angustifolia*), are also present.

The tree layer is chestnut oak, as on the summit, but the trees on the upper slopes are taller, although not all of them are larger in diameter. Farther from the summit other species of trees are found.

MIXED OAK FOREST OF THE MIDDLE SLOPES

This forest type, encountered below the upper slopes, covers the greatest area of the Western Highlands section. It is primarily a region of oaks—red oak (*Quercus borealis v. maxima*), white oak (*Quercus alba*), and chestnut oak—10 to 20 in. in diameter with heights of 50 ft or more. Trees other than oak are present in highly variable numbers, depending partly on the recency of lumbering and other disturbances—events evidenced particularly by the presence of black birch (*Betula lenta*), gray birch, and paper birch (*Betula papyrifera*). The understory is not predominantly laurel as it is on the summit. Shrubs, many of them maple-leaved viburnum and witch hazel, are present.

LOWER SLOPE FOREST

This forest is so variable and its tree species so different in quantity that it is impossible to characterize it in terms of species abundances. Almost nowhere does one species cover more than 25 percent.

In composition and structure the lower slope forest resembles the general upland beech-birch-maple-hemlock zone typical of the northwestern part of the state. There are, however, consistent and significant differences. Various oaks (other than red oak) and hickories are present everywhere on the lower slopes. The "southern" lower slope tulip tree (*Liriodendron tulipfera*) occurs, although never abundantly. There are also very many more "northern-hardwood" species such as sugar maple (*Acer saccharum*), yellow birch (*Betula lutea*), hemlock (*Tsuga canadensis*), beech (*Fagus grandifolia*), and even white ash (*Fraxinus americana*) and basswood (*Tilia americana*).

FERN BELT AND SWAMP FOREST

At the lowest part of the lower slope forest cinnamon and interrupted ferns (*Osmunda cinnamonea* and *Osmunda claytoniana*) are abundant, forming fern swales which extend up the larger tributary valleys in obvious correlation with soil moisture.

Locally, low areas adjacent to the eastern boundary of the Western Highlands bear a red-maple swamp forest with many typical swamp species, including skunk cabbage (*Symplocarpus foetidus*) and tussock sedge (*Carex stricta*). No such specific site was studied in the present survey.

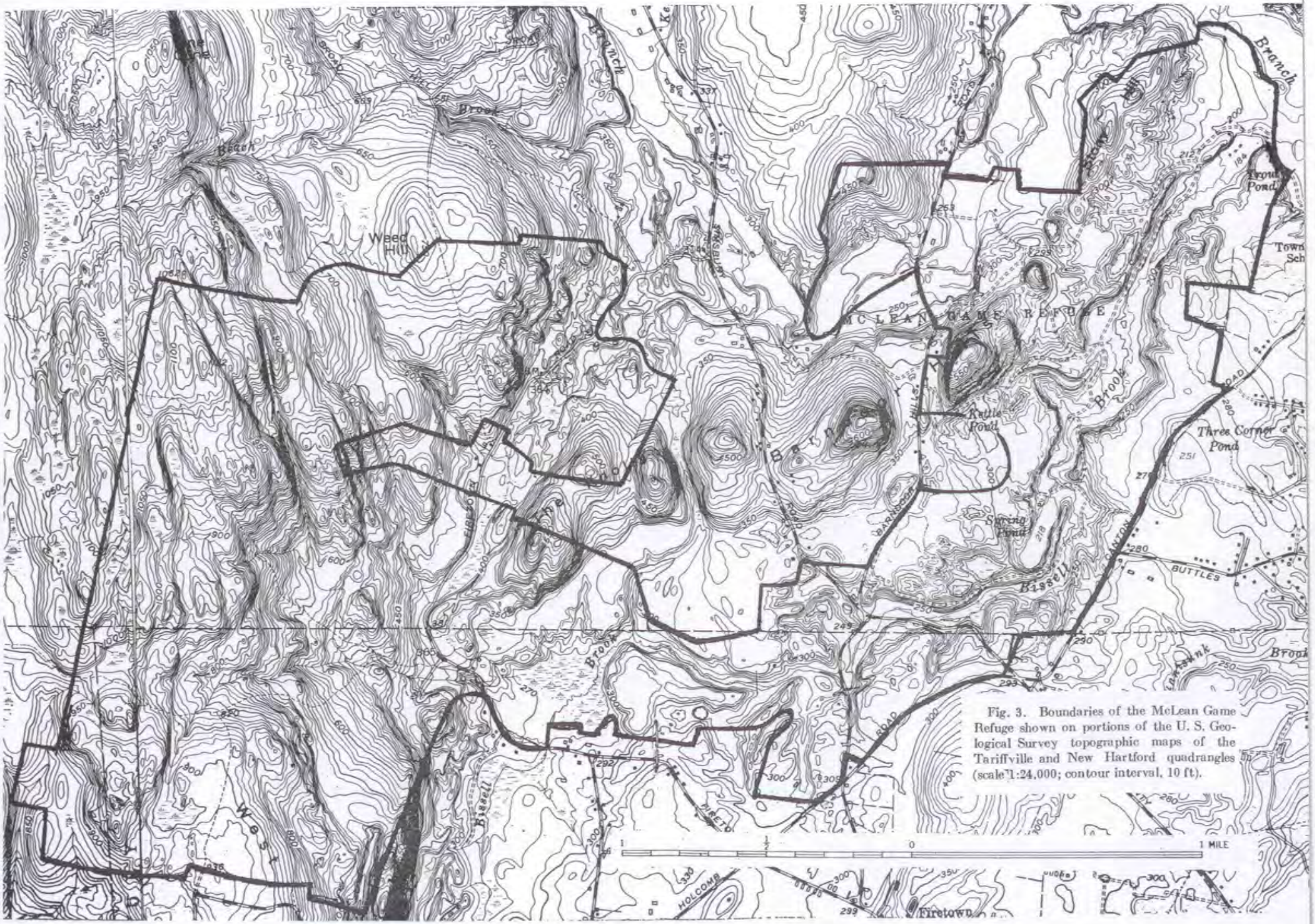

Fig. 3. Boundaries of the McLean Game Refuge shown on portions of the U. S. Geological Survey topographic maps of the Tariffville and New Hartford quadrangles (scale 1:24,000; contour interval, 10 ft).

Vegetation of the trap-rock ridges

Steam erosion of the sill-like diabase intrusion has produced several trap-rock ridges. The northwestern slope of each of these hills is steep; the southeastern slope gentler, reflecting the tilting of the enclosing Triassic beds (fig. 6). The vegetation forms a series of elongated belts, parallel to the strike of the ridges, rather than a series of concentric belts as is the case on round mountains. The vegetation belts on the steep slopes are quite different from those on the more gradual slopes. Barndoor Hills are two such ridges; the vegetation of the eastern one (fig. 3), just east of Barndoor Hills Road, is described in this report. Nine vegetation belts are recognized on it (fig. 6).

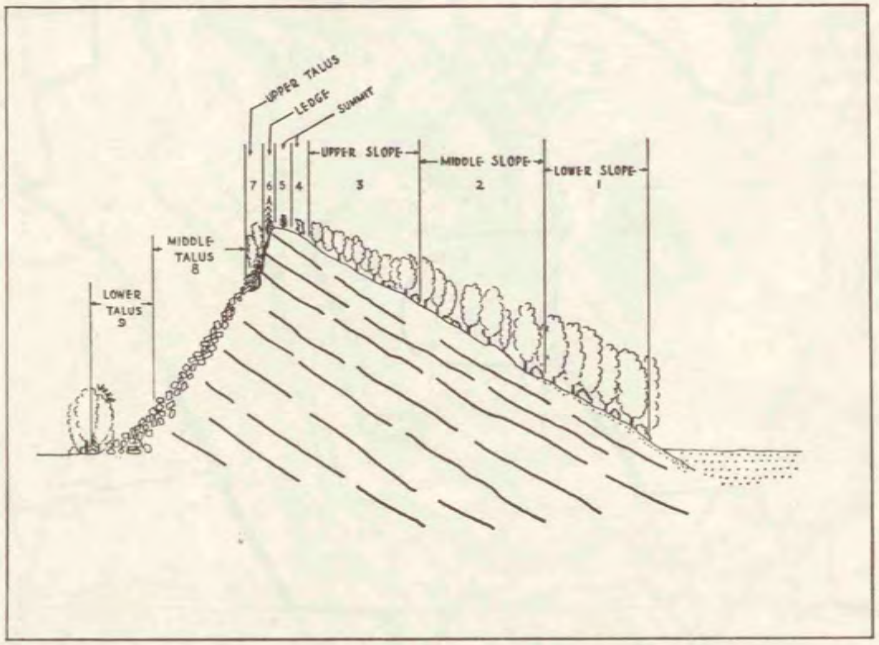

Fig. 6. Diagrammatic cross section of trap-rock ridges, illustrating major site types.

FOREST OF THE LOWER GENTLE SLOPES

This site, gentle in gradient and thinly soil covered, bears a relatively luxuriant forest of quite diverse floristic composition. In the area studied, the trees are less than 12 in. in diameter and up to 50 ft in height. Red oak and pignut hickory (*Carya glabra*) comprise up to 70 percent of the forest. Other species include sugar maple, hemlock, white ash, white pine, various oaks, hop hornbeam (*Ostrya virginiana*), flowering dogwood (*Cornus florida*), and red cedar.

Scattered shrubs occupy less than 20 percent of the surface. The herbaceous stratum includes a variety of open-woodland plants, including asters and goldenrods.

OAK FOREST OF THE MIDDLE GENTLE SLOPE

Upslope there is a noticeable diminution in heights and diameters of the trees and the floristic composition becomes simpler, with oaks dominating. The shrubs are more sparsely distributed, and the sun-favoring herbs more prominent. It thus seems reasonable to separate this belt from the preceding one, even though there is no sharp transition between them.

HICKORY FOREST OF THE UPPER GENTLE SLOPES

Less than 100 ft farther up the slope is a forest sufficiently different in appearance to warrant recognition. The trees are smaller, only 30 ft high and 6 to 8 in. in diameter. Hickories predominate to the almost total exclusion of oaks and other trees. Furthermore, shrubs provide no significant coverage and the land surface is largely carpeted with grasslike dryland Pennsylvania sedge. The number of flowering herbs is greater and includes many of the conspicuous spring-flowering plants. This small-treed, grassy, hickory forest looks very different from the chestnut-oak summits of the Western Highlands with their ericad ground cover. The difference between them reflects the difference in the soil and in the underlying rocks.

RED-CEDAR SUMMIT BELT

There are two separate, narrow summit belts, the first dominated by red cedar, the second conspicuously marked by young, dead hemlocks. Although both belts vary in width, they average only about 10 to 20 ft wide.

The floristic diversity of both belts is quite remarkable. It is easy to find a dozen kinds of trees, a variety of shrubs, and over two dozen herbs. The characteristic plant is red cedar, growing more abundantly here than in any other belt. Its contorted, picturesque, weather-beaten forms are a striking contrast to the tall, straight cedars on the old agricultural lands.

Other less abundant species which characterize this belt are pitch pine, scrub oak (*Quercus ilicifolia*), shrubby chinquapin oak (*Q. prinoides*), and little bluestem grass (*Andropogon scoparius*). The number of large dead trees, of species that one would think "belong" here, is also significant—among them is a hickory 10 in. in diameter. In other words, although the oak-hickory belt lower on the slope may tend to invade, the death of these trees indicates that the red-cedar belt is here to stay.

DEAD-HEMLOCK SUMMIT BELT

In many respects this belt is very similar to the red-cedar belt. It has the same variety of trees, shrubs, and herbs, and the same summit

species, including pitch pine, scrub oak, chinquapin oak, and bluestem grass. In addition, however, it contains a whole series of dead and fallen hemlocks and pines from 2 to 12 in. in diameter, individuals which have invaded at various times. Both species appear to have come in from the steep, north-facing slope during periods of favorable conditions apparently related to moisture.

The senior author took extensive notes on the vegetation of the McLean Refuge during July, September, October, and November 1949. In July numerous dead or dying 10-ft pines were observed, all apparently of the same age, extending down even into the hickory forest of the upper slope. This was a year of very serious drought, and by early September the summits of all the hills in the vicinity were yellow with drying foliage.

It is clear that the vegetation of the summit is a tension one, to be described only in terms of decades. During cycles of favorable soil moisture, pine and hemlock invade from the north-facing slope and oaks and hickories from the south-facing slope. Droughts either kill these invaders directly or so weaken them that they die later from other causes. The typical summit vegetation endures. A short-term study of "plant succession" here could therefore give some highly erroneous results.

NORTH-FACING LEDGES

At the brow of the hill the land drops away as a small cliff; in most places it is too steep to climb (about 70° slope) and may reach a height of 30 ft. On the northward-facing part of the cliff is a most interesting forest community dominated by hemlock, paper birch, sugar maple, and striped maple (*Acer pensylvanicum*), species one usually associates with cool, moist, "northern" lower slopes. This situation is not an anomaly—it is expected and predictable. Although a cliff is dry, with soil thin or absent, and appears highly unfavorable for vegetation, where such a ledge faces north it has maximum protection from direct solar radiation and retains moisture efficiently. Furthermore, vegetation here is excellently protected from fire, pasturing, and woodcutting. This combination of circumstances has developed one of the most "advanced" types of vegetation of the area. No forest, in the usual sense of the term, exists, although individual trees reach heights of 40 ft and diameters of 12 in.

UPPER TALUS

Below the cliff stretches the talus slope, an accumulation of boulders up to 6 ft across that have tumbled from the cliff and formed an enormous pile with a surface angle of repose of about 30° (fig. 7).

Only a few examples of vegetation development on talus slopes have been scientifically described (Nichols, 1914). In many places in Connecticut, an upper slope (just under a cliff) and a lower slope have both developed into forests, while the major area, the midslopes, continues to remain as bare boulders. It has been said—perhaps too quickly—that "plant succession advances" more rapidly at the top and at the bottom, the vegetation "pushing in" from the forests adjacent to the talus. Like so many theories on "plant succession," this interpretation seems naive, erroneous, and unscientific.

Fig. 7. Westerly talus slope of a trap-rock ridge, showing open, middle talus belt dominated by huge, lichen-covered boulders and lower talus belt with limited forest development. Hemlock, white birch, and black birch are conspicuous trees. Photograph taken in 1961.

There is a broken and irregular band of arboreal vegetation up to 20 ft in width on the upper talus, containing basswood, hemlock, sugar maple, dogwood, black birch, red oak, and hop hornbeam.

Physical weathering processes which form talus cause the large boulders to tumble or gradually "flow" downward. Smaller rocks and soil particles fill the crevices just below the cliff. The smaller particles drop straight down rather than flowing away from the cliff, with the result that solid land (which can retain moisture), rather than a loose pile of rocks, forms at the top of the talus. The slope of the talus surface is 30°, the average slope of the cliff is 70°—limiting the thickness of the talus accumulation (the depth to bedrock) on the upper part of the talus slope to possibly 10 or 12 ft.

This combination of circumstances makes the upper talus a site type definitely conducive to the development of trees. Close observation of the larger trees growing at the very top of the talus shows that they are not rooted in talus boulders nor in the soil of the talus itself but in pockets of the cliff lying just below the talus surface.

MIDDLE TALUS

The middle talus of the McLean Refuge, with a linear downslope distance of approximately 200 ft, is the finest such talus slope preserved by a private organization in the state of Connecticut. This enormous boulder field is a superb situation for the study of lichen development on rock surfaces. The very nature of the terrain has excluded the effects of man and fire for thousands of years, making it possible to see what vegetation alone can do in a terrain which is far more stable than surfaces exposed to soil erosion, trampling, cutting, and fire. And we find that this several-thousand-year-old "climax" is—lichens!

Crustose lichens (adnate forms), foliose lichens (leafy forms), and fruticose lichens (upright forms) all clamber over each other here—dying, disintegrating, and flaking off in total disregard of the way they are supposed to act according to the crustose-foliose - fruticose sequence of "succession" of the textbooks. To those who would read nature rather than books this small stretch of barren talus is one of the most instructive areas of the entire McLean Game Refuge.

LOWER TALUS

Downslope is a 30-ft-wide belt with about a 70-percent forest coverage. The trees include sugar maple, basswood, paper birch, black birch, white pine, hickory, and gray birch. There are many shrubs and vines. Even herbs pop up from between the boulders.

One's first impression that the forest has "advanced" onto the talus from the old adjacent agricultural lands is quickly dispelled by observation. There is only a thin scattering of talus boulders over the surface. Trees, shrubs, vines, and herbs are rooted in the soil below the boulders. This is really not a talus site at all, but sand plain covered with an insignificant and superficial layer of talus boulders—a layer which tends to keep it protected from trampling, grazing, and fire.

Vegetation of the sand plains

The vegetation of the plains of coarse sand in the McLean Game Refuge is an enormously varied assemblage of types, segregated not only by the local site type but also by their histories of fire, cropping, pasturing, lumbering, and the passage of time itself. The entire sand-plain complex is here divided into four major subdivisions: 1) the flat, high terraces, 2) the drained Bissell Brook valley pattern, 3) the eroded and collapsed high terraces, and 4) the undrained kettles (fig. 8).

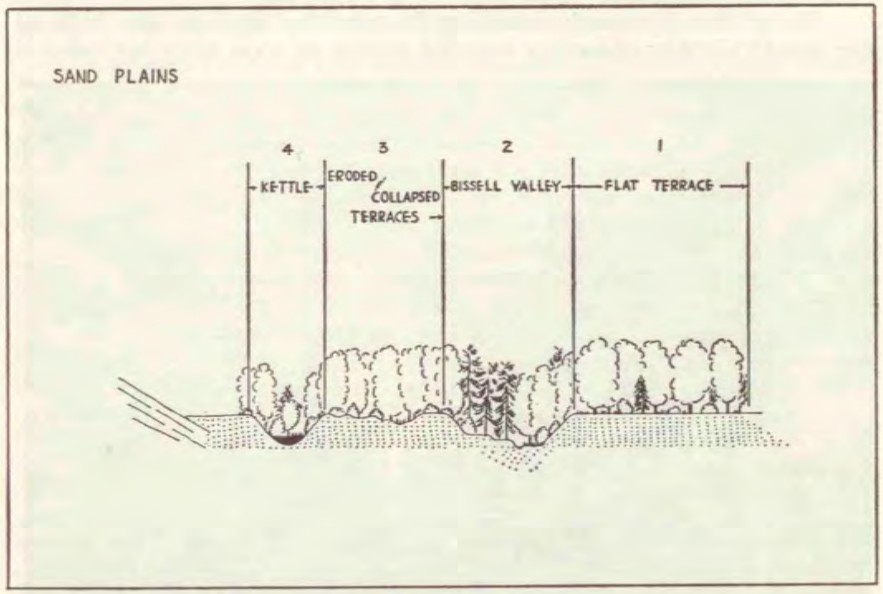

Fig. 8. Diagrammatic cross section of sand plains, illustrating major site types.

FLAT HIGH TERRACES

These terraces, especially those in a mile-long stretch east of Bissell Brook (between Trout Pond and Spring Pond), are worthy of preservation for their scientific value.

The flatness of the terraces led to their use for cropland agriculture, perhaps until about 1900, and plough furrows are still visible in some areas.

Pasturing, however, probably continued longer. Because cattle graze selectively, such nonpalatable species as cedar, juniper, and laurel would have been encouraged and hardwoods like gray birch, which are grazed down but not root killed, would have sprung into prominence with the cessation of grazing. While grazing continued, fire would have been unimportant, the flammable material being continually consumed by the cattle.

It is likely that fire increased when pasturing ceased, perhaps before 1932 when the land became part of the Refuge. Such fires would have been highly destructive to seedling conifers and regenerating hardwoods would have become more abundant.

Land use has included cropping, followed by pasturing, and then abandonment and periodic fires. We are now in a fifth phase with a high degree of fire protection. As a result, the fire-sensitive conifers are staging a strong invasion, with hemlocks surging into the shadiest forests, white pine entering where the oak stand is relatively open, and pitch pine invading where there is still open bluestem grassland (fig. 9).

Except for the newly invading fire-sensitive conifers, the bulk of the woody plants apparently invaded during or soon after agricultural

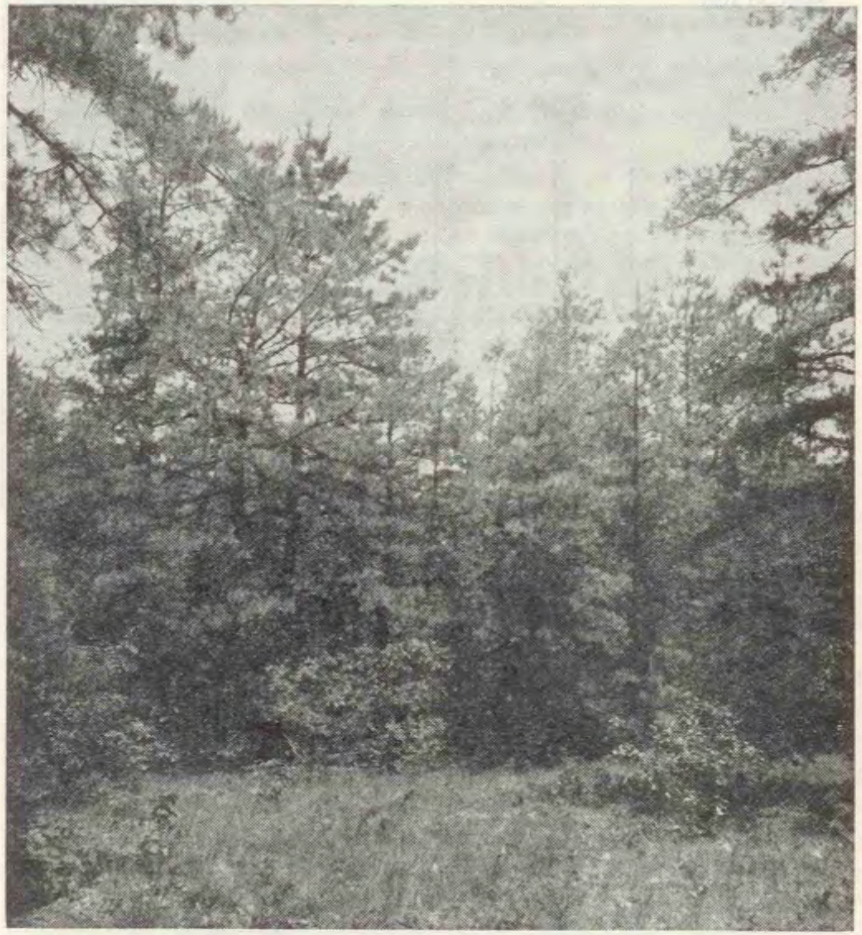

Fig. 9. One of the few remaining openings on the sand plains. Here on the flat, sandy terrace, pitch pine and little bluestem (foreground) are indicators of former agricultural land. Photograph taken in 1961.

abandonment. The success of their growth depended on subsequent pasturing and fire, as well as on the ever-present rodents such as mice and rabbits. There has been little if any hardwood invasion since that time.

Finally, in the 1960s the short-lived trees like gray birch, trembling aspen (*Populus tremuloides*), and red cedar are beginning to die out, with no opportunity to invade in the shady forest canopy.

The present forests are a reflection of this complex history. Clearly, this is not the orderly stage-by-stage, cause-and-effect "secondary plant succession" of textbook ecology, nor has such "succession" been found by either author anywhere in southern New England.

Tabulated data on the composition and structure of this vegetation, taken on June 16, 1961, make it readily apparent that the forest is or will be dominated by white oak and black oak as well as red and scarlet oaks. Hickories are now frequent. Red maple, black cherry, and sugar maple are present, and there are occasional white pines, hemlocks, and pitch pines. In the shrub layer, maple-leaved viburnum and three ericads, *Gaylussacia baccata*, *Vaccinum vacillans*, and *V. angustifolium*, will continue to become more abundant, with no essential ecological distinction between them. It is rather interesting that there is a solid cover of low ericads at what was apparently the edge of the cropland, just over a former fence line at the top of the slope to Bissell Brook. Apparently, ploughing on the former farmland completely destroyed these ericads and it may take them a century or more to develop again to their full potential. The herbaceous layer probably averages no more than 25 percent coverage; it is composed of a wide variety of species typical of relatively "dry" forests. Patches of club mosses (*Lycopodium complanatum*, *L. obscurum*) are frequent, probably encouraged by past grazing.

As indicated previously, the coniferous component of this forest will increase. It is entirely possible that fires will again burn through these lands. A single fire can wipe out the fire-sensitive invasion of a decade or two, returning the forest to its previous condition with little other change. Only in one place, 100 ft across, was the land still open enough to be classed as bluestem grassland, with pitch pines invading (fig. 9). This open landscape has high aesthetic and recreational values, and it may be desirable some day to insure that small areas like this are kept open.

DRAINED BISSELL BROOK VALLEY PATTERN

In this area is a wide variety of site types. In post-glacial times the valley was mainly eroded by a stream which was larger than the present Bissell Brook, and thus active floodplains are now small and inconsequential. There are many terraces at various levels above the present brook. In addition to these low streamside terraces, steep slopes rise about 50 ft to the sand plains.

In general, it may be said that this valley is moist, protected from drying winds, and infrequently destroyed by fire. It bears and will continue to bear a luxuriant forest of large trees typical of the lower

slope, including hemlock, sugar maple, beech, yellow birch, and an admixture of oaks and hickories. A variety of shrubs is present together with a considerable number of "northern" herbs of moist sites. The variety of shrubs lessens upslope, where maple-leaved viburnum tends to drop out and the low ericads to emerge into dominance, although there is much intergradation among these species.

In many places it is possible to recognize a series of belts along the stream margins. Where these belts widen considerably they are called terraces. Lowest is the skunk-cabbage belt, in places found only along the edge of the brook, in other places widening considerably and becoming a red-maple swamp on low floodplains.

Above the skunk cabbage is the cinnamon-fern belt. In places this also is merely a line paralleling the brook. In other places it broadens to 20 or 30 ft, either as a terrace or on the lowest part of the slope.

One terrace of Bissell Valley deserves special mention. It lies about half way between Spring Pond and Trout Pond on the west side of the brook, crossed by the road, about 20 ft above stream level. It occupies an acre or more and probably was used for farming until the turn of the century, when it was abandoned, apparently without pasturing or fire. The trees of the present forest are two aged. Apparently it was first invaded by pitch pine. These trees, with a few white pines, are now 18 in. in diameter. Some years later there was another heavy invasion of pine, this time, as would be expected, of the more shade-tolerant white pine. These trees are slender and spindly. At present there is essentially no understory of shrubs or herbs, and the ground is covered with pine needles. Barring such disturbances as fire, as the trees of this forest become over mature and begin to die, other tree species of the lower slope will begin to appear: sugar maple, beech, hemlock, white oak, and black cherry. Whether or not these species will eventually predominate is hypothetical.

ERODED AND COLLAPSED HIGH TERRACES

These sites include shallow tributaries of Bissell Brook that have been eroded from the flat sand plain, as well as various minor depressions caused by the melting of buried ice blocks. Their surfaces are so irregular that they probably have never been used for plowed croplands; they are not too steep, however, to have been used as grazing lands.

The absence of plowing seems reflected in the abundance of maple-leaved viburnum and the three ericads. Past grazing of these slopes is commonly evidenced by the persistence of an anastomosing system of cattle trails that run more or less along the contours. Although the relief is of an order of only an inch or two, it is sufficient to affect the relative distribution of moss and of dead-leaf patches.

In other respects, the tree, shrub, and herbaceous vegetation is very similar to that already described for the flat high terraces (fig. 10). One observation, made often enough to be mentioned here, is the tendency for maple-leaved viburnum to dominate on the lower portions of these slopes while the three shorter ericads dominate on the upper portions—a tendency which possibly will become more conspicuous in the future.

These are unquestionably some of the most fascinating areas of the McLean Refuge. They are deep, circular depressions, 100 to 300 ft across and 20 to 40 ft below the surrounding landscape. Their sides slope steeply, though generally they are at a lower angle than the angle of repose of the sandy materials when the original buried ice block melted. The bottoms of the kettle holes are lakes, swamps, or bogs, with fluctuating water levels throughout the seasons. Three kettles that were studied are marked on the map, figure 2, as 1, 2, and 3. In the discussion below they are referred to as I, II, and III, respectively.

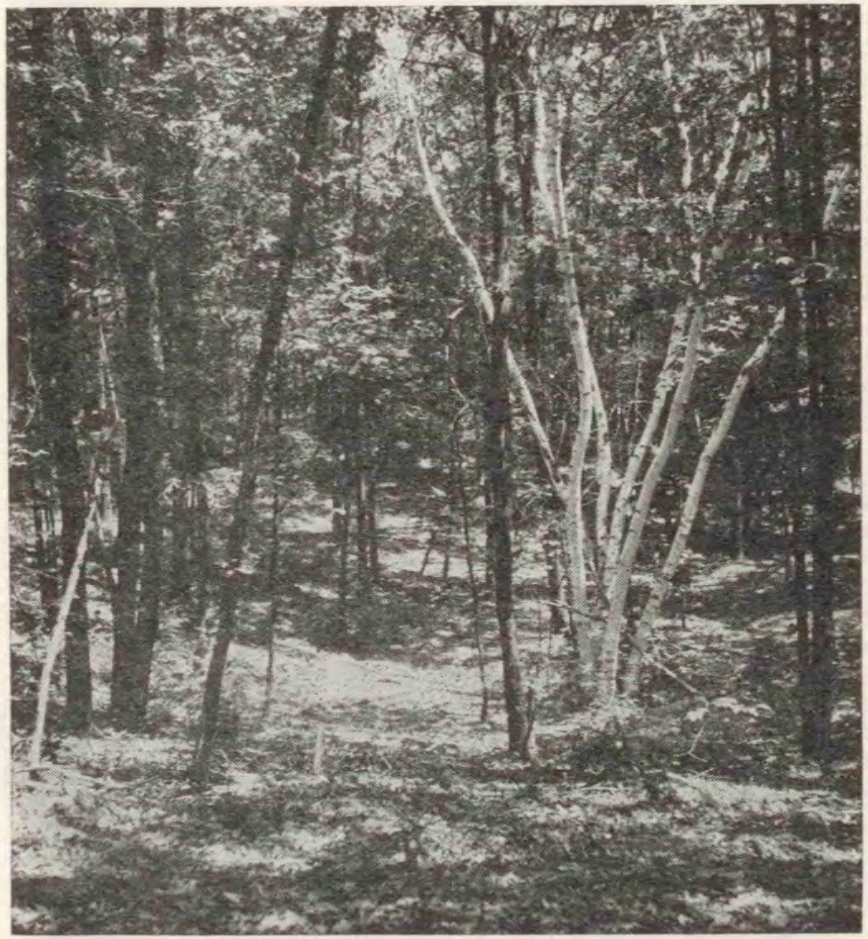

Fig. 10. Oak forest mixed with white birch on the eroded sandy terrace. Fire protection in recent decades has favored the entry of white pine and hemlock on many such sites. Photograph taken in 1961.

Kettle I. This hole contains a permanent pond with fluctuating water levels. In June 1961, the water was high enough to submerge a band of living meadow sweet (*Spiraea latifolia*) as well as a band of young gray birches. Furthermore, a ring of killed red cedar about 8 ft high not only indicates a water level sufficiently high and long lasting to have killed the cedars but points to preceding low levels which lasted long enough to allow the development of these trees.

In June 1961 four belts of vegetation appeared reasonably stable: a) a grassland of *Calamagrostis canadensis*, b) a thicket dominantly of *Spiraea* also containing some gray birch seedlings, c) a band of abundant low dewberry as well as many drowned red cedars and pines, and d) the oak forest on the edge of the slope with its cow-contour trails and a scattering of maple-leaved viburnum.

Kettle II. This is a bog with an organic substratum of unknown depth. The vegetation is a complex mosaic of herbland, shrubland, and forest—in the ratio 4:2:2. There is no evidence of successional development among these three physiognomic types. It is quite possible that the types themselves change from one to another through the decades as trees and shrubs die out and others take their places.

In the forest community the trees are 4 to 6 in. in diameter and not more than 18 ft high. White pine is the most abundant species, gray birch second. There is a sprinkling of dead trees with heights up to 15 ft and some pine stumps 6 to 8 in. in diameter. The leaders of the pines show a growth of only 6 in. a year. Other tree species are red maple (*Acer rubrum*), black spruce (*Picea mariana*, which is frequently layering), paper birch, hemlock, yellow birch, and even one pitch pine.

Tall blueberry (*Vaccinium corymbosum*) is the most common shrub and accounts for 90 percent of the shrubs. Swamp azalea is the next most abundant species. In addition, there are black chokeberry (*Pyrus melanocarpa*), sheep laurel, leatherleaf, and a small birch identified as *Betula pumila*.

The herbland is formed around a thick, heavy mat of sphagnum. There are large chain ferns (*Woodwardia virginica*) and leatherleaf, normally a taller shrub, forms a layer 6 in. high in places in this community. The large cranberry (*Vaccinium macrocarpon*) is frequent and, in addition, the small cranberry (*V. oxycoccus*), cotton grass (*Eriophorum viridi-carinatum*), and an unusually heavy growth of lichens are found.

Around the entire edge of the bog is a 20-ft-wide belt that is a typical marginal ditch, low and wet enough to make passage difficult until one reaches the higher, drier central bog. According to one of the most commonly accepted explanations, the shade of the adjacent upland forest and the inflowing fresh waters, combined with the failure of the bog mat to develop (plus other unrecognized factors) leads to the continuation of this ditchlike phenomenon. It is a shrub community, 90 percent of it chokeberry. Leatherleaf grows taller in the marginal ditch—up to 18 in. high.

Kettle III. This kettle hole is a bog with a deep organic substratum similar to, and yet individually different from the bog of the second kettle.

The forest, which covers 50 percent of the bog, is approximately 90 percent black spruce. Approximately half of the spruce over 20 ft tall are dead, yet small spruce and white pine are numerous enough to perpetuate the vegetation. Other trees present are white pine, red maple, pitch pine, and gray birch.

Under and around the trees is a shrubland covering about 90 percent of the bog. Generally an impassable tangle, 90 percent of it is tall blueberry 6 to 7 ft high. Swamp azelea (*Rhododendron viscosum*) is second in abundance and, in addition, there is chokeberry, bog laurel (*Kalmia polifolia*), sheep laurel, leatherleaf, mountain holly (*Nemopanthus mucronata*), and a tall-growing low-bush blueberry (*Vaccinum angustifolium*).

Unlike the bog in kettle II there is no open herbland, although the species of open herbland are found: pitcher plant (*Sarracenia purpurea*), chain fern, cranberry, and a considerable amount of sphagnum.

A marginal ditch is present, dominated by chokeberry, like the ditch in kettle II.

FUTURE VEGETATION TRENDS

To what extent is the enormous variety of plant communities and vegetation types of the McLean Game Refuge changing and showing evidence of developing toward a single, mature, stable type, popularly known as "climax"?

Cropping, pasturing, lumbering, fire, and animals have all played their roles within the last century in the history of the vegetation. To some extent the vegetation is now in a process of adjusting to the absence of the anthropeic factors. These changes do not seem to be involving stage after stage of traditional cause-and-effect "plant succession," each stage making the land unsuited for its own characteristic vegetation and suited for the invasion of seedlings of some new stage. On the contrary, most of the trees of the end stages seem to invade right at the start, although because of rodents, fire, and other factors it may take several decades before they predominate in the landscape.

Fires may still occur. It would be difficult to say which fires are "natural" and which are caused by man. In fact, it is logical to reason that the great amount of fire protection now practiced serves only to build up the amount of inflammable material into a tremendous fire hazard. When fire does spread through such vegetation it can be far more destructive than frequent light fires.

The marginal ditch appears to be a permanent feature in the kettle bogs. Each bog is a complex of forest, shrubland, and herbland, certainly without any successional trends among them. It appears that these three physiognomic types fluctuate among themselves throughout the decades.

In those kettles with lakes the wide annual fluctuations in the water levels (including extremes that may occur only two or three times a cen-

tury) condition the belts of shore vegetation.

Periodic droughts on the summits (and periodic moist cycles there) keep the summit belts in a dynamic equilibrium of expansion and contraction. The adjacent talus-boulder field appears relatively stable, with lichens as the "climax" vegetation (if one wishes to use that term).

The three sorts of substrata, the schists of the Western Highlands, the diabase of the trap-rock ridges, and the alluvial deposits of the sand plains, are reflected in the soils and provide quite different chemical and physical characteristics that are essentially permanent in terms of centuries or even millenia.

Integration of all these observations makes it clear that a large number of the site types of the McLean Refuge are relatively permanent—at least as permanent as the topography itself, which is constantly being eroded. Each site type has its own combination of plant communities which fluctuate back and forth in certain natural oscillations within certain bounds, even though those bounds involve a striking variety of plant communities.

There is no field evidence for the eventual attainment of one single "climax" vegetation type (the so-called "climatic climax") over the entire McLean Refuge, nor for the eventual attainment of one single "climax" vegetation (the so-called "edaphic climax") for each site type. As shown in this report, the Western Highlands, diabase hills, sand plains, and bogs each exhibit a mosaic of vegetation types with no evidence that a single type will become dominant on any one. Nature is more complex than pictured by simple arm-chair theories that served their purpose when they were proposed half a century ago. Their simple orderliness continues to make them so attractive that they may never die but form a permanent part of the wishful wisdom of the human race. Field ecologists must always be alert, questioning these theories and critical of them, and ready to propose other hypotheses in closer conformity to the empirical data.

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APPENDIX

ANNOTATED LIST OF VEGETATIONALLY IMPORTANT SPECIES

This is not intended as a complete floristic list. In estimating species abundances, five categories have been used to indicate the percentage of the vegetation cover which a given species comprises:

Abundant = 75 to 100 percent
Common = 50 to 75 percent
Frequent = 5 to 50 percent
Occasional = 1 to 5 percent
Rare = less than 1 percent

Those species found on the Western Highlands are designated by WH, those on the sand plains by SP.

Ferns and club mosses

Athyrium filix-femina (L.) Roth., lady-fern—rare, WH.
A. thelypteroides (Michx.) Desr., silvery spleenwort—rare, WH.
Botrychium virginianum L., rattlesnake fern, Virginia grape-fern—rare, WH.
Dennstaedtia punctilobula (Michx.) Moore, hay-scented fern—occasional, generally common where found, WH; occasional in small colonies, especially on lower sites, SP.
Dryopteris marginalis (L.) Gray, evergreen wood-fern, marginal shield-fern—occasional in the drier, higher forest, WH; rare on the floodplain terrace, SP.
D. noveboracensis (L.) Nieuwl., New York fern—frequent at the higher margins of fern glades, WH; frequent on the floodplain terrace, SP.
D. spinulosa (Mill.) Fiori, spinulose shield-fern—rare on the floodplain terrace, SP.
D. thelypteris (Adaus.), shield-fern—occasional on the floodplain terrace, SP.
Equisetum arvense L., common horsetail—occasional on the floodplain terrace, SP.
Lycopodium clavatum L., running pine—rare on the floodplain terrace, SP.
L. complanatum L., ground cedar—rare; common where found, WH; occasional in forest, SP, the narrow-leaved form more common than the variety described below.
L. complanatum var. *flabelliforme* L., ground cedar—occasional in SP forest; the common variety in most of Connecticut.
L. lucidulum Michx., shining club moss—rare, WH.
L. obscurum L., tree club moss—occasional in SP forest.
Onoclea sensibilis L., sensitive fern—frequent on the floodplain terrace, SP.
Osmunda cinnamonea L., cinnamon fern—occasional to frequent in low fern glades, WH; frequent on the floodplain terrace, SP.
O. claytoniana L., interrupted fern—occasional to frequent in low fern glades, WH.
O. regalis L., royal fern—occasional on the floodplain terrace, SP.
Polystichum acrostichoides (Michx.) Schott, Christmas fern—rare, WH; occasional on various sites, SP.
Pteridium aquilinum (L.) Huhn var. *latiusculum* (Desu.) Underw., bracken—occasional but not in solid, dense stands, SP.
Woodwardia virginica (L.) Sm., Virginia chain-fern—locally found in kettles, SP.

Grasses and sedges

Andropogon scoparius Michx., little bluestem—rare, as small colonies at summits, WH; forming small areas of dense grassland on old agricultural land, SP.

Brachyelytrum erectum (Schreb.) Beauv., bearded short-husk grass—occasional in the forest, SP.

Bromus sp. (L.), brome grass—occasional in grassland, SP.

Calamagrostis canadensis (Michx.) Beauv., bluejoint—forming a belt of vegetation in the deeper water of a kettle pond, SP.

Carex pensylvanica Lam., Pennsylvania sedge—becoming frequent toward the summits, WH; frequent as herb layer in more open forests, SP.

C. stricta Lam., tussock sedge—local in swampy areas, WH; forming tussocks in swamps but not forming a vegetation belt, SP.

Dactylis glomerata L., orchard grass—open grassy areas, SP.

Eriophorum viridi-carinatum (Engelm.), fern, cotton grass—occasional in one kettle, SP.

Phelum pratense L., timothy—occasional in the forest, SP.

Other herbaceous plants

Antennaria neglecta Greene, everlasting—occasional in unmown meadows, SP.

Aquilegia canadensis L., wild columbine—rare in SP forest.

Aralia nudicaulis L., wild sarsaparilla—frequent, WH; rare on the SP forest.

A. racemosa L., spikenard—rare, WH.

Arisaema triphyllum L., Schott., jack-in-the-pulpit—occasional, WH.

Aster acuminatus Michx.—occasional, WH.

A. divaricatus L., white wood aster—occasional, WH.

Baptisia tinctoria L., R. Br., wild indigo—rare in open pitch pine, SP.

Barbarea vulgaris R. Br., yellow rocket—occasional in unmown grassland, SP.

Campanula rotundifolia L., harebell, bluebell—WH.

Chimaphila maculata L., Pursh., striped wintergreen—rare to occasional, SP forest.

C. umbellata L., Bart., prince's pine, pipsissewa—rare, WH and SP forest.

Chrysanthemum leucanthemum L., ox-eye daisy—locally abundant in unmown meadows, SP.

Comandra umbellata L., Nutt., white-flowered toad flax—rare in SP forest.

Cypripedium acaule Ait., pink lady's slipper—rare, WH; frequent in SP forest.

Echinocystis lobata Michx., T. & G., balsam apple, wild cucumber—reported as having become more abundant in the years preceding 1961, especially along roadsides and on open soils, SP.

Epifogus virginiana L., Bart., beech-drops—occasional, WH.

Epigaea repens L., trailing arbutus, mayflower—rare on moss mats in WH forest; in places frequent on the mossy shoulders of roads, SP.

Erigeron pulchellus Michx., daisy fleabane—occasional in unmown meadows, SP.

Fragaria virginiana Duchesne., wild strawberry—occasional in unmown grasslands, SP.

Gaultheria procumbens L., wintergreen—rare, locally frequent, WH; occasional in floodplain forests, SP.

Geranium maculatum L., wild geranium—occasional as small individuals in SP forest.

Helianthemum canadense L., Michx., frostweed—rare on open sites, WH.

Hemerocallis flava L., lemon lily—established on the dam at Spring Pond together with several exotic irises, SP.

Hieracium pratense Tausch., king devil—frequent in unmown meadows, SP.

Houstonia caerulia L., bluets—occasional on unmown meadows, SP.
H. longifolia Gaertn.—rare in rock crevices of the summit trap-rock forests.
Impatiens L. sp., touch-me-not—occasional in low areas, SP.
Iris versicolor L., blue flag—rare in low areas, SP.
Lycopus virginicus L., bugleweed, water-harehound—occasional, WH.
Lysimachia quadrifolia L., whorled loosestrife—occasional, WH and open parts of SP forest.
Maianthemum canadense Desf., Canada mayflower, wild lily-of-the-valley—occasional as a thin ground cover in SP forest.
Medeola virginiana L., Indian cucumber root—rare in SP forest.
Melampyrum lineare Desr., narrow-leaved cow wheat—occasional in open SP forest.
Mitchella repens L., partridge berry—occasional, WH and as a ground cover in SP forest.
Monotropa uniflora L., Indian pipe—rare in the forests, SP.
Polygala verticillata L., milkwort—rare, WH.
Potentilla argentea L., silvery cinquefoil—occasional in unmown grasslands, SP.
P. canadensis L., common cinquefoil—frequent in unmown grasslands, SP.
P. recta L.—occasional in unmown grasslands, SP.
Pyrola sp. L., shinleaf—rare in SP forest.
Ranunculus acris L., buttercup—frequent in unmown grasslands, SP.
Rumex acetosella L., sheep sorrel—occasional in open areas, SP.
Sanguinaria canadensis L., bloodroot—rare, WH.
Saponaria officinalis L., soapwort, bouncing-bet—occasional in open areas, SP.
Sarracenia purpurea L., pitcher plant—occasional in one of the kettles.
Sisyrinchium sp. L., blue-eyed grass—flowering abundantly in the unmowed meadows' SP.
Smilacina racemosa L., Desf., false Solomon's seal—occasional in SP forest.
Solidago caesia L., blue-stemmed goldenrod—occasional, WH and SP forest.
S. juncea Ait., early goldenrod—occasional in unmown meadows, SP.
S. odora Ait., sweet goldenrod—rare in SP forest.
Symplocarpus foetidus L. Nutt., skunk cabbage—its abundance is indicative of swampy streamside conditions, SP.
Thalictrum polygamum Muhl., meadow rue—rare, WH; occasional in unmown grasslands, SP.
Trientalis borealis Raf., star flower—rare in floodplain-terrace forest, SP.
Trifolium agrarium L., hop clover—occasional in unmown meadows, SP.
T. pratense L., red clover—locally abundant in unmown grasslands, SP.
Uvularia sessilifolia L., sessile-leaved bellwort, wild oats—occasional as small colonies in SP forest.
Veratrum viride Ait., white hellebore—occasional in low areas, SP.
Veronica officinalis L., speedwell—occasional in unmown areas, SP.
Vicia cracca L., tufted vetch—occasional on unmown meadows, SP.
Viola rotundifolia Michx., round-leaved yellow violet—rare, WH.
Zizia aurea L., Loch., golden Alexanders—rare in unmown meadows, SP.

Shrubs

Cephalanthus occidentalis L., buttonbush—in low, swampy areas where it occupies sites lower than the *Carex stricta* tussocks, SP.
Cornus racemosa Lam., gray dogwood—rare, WH.
Corylus americana Walt., hazelnut—rare, WH; colonies occur rarely as a thin understory in SP forest.

Gaylussacia baccata (Wang.) K. Koch, huckleberry—one of three typical summit ericad species, rare on lower slopes, WH; common as one of the three major components of the ericad understory of SP forest.

Hamamelis virginiana L., witch hazel—a typical shrub-stratum species, WH; occasional in the forest, more abundant on the floodplain terrace than on the upper SP surface.

Ilex verticillata L., Gray, winterberry—rare in swamps, WH; occasional in floodplain-terrace forest, SP.

Juniperus communis L., common juniper—rare in SP forest.

Kalmia angustifolia L., sheep laurel—occasional on some summits, WH; rare in the forests, SP.

K. latifolia L., mountain laurel—a typical shrub-stratum species; abundant near some summits, WH; rare in SP and small and relatively unimportant colony in SP forest.

K. polifolia Wang., bog laurel—occasional in one kettle, SP.

Lindera benzoin L., DC., spice bush—frequent on the floodplain terrace, SP; on lower slopes and swamps locally forming a stratum, WH.

Myrica asplenifolia L., Gaertn., sweet fern—rare to common where found, WH; small colonies occur rarely in openings in SP forest.

Parthenocissus quinquefolia L., Planch., Virginia creeper—locally sparse as gradual cover, WH; occasional, especially in low areas, SP.

Pyrus melanocarpa Gray, black chokeberry—rare in SP forest and in open shrubby areas; abundant in marginal ditch of boggy kettles.

Quercus prinoides Willd., chinquapin oak—rare on trap-rock summit.

Rhododendron nudiflorum L., Torr., pink azalea—rare in SP forest.

R. viscosum L., Torr., swamp azalea—frequent in the boggy kettles, SP.

Rhus glabra L., smooth sumac—rare in open pitch-pine stands, SP.

R. radicans L., poison ivy—locally sparse as gradual cover, WH; occasional in open areas and in SP forest, especially in lower areas.

Rosa carolina L., wild rose—occasional on the floodplain terrace, SP.

Rubus alleghaniensis Porter, mountain blackberry—occasional in open, shrubby areas, SP.

R. flagellaria L., dewberry—occasional in unmown grasslands, SP.

Smilax rotundifolia L., greenbrier, catbrier—frequent in the open, swampy belt around a kettle pond, SP.

Spiraea latifolia (Ait.) Borkh., meadow-sweet—occasional in old fields; dominant in a belt at the margin of one of the kettle lakes, SP.

S. tomentosa L., hardhack—rare in old fields and at the edges of kettle lakes, SP.

Vaccinium angustifolium Ait., low blueberry—one of three typical summit ericad species, rare on lower slopes, WH; common as the least important of the three major components of SP forest.

V. corymbosum L., high-bush blueberry—rare to occasional on summits, WH; only rarely in the floodplain-terrace forest and abundant in some kettles, SP.

V. macrocarpon Ait., large cranberry—frequent in kettles, SP.

V. oxycoccos L., small cranberry—in kettles, SP.

V. vacillans Torr., swamp azalea—one of three typical summit ericad species, rare on lower slopes, WH; common as one of the major components of the ericad understory of the SP forest.

Viburnum acerifolium L., maple-leaved viburnum—occasional to frequent, WH.

V. cassinoides L., withe-rod—rare in the forests and along forest edges, SP.

Acer pensylvanicum L., striped maple—rare on north slope of eastern Barndoor Hill.

A. rubrum L., red maple—occasional to frequent, abundant in swamps, WH; occasional in all forests and open areas, SP.

A. saccharum Marsh, sugar maple—from common on lower slopes to rare on upper slopes WH; occasional in SP forest.

Amelanchier sp. L., shadbush—occasional in forest, SP.

Betula lenta Michx., black birch—occasional to frequent, WH; frequent in SP forest.

B. lutea Michx., f., yellow birch—occasional on lower slopes and in stream valleys, WH; rare in SP forest.

B. papyrifera Marsh., white birch, canoe birch, paper birch—occasional, especially in old agricultural lands, WH, and in SP forest.

B. populifolia Marsh., gray birch—occasional to frequent on old agricultural lands, WH; now rare in SP forest where it had been locally common in earlier years; dead trunks now on the ground.

Carpinus caroliniana Walt., American hornbeam, ironwood—occasional in SP forest.

Carya glabra (Mill.) Sweet, pignut hickory—rare to occasional, WH; occasional in SP forest.

C. ovata (Mill.) K. Koch, shagbark hickory—rare, WH; occasional in SP forest.

C. tomentosa (Poir.) Nutt., mockernut hickory—rare to occasional, WH; rare in SP forest.

Castanea dentata (Marsh.) Borkh., chestnut—rare in SP forest.

Cornus alternifolia L.f., alternate-leaved dogwood—rare in floodplain-terrace forest, SP.

C. florida L., flowering dogwood—rare to occasional as an understory forest tree in forest and floodplain-terrace forest, SP.

Fagus grandifolia Ehrh., American beech—rare, WH.

Fraxinus americana L., white ash—occasional, WH; rare as a component of SP forests.

Juglans cinerea L., butternut—rare, WH and SP forest.

Juniperus virginiana L., red cedar—rare in SP forest.

Liriodendron tulipfera L., tulip tree—rare to occasional on lower slopes, WH, and on floodplain terrace and lower adjacent slopes, SP.

Nyssa sylvatica Marsh, black gum, sour gum, pepperidge—rare in a kettle forest, SP.

Ostrya virginiana (Mill.) K. Koch, hop hornbeam—rare in SP forest, many dead or dying.

Picea mariana (Mill.) BSP., black spruce—common in one of the kettles, SP.

Pinus rigida Mill., pitch pine—common on SP, especially on old agricultural lands.

P. strobus L., white pine—occasional to common, rare at the summits, WH; common on all sites; younger trees invading the SP forest.

Populus grandidentata Michx., large-toothed aspen—rare, common where found, WH; rare in SP forest; dead specimens indicate greater past abundance.

P. tremuloides Michx., trembling aspen—occasional in SP forest.

Prunus serotina Ehrh., wild black cherry—occasional in all forests; frequent in SP forest but generally as small shoots and rarely as a tree of the upper canopy.

Quercus alba L., white oak—rare to occasional, WH; one of the most common trees of SP forest.

Q. borealis Michx. f. var. *maxima* (Marsh) Ashe., (*Q. rubra* L., Gray's *Manual*, 8th ed.), red oak—occasional to frequent, WH; one of the most common trees of SP forest.

Q. coccinea Muerchh., scarlet oak—rare to occasional in SP forest.

Q. prinus L., chestnut oak—rare to abundant on summits, WH.
Q. velutina Lam., black oak—rare, WH; one of the most common trees in SP forest.
Sassafras albidium (Nuth.) Nees., sassafras—rare to occasional, WH.
Tilia americana L., basswood, American linden—rare in SP forest.
Tsuga canadensis L., Carr., hemlock—occasional to frequent, rare at the summits, WH; common on all sites; largest, oldest trees of this species are along the stream banks; younger trees are invading SP forest.
Ulmus americana L., American elm—occasional on the floodplain terrace, SP.