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The vegetation of the William L. Hutcheson Memorial Forest, New Jersey

Carl D. Monk

Department of Botany, University of Florida
Gainesville, Florida

MONK, CARL D. (U. Florida, Gainesville.) The vegetation of the William L. Hutcheson Memorial Forest, New Jersey. Bull. Torrey Bot. Club 88(3): 156–166. 1961.—The upland portion of the Hutcheson Memorial Forest (82% of the area) is dominated by white oak, black oak, red oak, and red hickory. These species form an almost continuous canopy about 95 ft. in height. Beneath the canopy is a pronounced dogwood understory. The shrub layer is characterized by maple-leaved viburnum. The herb layer is best developed in spring when May-apple is abundant. The poorly drained areas are dominated by white oak, white ash, red maple, and pin oak. Recent wind damage has created many openings in the canopy. The understory is not as distinct as it is on the better drained soils. Transgressives of red maple are the principal components. The shrub layer is characterized by arrowwood, spicebush, and greenbrier. Spotted touch-me-not and skunk cabbage are the principal herbs. Hutcheson Memorial Forest is a variant of the oak-hickory forest type complex of the Piedmont, but it does not have the climax status which this community exhibits on the southern Piedmont. Openings in the forest resulting from occasional severe windstorms or other catastrophe are closed again by a process in which local old field species play a minor role in the re-establishment of typical forest structure and composition. Red maple and white ash, much more often than oaks and hickories, are the tree species that in the recent past and at present are destined to fill the gaps in the canopy.

The William L. Hutcheson Memorial Forest is 65 acres in extent and is located on the Piedmont of New Jersey (40°30′N, 74°34′W). It is a mature oak forest (Buell 1957). A study of growth rings has shown that some of the older trees date back to pre-colonial days (Buell *et al.* 1954). Bard (1952), who studied succession on the Piedmont of New Jersey, referred to Hutcheson Forest as "the nearest approach to climax" in the area.

The Piedmont of New Jersey is underlain primarily by highly weathered, soft, red Triassic shales of the Brunswick Formation (Lewis and Kummel 1915). The terminal moraine of the Wisconsin glacier crosses the Piedmont a few miles north of the Hutcheson Memorial Forest. Even though the area of the forest is south of the moraine, gravel of origin foreign to the area is scattered throughout. On a few acres at the western end, sand of glacial alluvial origin (Salisbury 1902) overlies the shales.

In early soil surveys, the soils of most of the woods were mapped as the Penn silt loam (Lee and Seltzer 1926). Since the soil is not entirely residual, derived from red shale, but contains gravel brought in from elsewhere it is separated from the Penn and given the name Norton (Quakenbush 1955).

The prevailing influence, however, has been that contributed by the red shale over most of the area. The ferrous aluminum shales were weathered to near completion during sedimentation in Triassic time (Joffe 1937), and this highly weathered condition has inhibited the development of the normal podsolic soil of the region.

The mean annual temperature of the general area, as shown by the records at the weather station eight miles away at New Brunswick, is 53.9° F. Sparkes and Buell (1955), in a microclimatic study in the forest, found the year's extremes to be −3° F. minimum and +96° F. maximum. The temperature range would probably be extended during extremely warm or cold years; the duration of the growing season for the area is approximately 240 days. The annual rainfall is 40.15 inches and July and August receive slightly more than the other months (Biel 1958).

The objectives of this study were to (1) describe the forest, its composition and structure; (2) to discover its relations to other adjacent forests of the region; (3) and to learn the process of recovery from local catastrophe within the forest—an important part of the forest's dynamics.

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METHODS. A detailed tree census was conducted during the winter of 1956–57 in which all individuals over 1 inch d.b.h. were measured. The census was accomplished by dividing the forest into strips of convenient width. Species which were present in the forest only as a few scattered trees, sassafras (*Sassafras albidum*), black cherry (*Prunus serotina*), tree-of-heaven (*Ailanthus altissima*), American hornbeam (*Carpinus caroliniana*), and hackberry (*Celtis occidentalis*) were not included. Nomenclature follows Gray's Manual (Fernald 1950).

Cover data on the shrub and understory layers was obtained by the line intercept method (Buell and Cantlon 1950). A total of five 200m. transect lines were used in both the well-drained and the poorly-drained areas. Forty one-square-meter quadrats were used to sample the herb layer in the well-drained area each season and for the late summer in the poorly drained area. The spring herb cover data of the low areas were obtained from thirty-six one-square-meter plots. Gap closure was studied only by making reconnaissance notes.

RESULTS. Of approximately 65 acres in the Hutcheson Memorial Forest about 82% is situated on well-drained sites while the remainder occupies soil that has poor drainage. For the purposes of this paper, data collected from these two situations are considered separately for both cover and gap closure.

COVER DATA.

Trees.—White oak (*Quercus alba*) is clearly the dominant on both the well-drained and poorly drained areas. On the former, black oak (*Q. velutina*), red oak (*Q. rubra*), and red hickory (*Carya ovalis*) are important associates. White ash (*Fraxinus americana*), red maple (*Acer rubrum*), pin oak (*Q. palustris*), red oak, black gum (*Nyssa sylvatica*), American elm (*Ulmus americana*), and swamp white oak (*Q. bicolor*) are the more important associates of white oak on the poorly drained areas (Table 1). These

TABLE 1. *Trees per acre (Trees/A) and percent basal area (%B.A.) for trees over 1 inch d.b.h. on well-drained and poorly drained sites in the Hutcheson Memorial Forest.*

Species	Well-drained Areas		Poorly Drained Areas	
	Trees/A	% B.A.	Trees/A	% B.A.
Quercus alba	30	52	13	27
Quercus velutina	13	22	3	3
Quercus rubra and *Q. coccinea*	13	12	10	8
Carya ovalis	7	6	6	2
Fraxinus americana	22	3	47	15
Acer rubrum	18	3	62	15
Prunus avium	8	2	1	< 1
Acer saccharum	2	< 1	< 1	< 1
Fagus grandifolia	2	< 1	2	1
Acer platanoides	2	< 1	< 1	< 1
Ulmus americana	1	< 1	10	5
Carya ovata	1	< 1	4	1
Nyssa sylvatica	< 1	< 1	27	6
Quercus palustris	< 1	< 1	3	10
Quercus bicolor	—	—	2	5

All figures have been rounded to the nearest whole number. The total basal area per acre was 89.5 sq. ft. in well-drained areas, and 74.2 sq. ft. in poorly drained areas.

species together form a canopy in places as much as 95 feet in height. Storms in 1950 and 1956 blew over more than 300 large trees in the forest. The most severe wind damage occurred in a 6-acre portion of one of the poorly drained areas. Studies made after the storm in 1956 showed that the canopy on the upland areas had approximately 7% unoccupied space against 27% in the poorly drained sites (Table 2). This together with the fact that the poorly drained areas had 16.3 square feet basal area per acre less than the well-drained areas is largely the result of the recent wind damage.

The trees of all species are not equally distributed throughout the forest. White oak, black oak, red oak, and red hickory are evenly distributed on the upland portion, but on the poorly drained sites they are spasmodic in occurrence. The other canopy representatives are less evenly distributed even on well-drained sites. White ash and red maple are associated mainly with former windthrows and other disturbances that open the canopy. Canopy individuals of beech (*Fagus grandifolia*), Norway maple (*Acer plata-*

TABLE 2. *Percent cover for species with more than one percent in the shrub layer and understory, on the well-drained and poorly drained areas and data on unoccupied space in the canopy.*

Species	Well-drained Areas	Poorly Drained Areas
	% Cover	% Cover
CANOPY		
Unoccupied Space	7	27
UNDERSTORY		
Cornus florida	84	9
Fraxinus americana	7	1
Acer saccharum	5	—
Acer rubrum	4	27
Viburnum prunifolium	1	—
Celtis occidentalis	1	—
Carpinus caroliniana	—	4
Nyssa sylvatica	—	3
Ulmus americana	—	3
Carya ovalis	—	2
Unoccupied Space	13	52
SHRUB		
Viburnum acerifolium	24	7
Lonicera japonica	7	—
Cornus florida	6	1
Fraxinus americana	2	4
Acer rubrum	1	7
Viburnum dentatum	—	17
Lindera benzoin	—	11
Smilax rotundifolia	—	11
Prunus serotina	—	5
Viburnum prunifolium	—	4
Rhododendron nudiflorum	—	2
Quercus alba	—	2
Ulmus americana	—	1
Rubus allegheniensis	—	1
Sassafras albidum	—	1
Unoccupied Space	61	56

noides), and sugar maple (*Acer saccharum*) are less frequent and their distribution does not appear to be related to windthrows. Aggregations of all reproductive stages of sugar maple and Norway maple are present in the forest around a few seed trees. Scattered individual seedlings and saplings and occasionally small trees of these species are also encountered throughout the upland areas. Isolated individuals of beech occur occasionally but more commonly are in clones. Shagbark hickory (*Carya ovata*) and American elm are usually found in the transition zone between the well-drained and poorly drained areas. Black gum is almost entirely restricted to the poorly drained area fringing a small stream. Sweet cherry (*Prunus avium*) is rarely encountered in the canopy but is represented by frequent individuals with crowns betwen the canopy and understory. It is most abundant in the forest where light is greatest.

The understory on upland areas forms a stratum about 35 feet in height. Flowering dogwood (*Cornus florida*) is the only abundant tree species restricted to this layer, and its importance is clearly illustrated in Table 2.

Basal area data for dogwood are not included in Table 1 since tree census of this species was not done for the entire forest. However, a complete tally of dogwood was made on 26 acres of upland forest. Based on this, dogwood contributes approximately 17% to total basal area on upland sites. This would make dogwood the third most important tree in respect to basal area. However, since dogwood is a small tree, its basal area is even more striking when only individuals between 1 and 9.9 inches d.b.h. are considered. In this size class it contributes 71% to total basal area and 79% to total density.

The understory on the poorly drained areas does not form as distinct a stratum as it does on the well-drained sites. Dogwood, the principal understory tree of the upland forest, is less common in the lowland portion and is absent from the wetter areas. The small amount of dogwood, the sparsity of other tree species with low stature, and the abundance of red maple (Table 2) of various heights result in a less distinct understory on the poorly drained section.

Red maple is the principal contributor to the understory in the poorly drained areas (Table 2). Transgressives of this species, though distributed throughout, are more important on sites with the greatest wind damage. In such sites transgressives of seed origin are less important than those of stump sprouts. Red maple is rarely uprooted but rather broken off near the ground. Numerous sprouts begin to grow. Two or three eventually gain dominance while the others die. In areas of little wind damage, transgressives from stump sprouts are not as important as those from seed origin.

Shrubs.—Maple-leaved viburnum (*Viburnum acerifolium*) is by far the principal species of the shrub layer on upland areas (Table 2). The species forms a distinct layer 3 to 4 feet in height. In windthrow areas Japanese honeysuckle (*Lonicera japonica*) is quite abundant but it is usually suppressed in dense shade. Whenever a windthrow occurs near a honeysuckle vine, its growth rate increases and it begins to climb onto surrounding vegetation. Dogwood transgressives form a conspicuous part of the shrub stratum, particularly in windthrow sites.

The shrub layer of the poorly drained areas differs from the shrub stratum on the drier sites in several respects: (1) more cover, (2) higher, and (3) more species involved. Arrowwood (*Viburnum dentatum*), spicebush (*Lindera benzoin*), and greenbrier (*Smilax rotundifolia*) are the most important. Transgressives of red maple, white ash, American elm, sassafras, and black cherry form an important part of the shrub layer in the vicinity of windthrows. Black haw (*Viburnum prunifolium*) and *Rubus allegheniensis* are also associated with windthrows.

Herbs.—On upland areas there are several distinct differences in the herb layer between spring and late summer. (1) Each season is characterized by different species: May-apple (*Podophyllum peltatum*) in the spring and *Circaea quadrisulcata* in late summer. (2) Total unoccupied space is 32% higher in late summer, and (3) *Circaea quadrisulcata* is the only species with an appreciable increase in cover from spring to late summer.

Pokeweed (*Phytolacca americana*) is the most commonly encountered herb with less than 1% cover. In shaded areas, individuals attain a height of a few inches and they never flower and fruit. Whenever a windthrow occurs, pokeweed may reach a height of about 6 feet and produce abundant flowers and fruits.

Two species, spring beauty (*Claytonia virginica*) and rue anemone (*Anemonella thalictroides*), are more important than the data indicate. They appear in early April, and by May 27 (time spring data were collected) they have completed active growth, flowering, and fruiting, and are beginning to die back.

Maximum herb cover on upland areas is reached during May, and May-apple is the principal contributor. Its period of most active development is before the leaves of woody species are fully expanded. By early June the canopy is completely closed, and subsequently herb cover begins to decline.

The spring herb layer on the lowland areas is never as pronounced as that on upland sites. On the poorly drained portions it is dominated by spotted touch-me-not (*Impatiens capensis*) which, at maturity, is about 4 feet in height. It occurs in great quantities along the stream and in those sections of the lowland areas that were not damaged by recent wind storms.

Skunk cabbage (*Symplocarpus foetidus*) is second to spotted touch-me-not in its contribution to ground cover. This species is mainly concentrated in a zone that fringes the stream.

Jack-in-the-pulpit (*Arisaema triphyllum*) and *Circaea quadrisulcata*, both important on the upland sites, are of equal significance on the lowland area. In spring, where windthrows have opened up the forest, the principal plants of the herb layer are Virginia creeper (*Parthenocissus quinquefolia*), poison ivy (*Rhus radicans*), and smartweed (*Polygonum* spp.).

A total of 41 herbaceous species were encountered in the spring sampling but only 37 in late summer.

The moss cover is one of the conspicuous characteristics of the poorly drained areas. This is partially a result of a greater concentration of windthrows which expose mineral soil as well as a tangled mass of fallen trees which become habitats for corticolous and epixylic mosses.

GAP CLOSURE DATA.

Closure of gaps created by windthrow trees follows general patterns that are largely dependent upon the size of the windthrow. The complexity of the process and the number of species involved in gap closure increases with the size of the windthrow.

In one-tree windthrows on upland sites, the process is simplest. The first stage in gap filling is a burst of growth of the plants that are present. This means an increase in density and height of the shrub layer in the opening. Tree seedlings and saplings already within the area of augmented light (most commonly dogwood and white ash) are the principal candidates to fill the gap, although all tree species participate to some degree. Red maple is also a frequent gap component. It, along with some white ash, seeds in after the gap is formed. The ability of these two species to become established by seeding in windthrow areas as well as sprouting from bases of fallen trees contribute to their aggressiveness in gap closure.

The most conspicuous components of young windthrow sites are pokeweed, *Rubus allegheniensis* and *R. occidentalis*. Pokeweed is an unusually common herb in the woods, but in shaded areas it is present as inconspicuous seedlings a few inches in height. Under the augmented light conditions in windthrow areas, pokeweed grows very rapidly and soon may attain a height of six feet. It reaches its peak of development during the first three to five years of the gap, after which suppression by shading begins to reduce pokeweed importance until it occurs again as inconspicuous seedings.

Rubus allegheniensis and *R. occidentalis* both make their appearance in the windthrow during the earlier years, and during the second and third are conspicuous members of the vegetation. These two species usually increase in importance for 4 to 5 years when adequate shade is present to eliminate them.

Many herbaceous, old field species appear in windthrow openings during the early years either from seeds brought in after the opening was made or from seeds already present in the soil (Oosting and Humphreys 1940). These form a consistent but unimportant group insofar as gap closure is concerned. The number and abundance of this group are dependent upon the size of the gap and the location of the gap in relation to a seed source.

Woody "weed" species common to openings are several, but none of them are important to gap closure. Sassafras, black cherry, tree-of-heaven, smooth sumac (*Rhus glabra*), winged sumac (*R. copallina*), and red cedar (*Juniperus virginiana*) are found in the forest, but their existence there is wholly dependent upon openings.

Gap closure in the canopy is primarily a function of the forest species present rather than the function of woody adventives. The presence of the latter reflects only the changed forest environment which makes their existence possible. It is primarily white ash and red maple with occasional oak or hickory that appear to be the ultimately successful large trees in the openings.

DISCUSSION. Two features of the William L. Hutcheson Memorial Forest reflected in this study stand out as especially interesting. In the first place, being an old forest dating back to the Indian period, it is instructive to compare it with the regional forest vegetation as described by other students. Secondly, since it is located in a region subjected periodically to damaging windstorms, the process of regrowth within storm created openings is an important feature.

Relationship to the regional deciduous forests.—The oak-hickory forest is typical of the southern Piedmont (Oosting 1942). There is a transition from this type of forest to the hemlock-white pine-northern hardwoods described by Nichols (1935) which occurs in western New England (Nichols 1913, Egler 1940), in New York (Bray 1930, Hotchkiss 1932), and in western Pennsylvania (Lutz 1930, Hough 1936, Goodlett 1954). The region between the Piedmont of New Jersey and the area of the hemlock-northern hardwoods dominance is characterized by mountainous or rugged terrain. In this transition zone considerable overlapping occurs between the oaks and hickories and the species of the northern hardwoods, the dominants being determined primarily by the water relations of the site, which are in turn governed by physiography. Niering (1953), working in the Ridge and Valley Province of northwestern New Jersey, mapped by Braun (1950) as the oak-chestnut forest region, found the local physiographic features to have a controlling influence. According to Niering's study, the vegetation is a matrix of chestnut oak with ericaceous shrubs on the xeric uplands, white oak and hickory in the broad valleys, and segregates of the hemlock northern hardwoods in the most mesic sites. Similar situations have been reported in the Palisades of northeastern New Jersey by Collins (1956), in the Jersey Highlands by McDonough and Buell (1956), and in the Watchung Mountains by Baird (1956). A few miles west of the Hutcheson Memorial Forest, Cantlon (1953) reported the oak forest present on the north-facing and south-facing slopes of Cushetunk Mountain, although the northern hardwood members were more important on the north-facing slope.

East of the Piedmont on the Coastal Plain the nature of the vegetation changes rapidly. A large portion of the fire-ridden Coastal Plain of New Jersey is occupied by the Pine Barrens dominated by *Pinus rigida* (McCormick 1955, Andresen 1959). The portions of the Pine Barrens not occupied by pines are dominated by oak (Little and Moore 1949, Buell and Cantlon 1950). On the heavier Coastal Plain sediments of the Delaware River Valley, the vegetation is richer in species and is more diversified.

There is little doubt that the Hutcheson Memorial Forest represents a variant of the oak-hickory forest of the Piedmont. This is borne out by the fact that white oak, black oak, and red oak contribute 43%, 19%, and 10%

respectively to total basal area on upland sites. Red hickory ranks fourth with 5%. The problem that exists is, where in the Piedmont oak-hickory forest complex does Hutcheson Memorial Forest belong. Oosting (1942), in his work on the Piedmont of North Carolina, stated that three climax upland hardwood forest types were recognizable: (1) white oak-black oak-red oak type, (2) white oak-post oak type, and (3) white oak type. To illustrate the similarity in compostion between the white oak-black oak-red type on the Piedmont of North Carolina with Hutcheson Memorial Forest, Table 3

TABLE 3. *Percent basal area for species in the Hutcheson Memorial Forest and in the white oak-black oak-red oak forest type in the Duke Forest, North Carolina* (Oosting 1942).

Species	North Carolina	New Jersey
	% of Basal Area	% of Basal Area
Quercus alba	52	43
Carya spp.	13	5
Quercus rubra and *Q. coccinea*	8	10
Quercus velutina	5	19
Cornus florida	3	17
Nyssa sylvatica	2	< 1
Acer rubrum	< 1	2
Others	17	4

was compiled. The major differences in percent basal area involve a decrease in the importance of hickory, an increase in black oak and dogwood, and the absence of post oak (*Quercus stellata*) in the Hutcheson Forest. These differences may be associated with the effects that the more northerly latitude would have on temperature and moisture.

It is interesting to note that Niering's (1953) study shows that white oak contributes 32% to cover and hickory 15% as compared to 42% and 5% basal area respectively in Hutcheson Memorial Forest.

The above comparisons appear to establish Hutcheson Memorial Forest as a variant of the oak-hickory forest of the Piedmont. A study of size class distribution of tree species indicates that a principal northern hardwood element, sugar maple (*Acer saccharum*), is increasing in importance in the Hutcheson Memorial Forest (Monk 1961). White oak and hickory reproduction is very limited in the Hutcheson Forest. Perhaps this indicates the most significant difference between this forest and that of the southern Piedmont where the oaks and hickories appear to enjoy climax status.

Gap Closure.—As already described, the process of gap closure is essentially one of localized secondary succession. Components important in gap closure fall into three general categories: (1) shade tolerant species whose seedlings are capable of growing or remaining suppressed until a gap is formed; (2) shade intolerant species that are prolific seed producers, whose seedlings cannot withstand suppression for extended periods though present at all times through the replenishment of seedlings from year to year; and (3) species with wind transported seeds. When a gap is formed the old field species make their initial appearance and there is a burst of growth of the species present in shrub and herb layers. The omnipresent seedlings and saplings of flowering dogwood and white ash along with red maple which rapidly seeds into windthrow areas overtop the shrub layer in 5 to 6 years. Transgressives of the other forest trees are sometimes present. The crowns of the transgressives begin to coalesce, forming a stratum above the shrub layer. As this occurs, the old field shrubs and herbs begin to disappear rapidly. The herb and shrub layers begin to approach their normal appearance in the forest. Sassafras, black cherry, tree-of-heaven, red cedar, and sweet cherry may die through competition in gap closure. This occurs particularly during the interval between the time when the crowns of the young trees have essentially coalesced at 8 to 10 feet and the period when the dogwoods attain their understory height of 20 to 30 feet and are overtopped by the few remaining transgressives. These continue to fill the gap.

An interesting process is recognized when the phenomenon of gap closure is considered from the initial opening to closure. The initial opening of a forest destroys the pronounced stratification by removing the canopy and understory and by disturbing the shrub and herb layers. As the gap begins to close the sequence of re-stablishment progresses from the herb layer to the shrub layer to the understory and canopy.

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