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Relationships of natural vegetation to physico-chemical properties of soils in Massachusetts.

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RELATIONSHIPS OF NATURAL VEGETATION TO PHYSICO - CHEMICAL PROPERTIES OF SOILS IN MASSACHUSETTS

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INTRODUCTION

"Every plant is a measure of the conditions under which it grows." This statement was made by F. E. Clements (4) in 1920, but in general, such was not an entirely new idea for the early Greeks and Romans recognized soil differences as indicated by various types of vegetation. However, the work of these early investigators, along with that of later writers, was of a very general nature.

With the growth of plant Ecology, the more definite physical and chemical properties of the soil were associated with plant distribution within a given region. Naturally, in the establishing of such plant and soil relationships, there has been much disagreement of opinion among those actively engaged in the study, probably due to the fact that soil and climatic conditions vary tremendously the world over. In fact, such differences of opinion led to the establishing of two schools of thought. The chemical nature of the soil was cited by one school as having the greatest significance upon natural distribution of plants, while on the other hand, many contended that the physical properties of the soil exerted the most influence upon presence or absence of particular plant species or associations within a given locality. Of the different chemical and physical properties of the soil considered in this connection, perhaps the Hydrogen-ion concentration and the moisture relations of the soil have been studied the most intensively. These factors have been credited as exerting much influence upon plant cover, although results indicate that relationships existing in one region do not necessarily occur in other localities that have been under observation.

Today, the general concensus of opinion, among those interested in the subject, seems to be that both the Hydrogen-ion concentration and the moisture relations of the soil, among other factors, play in some manner or other important roles in governing the type of vegetation growing within a given region, much depending upon particular situation under question.

REVIEW OF LITERATURE

Rich (24) surveyed the vegetation on Oak Island, near Boston, Massachusetts, in 1902. Over four hundred different species were reported as having been found growing on the Island. However, no relationships between soil and flora were discussed.

Hilgard (14) in his book "Soils" published in 1906, wrote extensively on the recognition of character of soils from their native vegetation. Much data was presented to show that certain plant species grow on soils of a particular chemical and physical make-up. However, he was especially interested in chemical factors of the soil as influencing vegetation. The point was stressed that an ecological analysis aids materially in making a general estimate of the agricultural value of land. Clements (4) considers him to be one of the few outstanding pioneers in this particular field.

Fernald, M. L. (9) studied soil preferences of certain alpine and sub alpine plants as occurring in New York, New England, and eastern Canada (1907). After a rather exhaustive investigation, he concluded that ".... the alpine plants are much more dependent upon the chemical constituents of the soil than has been generally supposed."

Sampson (26) was of the opinion that many plants are sensitive to soil reaction while others are indifferent to degree of soil acidity or alkalinity, (1912). Conclusions were based on pH values of one hundred soil samples representing several types of habitats. In regard to influence of chemical and physical properties of a soil upon plant distribution, the physical properties were referred to as being important in many instances, but the chemical nature of the soil complex, especially Hydrogen-ion concentration, was considered the major factor.

Tillotson (28) speaking before the Society of American Foresters in 1913, stated that the physical properties of the soil, particularly the available soil moisture, are of the utmost importance in regard to the differences in plant growth and plant formations.

Brooks (2) offered suggestions for judging the value and adaptation of land in Massachusetts (1914). The soils were classified as follows:

1. Inferior Soils
2. Good Soils
3. The Best Soils

Such a classification was based on depth and color of surface soil, level of water table, soil texture, nature of subsoil, and natural vegetation. For each of the three types of soils, certain herbs, shrubs, and trees were noted as being characteristic of the various soil groups. In general, he suggested that the physical properties of the soil, especially the water-holding capacity, are most influential on controlling distribution of flora. However, it was stated that some plant species do best on soils of a particular soil reaction.

Kearney et al (16) made an intensive study of soil and plant relationships in Tooele Valley, Utah (1914). Various laboratory tests were made on the soil samples collected in areas of different flora. Results of soil tests showed great differences in their physical and chemical properties. Consequently, the conclusion was reached that a certain plant, or plant association in that region indicated a soil of certain moisture and salinity properties, all of which could be used in estimating value of land for various agricultural purposes.

Hershberger (11) made a detailed study of the Pine Barrens in New Jersey (1916). In respect to his investigations on plant and soil relationships, nine stations were selected on various soil types which were studied. Plants growing on these soils were noted while samples of both the top and subsoil were taken. Various laboratory soil tests were run on these soils. Of special interest was his work on moisture-retaining capacity of four of the soil types selected. His conclusions showed that soils with a low moisture-holding capacity supported the growth of certain plants while other soils with a comparatively higher moisture-holding capacity were characterized by presence of still other species.

Fernald (8) investigated certain lithological factors as limiting distribution of Pinus Banksiana and Thuja occidentalis (1919). It was emphatically stated that Pinus Banksiana grows in acid soils while Thuja occidentalis is found on alkaline soils. In Massachusetts, Thuja occidentalis was referred to as being commonly present on the limestone soils of Berkshire County.

Wherry (30) in 1920, conducted soil tests of Ericaceae and other reaction sensitive families in northern Vermont and New Hampshire. Five regions were selected for the experiment, soils of four of the regions being mediacid or subacid in reaction, while the fifth area was characterized by soil of a minimacid reaction. For each of the stations, plants were recorded and it was noted that members of the heath family were abundant on the mediacid and subacid soils, while such plants were rare on the minimacid soils.

The fact that every plant has an acid and an alkaline limit to its growth was pointed out, and if the margin is wide, the plant concerned is considered to be indifferent to soil reaction. Further, he stated that there occurs much variation within a plant family in respect to soil reaction preferences of the various species. Much evidence was presented to prove this point. Soil reaction was regarded as not the major factor in plant distribution but as one of the major factors affecting plant cover.

Pearson (23) conducted an extensive ecological survey in the San Francisco mountains region of Arizona (1920). Chemical analyses were made of the various soil samples collected during the investigation. Results seemed to indicate that chemical properties of soil were not the limiting factors in controlling the distribution of plants within a region having the same climatic conditions. On the other hand, his work indicated that certain physical properties of soil, namely; water-holding capacity, wilting coefficient and permeability were of great consequence in respect to plant distribution.

Wherry (31) published in 1920 an account of a study on plant distribution around salt marshes in relation to soil acidity. In his publication, he argued very forcibly that chemical factors, as well as physical factors of the soil, are of extreme importance in relation to plants that grow on any particular soil.

Atkins (1) carried on investigations in India and the British Isles (1921) on the relationship existing between the Hydrogen-ion concentrations of the soil and plant distribution. His work pointed out that certain species will tolerate a wide Hydrogen-ion range in the soil which other species will not grow under such conditions. He also showed that there are differences of certain species within a given genus in respect to preference of soil reaction. Further, he stated that "Presence or absence of a plant in a given locality stands in close relation to the Hydrogen-ion concentration of the soil."

Comber (5) writing in 1921 suggested that Hydrogen-ion concentration of the soil is only indirect in its influence on vegetation. He criticized previous work on the subject stating that the relation of Hydrogen-ion concentration to plant growth is a relatively simple problem, whereas the relation of the Hydrogen-ion concentration of the soil to plant growth is a very complex problem.

Salisbury (27) made a rather detailed study of plant successions and soil changes in 1922. The soils of sand dunes were under observation. Embryo dunes exhibited soils alkaline in reaction and had a particular plant cover. The soil of the older dunes was found to have rather acid pH values, all depending upon age of the formation--the older the dunes the more acid the soil. With this edaphic change in pH was correlated the accompanying successions in the vegetation.

Wherry (33) explained in 1922 that much work was being done in Denmark, Sweden, India, British Isles, and the northeastern section of the United States in respect to soil and plant relationships. He reported that in all cases, recognition had been made of the great significance of the soil in controlling the growth and distribution of plants. To point out that climate, location, and surroundings are not always the limiting factors in plant distribution, the fact was explained that certain plant species that grow on particular soils in this country, are also established on similar soils in Europe where climatic conditions are quite different from those in our country.

Kelley (17) working in Southeastern Pennsylvania (1922), set forth to determine as to whether or not a definite relation exists between soils and the flora growing on them. He was especially interested in soil acidity as being a factor in plant distribution. Soil samples were taken at various stations and the vegetation growing on these soils was recorded. No system for recording density of land cover was used in this investigation. A definite pH figure was assigned to each of the seven soil types studied, top soil alone being considered. Results indicated that soil acidity influences flora to such a degree that certain plants may be designated as indicators of particular soil types.

Kurz (18) in 1923, conducted an investigation in Illinois studying the influence of Hydrogen-ion concentration of the soil as a factor in plant distribution. He noted that many plants usually thought to be so-called acid soil plants were found growing in soils having a wide range in Hydrogen-ion concentrations. Hence, he concluded that pH of the soil is not the main factor in determining the distribution of the plants considered in his work.

Olsen (22) published results of an extensive research problem on the Hydrogen-ion concentrations of certain Danish soils and influence of such upon the vegetation, 1923. The soils examined varied from 3.4 to 8.5 in pH values. In his survey, both meadow and woodland species were studied, seventy-six localities having been represented in the experiment. Data on several plants was presented and it was found that the Hydrogen-ion concentration of the soil appeared to have a decided influence upon distribution of natural vegetation.

Christopherson (3) conducted a very careful survey in the high mountains of Southeastern Norway on the soil reaction in relation to plant distribution, (1925). Soils in the region were found to vary from a pH of 3.6 to 7.1. The results of his investigation clearly showed that each plant association is characteristic of soil having a rather narrow range in the pH limits.

Wherry (32) wrote on soil reaction preferences of thirty groups of related plants as found in eastern North America, (1927). It was found in general that the southern and southeastern species preferred the acid soils while the northern and western species were associated with the less acid soils.

Craib (6) has done a considerable amount of research work on aspects of soil moisture in the forest and its relation to vegetation. His experiments were conducted in New Hampshire, results being published in 1929. Of special interest, was the idea that the index of productivity of a soil can be measured by the maximum volume of available water and the actual volume of available water the soil holds.

Morrow (21) attempted to correlate plant communities with the reaction of certain soils as found in Southeastern Texas (1931). Determinations of pH value were made for several soil samples taken at depths of four and twelve inches. It was found that the Hydrogen-ion values obtained for the two depths varied little for a given station. The stations under observation, having soils of various pH values, were closely associated with differences in plant cover. Hence, soil reaction was considered of much consequence in relation to flora distribution.

Hicock et al (13), working in Connecticut, (1931), attempted to establish relationships between forest composition and certain soil characters. Their results indicated that in the particular region studied there is apparently no real correlation between given tree species and specific soil types. The same held true for lesser vegetation. However, when the soils were classified into four broad groups on a basis of moisture conditions, some relationship did exist between these groups and the vegetation.

The lack of correlation between certain plants and specific soils types was explained as follows: first, that certain soil types might be biologically equivalent, and secondly, "the climatic conditions within the region in which the studies were made are generally favorable to the development of fairly luxuriant plant growth. The ecological margin of safety in the region is rather wide and it is reasonable to suppose that the general excellence of climatic factors may compensate to some extent for poverty of certain soil conditions."

Lawrence (19) conducted a land cover survey in Washington county, Rhode Island (1933) for the purpose of correlating major vegetation units with soil series.

His results show that there is a correlation between flora and soil. Such edaphic factors as moisture, relative fertility, and physical state of soil were stressed as being extremely important in regard to soil and plant relationships. Several plant species were cited as being characteristic of particular soil series. No correlation seemed to exist between vegetation and soil type, or brush and soil series. The point was stressed that certain soil types may be biological equivalents of each other. Further, he set forth the idea that "there is a high degree of correlation between productivity of soil series as evidenced by natural vegetation growing upon them, and the degree of selection on the basis of productivity--made by the agriculturist in the growing of cultivated crops."

Wilde (35), pursuing research work in the Lake States region, (1933), studied the relation of soils to forest vegetation. In his publication, he reported the following features to be of prime importance in correlating soils with forest growth: State of underground water, topography, soil texture, soil structure, and nature of soil profile. Water was considered to be a tremendous factor in governing distribution of species since soils constantly influenced by a high water table (peats, mucks), and poorly drained soils, were usually characterized by the presence of certain definite plant species. However, soils not influenced by the water table supported a forest stand determined by the texture of the soil. For each of the various textures of these soils, he listed characteristic associated plant species. Further, it was explained that a classification of such a nature according to texture might lead to difficulties (clays and podsols, for example) since other factors must be considered.

Wilde (36) determined the pH of several forest soils (1934). For the soils having rather low pH values, variour trees, especially the conifers, were characteristic. On soils having higher pH values, the better hardwoods grew abundantly. Continuing, he stated that "Some members of the ground-cover, particularly, show a remarkable correlation with the pH value of the soil, and this helps considerably in practical classifications of forest areas."

Ikenberry (15) carried on research work (1936) on the relation of Hydrogen-ion concentration to the growth and distribution of mosses. Twelve hundred Hydrogen-ion determinations were made on substrata of mosses from several different stations. Among the forty-six different mosses studied, there seemed to be much variation in respect to their soil reaction preferences. In general, there was no apparent correlation, yet, a few species were limited to narrow pH ranges and can be called reliable indicators. However, the author argued that other soil factors are more important in respect to governing distribution of mosses than is the pH value of the particular soil in question.

Hazard (12)in 1936, worked in Southern New Hampshire on indicator types in relation to pure white pine sites. Five major vegetation types were described as being characteristic of soils varying primarily in pH, texture and moisture relations. For each vegetation type, several of the more important plant species were cited. It was pointed out that presence of a particular vegetation type in a given region might serve very well to indicate trend of future plant successions on the area in question.

Turner (29) reported in 1937 that certain soil-topographic features are extremely important in influencing the distribution of forest types in Arkansas. Important factors considered were degree of slope, its effect upon drainage, depth of soil and physical structure of horizons. Several different soils, varying in previously stated factors, were examined and for each, certain forest types were listed as being characteristic. This paper stressed the importance of soil water and plant relationships.

PURPOSE OF THE INVESTIGATION

In scattered regions of this country and elsewhere, a fair amount of work has been done on soil conditions as affecting the natural distribution of plants, but such has received comparatively little attention in Massachusetts. Because of this, it was felt that if certain plant and soil relationships could be uncovered, such might add that much more to already existing knowledge on the subject, and further, any information obtained might prove to be valuable in serving as a basis for future work in such a direction in this state.

With this in mind, the purpose of the problem under study resolves itself into two major divisions; namely,

1. An attempt to establish relationships between the maximum water-holding capacity of certain soils and the vegetation found growing on these soils.
2. An attempt to show relation between natural distribution of plants and soil reaction.

The maximum water-holding capacity of the soil was chosen as a typical physical property to investigate since any factor that affects soil moisture to an appreciable degree can be considered as being important in relation to the growth of plants. Craib (6), Kearney (16), Harshberger (11), Pearson (23), Tillotson (28), Hicock et al (13), Wilde (35), and others have all stressed the importance of soil water as influencing distribution of native plants.

In a similar manner, the pH of the soil was selected as a chemical factor to study since many workers, among whom are Fernald (8, 9), Wherry (30, 31, 32, 33), Atkins (1), Salisbury (27), Morrow (21), Kelley (17), Wilde (36), Sampson (26), Olsen (22), and Christophersen (3), have shown that the Hydrogen-ion concentration of the soil does influence, in some manner or other, the distribution of plants.

Not losing site of the fact that the B soil horizon, as well as the A soil horizon is of importance in affecting the growth of plants, both the top soil and the subsoil were considered in this investigation.

Further, this problem does not have for its purpose that of discussing why or why not particular plants occur on different soils. The object has been merely to present a picture of the situation as it was found in the field.

METHOD OF PROCEDURE

Field Technique

Field Stations

The field work of the investigation was conducted during the year of 1938. Because of the nature of the problem, stations examined were located in widely scattered sections of the state, the following counties being represented: Berkshire, Franklin, Hampshire, Hampden, Worcester, Norfolk, Plymouth and Bristol.

Areas under direct observation were located with much care and discretion such that vegetation studied was as nearly typical of the territory as possible. In all cases, sites were selected on land not now or recently under cultivation. During the course of the field work, thirty different soil series were encountered, thus insuring a wide variety of soil conditions. Table I lists the soil series on which data was recorded.

TABLE I

SOIL SERIES REPRESENTED IN THE SURVEY

Glacial Till Soils Predominantely From Granite, Sandstone or Quartzite, (crystalline rocks).

Parent Rock Material	Drainage	Name of Soil
Granite, Gneiss Sandstone	Well-Drained	Gloucester
Granite, Gneiss	" "	Narragansett
Quartzite	" "	Coloma
Granite, Slate	" "	Becket
Granite, Gneiss Sandstone	" "	Plymouth
Red Sandstone Shale	" "	Cheshire
Granite, Gneiss Sandstone	Imp. Drained	Essex
Granite, Slate	" "	Woodbridge
Granite, Sandstone	" "	Whitman

Glacial Till Soils From Slate, Shale or Schist

Parent Rock Material	Drainage	Name of Soil
Schist, Gneiss	Well-Drained	Brookfield
Schist, Slate	" "	Charlton
Red Shale, Sandstone	" "	Wethersfield
Schist	" "	Berkshire

TABLE I (Con't)

Glacial Till Soils With More or Less Lime Influence

Parent Rock Material	Drainage	Name of Soil
Limestone, Slate	Well-Drained	Pittsfield
Schist, some limestone	" "	Worthington
Limestone	" "	Dover

Glacial Lake or Terrace Soils Mainly From Granite or Crystalline Rocks

Parent Rock Material	Drainage	Name of Soil
Granite, Sandstone, Gneiss	Well-Drained	Merrimac
Red Shale & Sandstone	" "	Chicopee
Granite, Gneiss & Sandstone	" "	Hinckley
Red Shale & Sandstone	" "	Enfield
Granite, Sandstone	" "	Carver
Sandstone & Shale	Imp. "	Scarboro
Gray Slate & Shale	" "	Suffield
Red Shale & Sandstone	Well-Drained	Manchester
Granite, Gneiss Shale	" "	Warwick

TABLE I (Con't)

Flood Plain or River Terrace Soil

Parent Rock Material	Drainage	Name of Soil
Sandstone, Shale, Schist	Well-Drained	Hadley
Sandstone, Shale, Schist	" "	Agawam
Miscellaneous Materials	Imp. "	Meadow
Miscellaneous		
Rough Stony	Muck	

Field Data

A special form sheet was devised for use in recording field data. This sheet allowed for noting the station number, location of station, date, soil type, various species and number of each growing within a designated area, and other ecological notes. For convenience in conducting the laboratory work and the compilation of data, space was also provided for computing the maximum water-holding capacity and recording of the pH of both the A and B horizon soil samples taken at each station.

A modification of the "belt transect" system (34) was employed in listing the species and number of trees and shrubs growing on a definite area of soil. A fiftyfoot steel tape was used as a transect line and the species and numbers of individuals, occurring within a three-foot area along this line, were recorded. In several instances, it seemed advisable to establish more than one transect line, especially in regions which exhibited a wide variety of species. Naturally, such a system must be used with much discrimination in order to make fair comparisons between the various stations examined.

The transect lines established for surveying the trees and shrubs were used as a basis for studying the herbaceous cover. List quadrats, one yard square, as described by Weaver and Clements (34) were located along the transect lines, a yardstick and pegs being used to accurately establish the quadrats. This type of quadrat seemed most applicable in this case since Hanson et al (10) say that "The purpose of the quadrat and the nature of the vegetation are major factors in determining method to employ." Here again, the species and numbers of each were recorded, the average number of individuals for each species per quadrat being reported for the station.

During the survey, over two hundred species were encountered and data for each was recorded. However, not enough information was obtained for many of the species to warrant statistical analysis as presented later for plants reported on. Throughout the entire study the common names of the plants concerned have been used, Latin names for which appear in the Glossary.

It should be noted that trees only shoulder high or over were considered. Also, due to habit of growth of certain plants, they did not lend themselves applicable to ecological analysis as previously described. Hence, low blueberry, huckleberry and Kentucky blue grass were reported for on an estimated percentage of ground cover. Further, figures presented for broomsedge are on the transect basis, while Wintergreen was tabulated on the quadrat basis.

Soil Samples

Soil samples of both the A horizon and the B horizon were taken at each station. To insure a fair sample, several borings were made with a soil auger ($1\frac{1}{2}$ inch diameter) along each transect line and a composite sample from these borings was made. Samples were kept in regular soil tins until needed for further use.

LABORATORY TECHNIQUE

Determination of Maximum Water-Holding Capacity of Soil.

The maximum water-holding capacities of the soil samples, representing the A and B horizons, were determined according to the Hilgard method as outlined by Lyon, Fippin and Buckman (20) with a few minor changes. Instead of starting with a definite weight of air dried soil, wetting the soil, and then weighing again, the samples were first wetted, then weighed, dried for twenty-four hours in an oven at 110° C, and finally, weighed a second time. Percentage of water retained was calculated on a dry soil basis. It is realized that such capacities obtained cannot be considered as actual values normally occurring in undistrubed soil but rather as comparative values.

Determination of pH

The Beckman glass electrode potentiometer was employed in finding pH values of soil samples collected.

PRESENTATION AND DISCUSSION OF DATA

Maximum Water-holding Capacity Of The Soil And Plant Distribution.

Statistical Treatment of Data

For convenience in tabulating data, the maximum water-holding capacities, which varied from approximately 30 percent to 130 percent for various soils collected, were grouped into ten classes. The first class included those soils that held 30 percent to 40 percent moisture, the second class of soils retained 40 percent to 50 percent water, etc. According to this purely arbitrary system, the number of stations represented in each class is shown in table II.

It should be made clear at this point that samples of both the top soil and subsoil were taken at each station, but the number of stations represented in each corresponding maximum water-holding capacity class of both the top soil and the subsoil varies since invariably, the moisture retaining power of these two soil horizons at given station differs, the subsoil almost always holding less water than the surface layer does.

TABLE II

Number of Stations Represented In Each Maximum Water-holding Capacity Class Of Soils Considered.

M. W. H. C. Class	Horizon A	Horizon B
30-40	22	42
40-50	22	33
50-60	32	44
60-70	27	28
70-80	28	19
80-90	23	11
90-100	15	7
100-110	7	0
110-120	6	0
120-130	7	0

Since an equal number of stations was not represented in each maximum water-holding capacity class as indicated in Table II, it was necessary to resort to comparative figures in order to reveal any true relationships that might occur between plant species and water retaining power of soil. Hence, each plant species was treated separately in the following manner:

1. The number of individuals, occurring in each maximum water-holding class, was determined from data as secured from field

sheets.

2. The average number of individuals, per quadrat or transect, as the case might have been, was found for each class of soils by using the total number of plants obtained for each capacity class (step 1) as the numerator and the number of stations representing that particular water-holding capacity range as the denominator.
3. The average number of individuals per station for each class was added to obtain the sum total of the average number of individuals per station.
4. Finally, the relative abundance in percent for each maximum water-holding capacity class was computed by using the various values obtained in step 2 as the numerators and the sum found in step 3 as the denominator.

To illustrate this method, Table III shows how relative abundance values (in percent) were obtained for broomsedge.

Accordingly, Table IV shows relative abundance in percent of certain plants present in each soil water-holding capacity class recognized.

In order to study the picture more clearly, a purely arbitrary system, based on values obtained in this investigation, has been devised dividing the maximum water-holding capacity range into three major groupings as follows:

30%-60% represents comparatively low M. W. H. C.

60%-90% represents a medium M. W. H. C.

90%-130% represents a comparatively high M. W. H. C.

TABLE III

Basic Data

Broomsedge	Soil Hor.	Maximum W. H. C. of the Soil				
		30-40	40-50	50-60	60-70	70-80
Total Number of Plants	A	228	610	395	174	8
	B	924	300	141		
Average Number of Plants Per Station	A	10.36	27.72	12.34	6.44	0.28
	B	23.19	9.09	3.20		
Relative Abundance (%)	A	18.13	48.51	21.59	11.27	0.49
	B	65.36	25.62	9.02		

Plants Characteristic of Soil Having A Comparatively Low Water-holding Capacity.

Several plant species seem to be characteristic of the lighter soils that occurs in Massachusetts. Some plants usually found growing on well-drained areas, where both the top soil and the subsoil hold little water, are listed as follows; pitch pine, black oak, sweet fern, scrub oak, broomsedge, lespedeza, indigo, bird-foot violet, lupine, and cinquefoil. In general, these plants were found growing the most abundantly on the following soil series: Carver, Chicopee, Hinckley, Merrimac, and Plymouth, all of which (with the exception of Plymouth)

TABLE IV

Relative Abundance of Certain Plants
In Each Maximum Water-Holding Capacity Class of Soil Considered

Plant	Soil Hor.	Maximum Water-Holding Capacity of the Soil									
		30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
Alder (speckled)	A				18	47	15	12			8
	B		8	13	29	42	8				
Anemone	A			9	8	14	18	20			31
	B			23	20	36	21				
Arrow-wood	A		1	2	1	3	14	35	26		18
	B	8	18	1	19	16	19				
Ash (white)	A			10	8	6	10	21	32		13
	B		1	16	21	35	20	7			
Beech	A			1	4	10	9	9	39		28
	B		1	10	15	60	14				
Bellwort	A				1	8	7	13	19	11	41
	B					30	12	58			
Birch (Black)	A	5	9	4	23	21	16		17	5	
	B	9	16	23	11	39	4				
Birch (Canoe)	A	4	2	2	8	8	6	13	34		23
	B	5	9	11	18	20	37				

TABLE IV (Con't)

Plant	Soil Hor.	Maximum Water-Holding Capacity of the Soil									
		30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
Birch (grey)	A	9	26	18	18	10	5		13		1
	B	20	23	18	13	9	10	7			
Birch	A		4	3		32	61				
(Yellow)	B	10	7	83							
Blueberry	A	7	1	18	50	14		5			5
(low)	B	14	27	17	2	40					
Blueberry	A		5	4	7	11	14	21	26	7	5
(high)	B	1	11	10	7	38	28	5			
Broomsedge	A	18	48	22	11	1					
	B	65	26	9							
Buttercup	A			7	4	16	21	4	36		12
	B		10	7	45	18	2	18			
Cherry	A	36	12	17	8	13	5	7	2		
(choke)	B	16	29	17	13	11	7	7			
Cinnamon	A			2		21	9	17	18	17	18
fern	B		55	9		18		18			
Cinquefoil	A	15	5	28	30	6	9	4	3		
	B	21	9	46	24						
Dandelion	A					10	17		50		23
	B		11		43	22		24			

TABLE IV (Con't)

Plant	Soil Hor.	Maximum Water-Holding Capacity of the Soil 30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
Elm (American)	A			1	1	7	20	13	24		34
	B		25	8	17	18	34				
False Lily of the valley	A	2	1	1	5	5	13	6	1	12	54
	B	3	2	10	3	38		44			
Flowering Dogwood	A				23	62	15				
	B			38	43	10	9				
Hardhack	A		2	5	6	23	9	8	22	10	15
	B	1	16	22	31	8	18	4			
Hemlock	A	1	1	17	14	10	8	34	6		9
	B	3	37	20	16	4	6	14			
Hickory	A	2		3	15	11	26	32	5	6	
	B		1	15	42	33	9				
Huckleberry	A		29	15	6	46	4				
	B	33	24	4	18	21					
Indigo	A	70	22			8					
	B	57	23				20				
Ironwood	A			5	2	5	14	34	31		9
	B			27	47	7	19				
Jack-in-the Pulpit	A				4	1	25	25			45
	B		55	4			41				

TABLE IV (Con't)

Plant	Soil Hor.	Maximum Water-Holding Capacity of the Soil									
		30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
Kentucky blue grass	A			2	2	4	17		23		52
	B		3	1	24	12	16	44			
Ladys' Slipper	A	12	28	1	7	30					
	B	9	17	24		17	26	7			
Lespedeza	A	30	48	12	10						
	B	87	9	4							
Lupine	A	67	33								
	B	95	5								
Maple (red)	A	3	6	5	15	8	9	14	14	12	13
	B	1	10	25	8	20	14	22			
Maple (sugar)	A	2	1	2	9	10	13	17	32		14
	B	1	10	16	19	22	25	7			
Meadow-sweet	A		1	1	6	21	6	14	23	10	18
	B		6	12	20	19	35	8			
Mountain Laurel	A	6		25	22	16	21	7			
	B		17	60	11	2	4				
Mouse-ear Chickweed	A					2	20	10	52		18
	B			6	38	40	17				
Oak (Black)	A	55	6	12	11	11	5				
	B	42	40	9		9					

TABLE IV (Con't)

Plant	Soil Hor.	Maximum Water-Holding Capacity of the Soil 30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
Oak (red)	A	3	7	6	11	10	13	19	29		2
	B	4	6	16	21	18	18	17			
Oak (scarlet)	A		16	6	18	26	9	6	6	7	6
	B	3	15	11	6	34	26	5			
Oak (scrub)	A	60	23	6	9			2			
	B	80	14	5	1						
Oak (white)	A	2	10	14	23	12	11	8	11	9	
	B	6	19	11	19	11	9	25			
Pith pine	A	55	29	11	4			1			
	B	74	13	11	1			1			
Plantain (common)	A					12	11	5	31		41
	B			3	23	20	20	34			
Plantain (English)	A						13	25	44		18
	B				16	35	24	25			
Red Cedar	A	2	25	15	9	35	10	4			
	B	8	57	29	6						
Sarsaparilla	A	8	3		17	28	9	1	1	2	31
	B	5	22	15	17	41					
Sensitive fern	A					70	3	13			14
	B		58	9	33						

TABLE IV (Con't)

Plant	Soil Hor.	Maximum Water-Holding Capacity of the Soil									
		30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
Shad Bush	A		18	7	18	20	3	10		13	11
	B	39	3	3	3	45	7				
Sheep Laurel	A			2	9	24	22	28	7	6	2
	B		1	32	40	17	10				
Shrubby Cinquefoil	A					4	16	1	16	19	44
	B		5		19	5	25	46			
Skunk Cabbage	A					10	32	38			20
	B		34	8	4		54				
Sorrel	A	3	13	18	35	2	15	11	3		
	B	9	4	29	47	11					
Spotted wintergreen	A	3	28	2	21	7	13	26			
	B	8	6	18	14	21	33				
Spruce (Canadian)	A				14	6	16	19	37	3	5
	B			1	2	64	20	13			
Strawberry	A	7		4	2	7	12	5	34	14	15
	B	7	6	6	29	16	12	24			
Sweet fern	A	3	40	30	21	3	2	1			
	B	41	15	41	3						
Violet (Bird-Foot)	A		40	53	7						
	B	92	8								

TABLE IV (Con't)

Plant	Soil Hor.	Maximum Water-Holding Capacity of the Soil									
		30-40	40-50	50-60	60-70	70-80	80-90	90-100	100-110	110-120	120-130
White pine	A	7	7	14	7	9	10	14	13	4	15
	B	8	19	14	13	7	14	25			
Wild oat grass	A	4	16	29	50	1					
	B	23	29	17		18	13				
Wintergreen	A		5	18	20	20	5	27			5
	B		14	32	20	13	21				
Witch-hazel	A		11	5	24	8	15	16			21
	B	4		12	29	33	26				

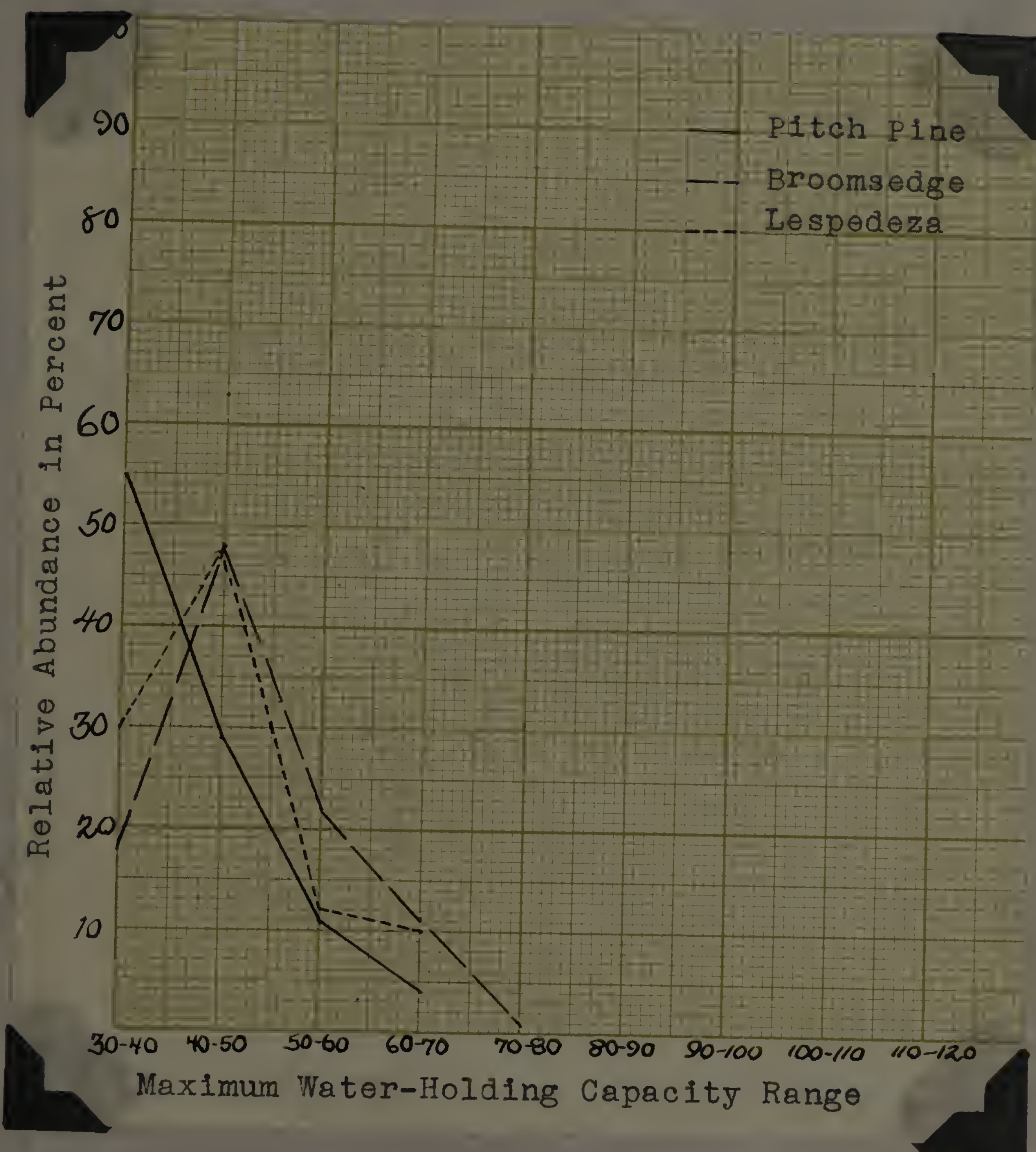
are outwash soils, light in texture, and underlain by stratified sand and gravel. Wilde, (35) reported black oak and shrubby oak as occurring on the poorer sandy soils of the Lake States region while sweet fern was noted as being abundant on the moraine sands. Pitch pine and scrub oak were listed by Lawrence (19) as being common on the well-drained, sandy soils of Southern Rhode Island. Hicock et al (13), have recorded black oak as being abundant on certain lighter well-drained soils of Connecticut. In the pine barren region of New Jersey, Harshberger (11), revealed that pitch pine and scrub oak grew abundantly on soils having a maximum water-holding of about 45 percent, while black oak was indigenous to soil that held about 56 percent moisture. Hazard, (12) observed in New Hampshire that although broomsedge and low blueberries were typical of the poorer soils, such soil was also characterized by an occasional white pine, pitch pine, gray birch, cherry and red maple. Further, Brooks (2) stated that the poorer soils of Massachusetts supported the growth of such plants as broomsedge, lespedeza, rabbit's foot clover, lupines, gray birch, scrub oak, scarlet oak and pitch pine.

Figure I shows curves for relative abundance of three species typical of soil having a low maximum water-holding capacity.

<u>Species Characteristic of Soil in Which Horizon A Soil Has A Medium Maximum Water-holding Capacity While Horizon B Soil Has A Comparatively Low Moisture-Retaining Capacity</u>.

On such soils, low blueberry, huckleberry, mountain

FIGURE I



Three plant species typical of soil having a low maximum water-holding capacity.

laurel and wild oat grass were observed as being present in the greatest amounts. Low blueberries were noted by Wilde (35) as growing the most abundantly on sandy soils. Harshberger (11) and Hazard (12) were of a similar opinion.

Plants Characteristic Of Soil Having A Medium Maximum Water-holding Capacity.

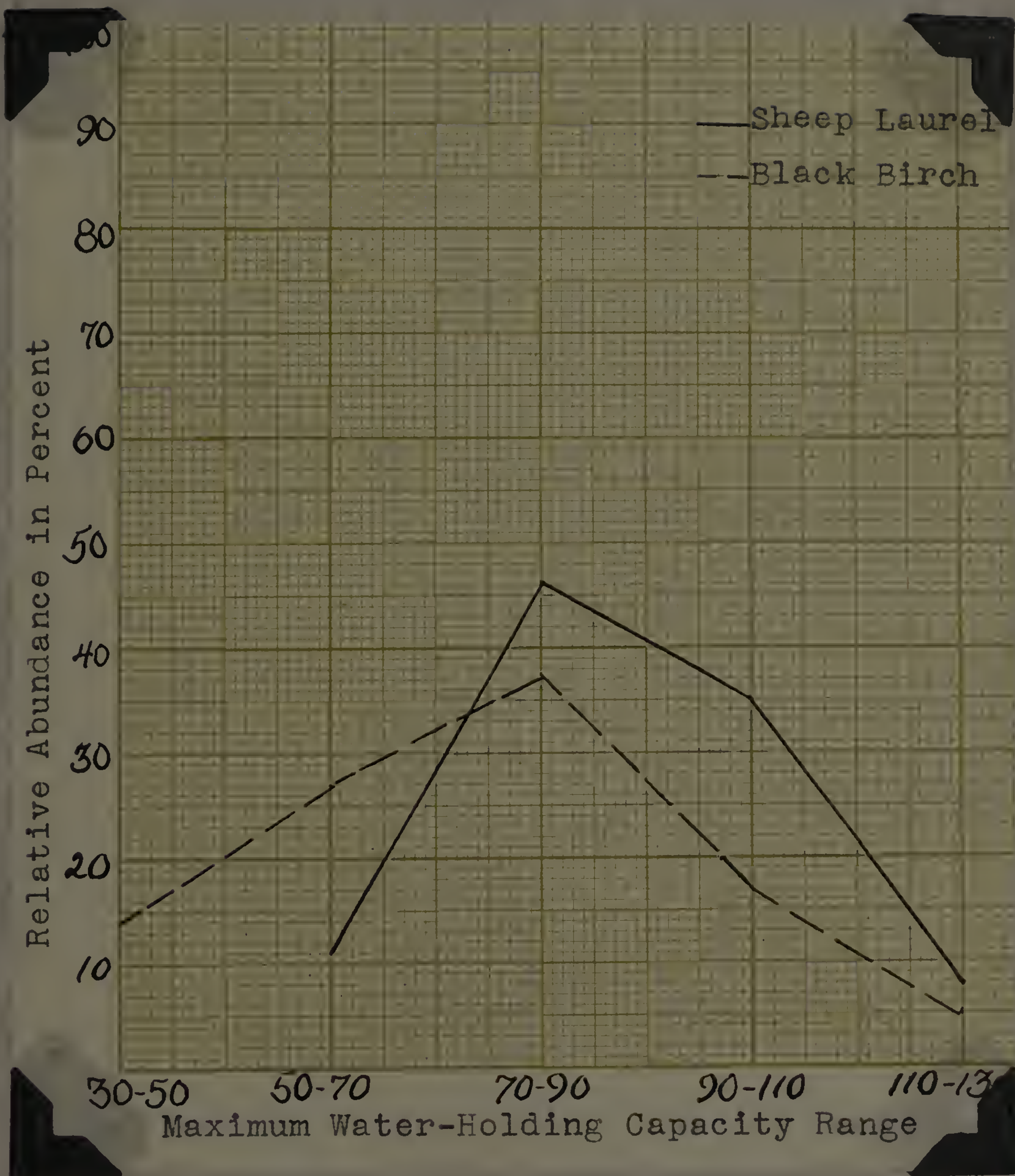
Black birch, flowering dogwood, hickory, sheep laurel, white oak, scarlet oak, and sorrel have been noted as growing on a wide variety of soils but generally speaking, these plants were most abundant in areas where both the top soil and the subsoil were found to have a medium maximum water-holding capacity. Wilde (35) found white oak, red oak, and canoe birch as being common on the better sandy soils. Red maple, flowering dogwood, white oak, and pitch pine were cited by Harshberger (11) as being common on the deciduous forest soils.

The above-mentioned species cannot be considered as a group commonly occurring on certain soil series since so many other ecological factors must be taken into consideration such as soil reaction, plant competition, and many others, perhaps several of which are not as yet fully understood.

The relative abundance curves for black birch and sheep laurel are given in figure II, these two species being common on soil that holds a medium amount of water.

Certain Species Found Growing The Most Abundantly On Soil Having A Comparatively High Maximum Water-holding Capacity.

FIGURE II



Two plant species characteristic of soil having a medium maximum water-holding capacity.

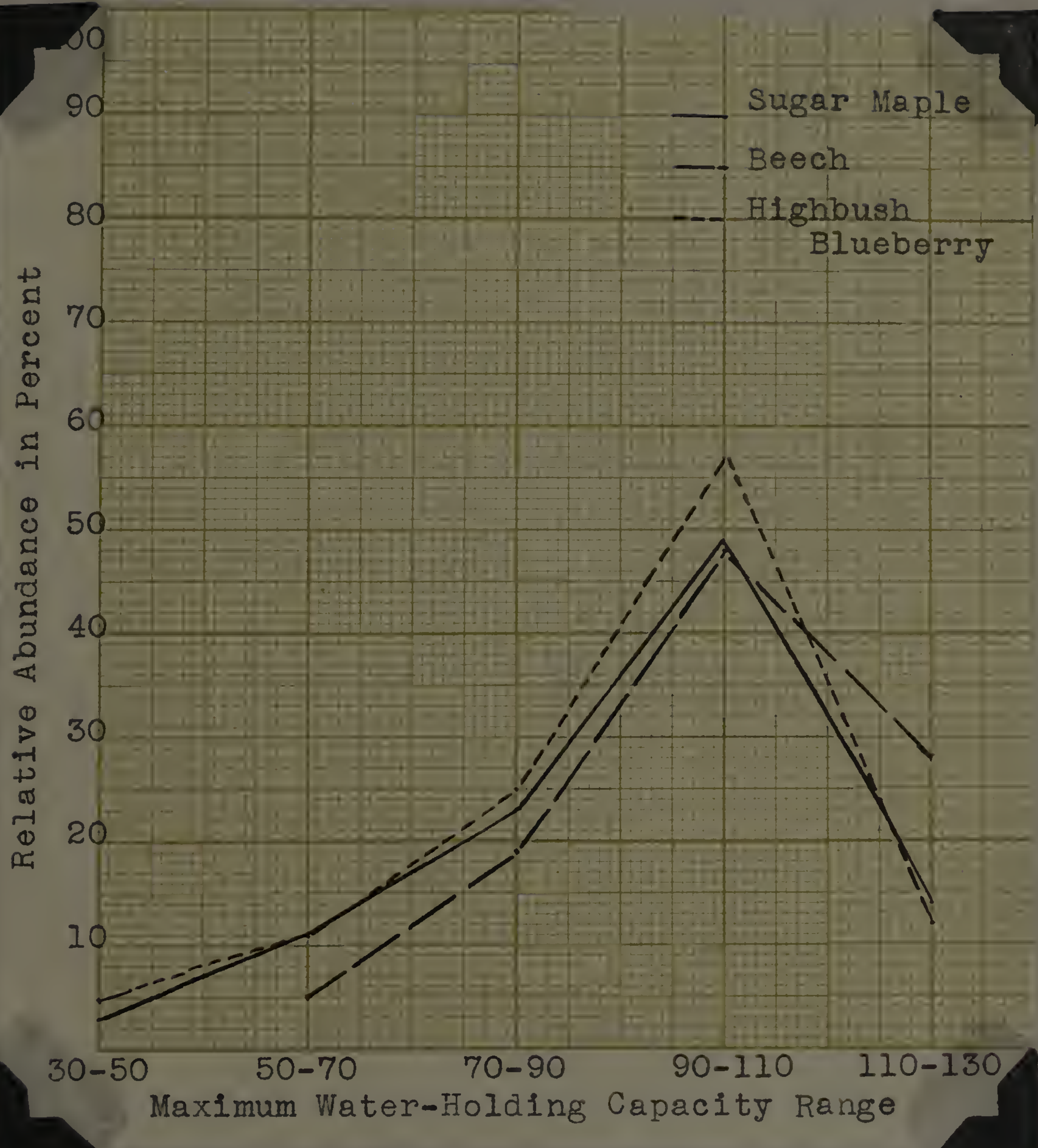
A fairly large number of plants were found to be growing in the greatest abundance in localities represented by top soil having a relative high maximum water-holding capacity and subsoil exhibiting a medium moisture-retaining capacity. A list of these plants reveals the following species: anemone, ash, beech, bellwort, high blueberry, buttercup, dandelion, ironwood, Kentucky blue grass, sugar maple, meadow sweet, mouse-ear chickweed, red oak, common plantain, English plantain, shrubby cinquefoil, spruce, and wild strawberry.

Brooks (2) observed that sugar maple, white oak, black oak and Kentucky blue grass were indicators of the "good soils" in Massachusetts, while elm, beech, ash, and Kentucky blue grass were typical of the "best" Massachusetts soils. His classification was of a very general nature to be sure, but many of the results obtained in this particular investigation seem to support several of his conclusions, although much rests upon how his soil classification is interpreted. Hazard (12) in her investigation, noticed that beech, ash, sugar maple, spruce, white oak, and red oak were associated with the better forest soils.

Figure III pictures the relative abundance of three species which were found growing in the greatest quantities on soils having comparatively high moisture-retaining capacities.

<u>Plants Apparently Indifferent To The Maximum Water-Holding Capacity Of The Soil.</u>

FIGURE III



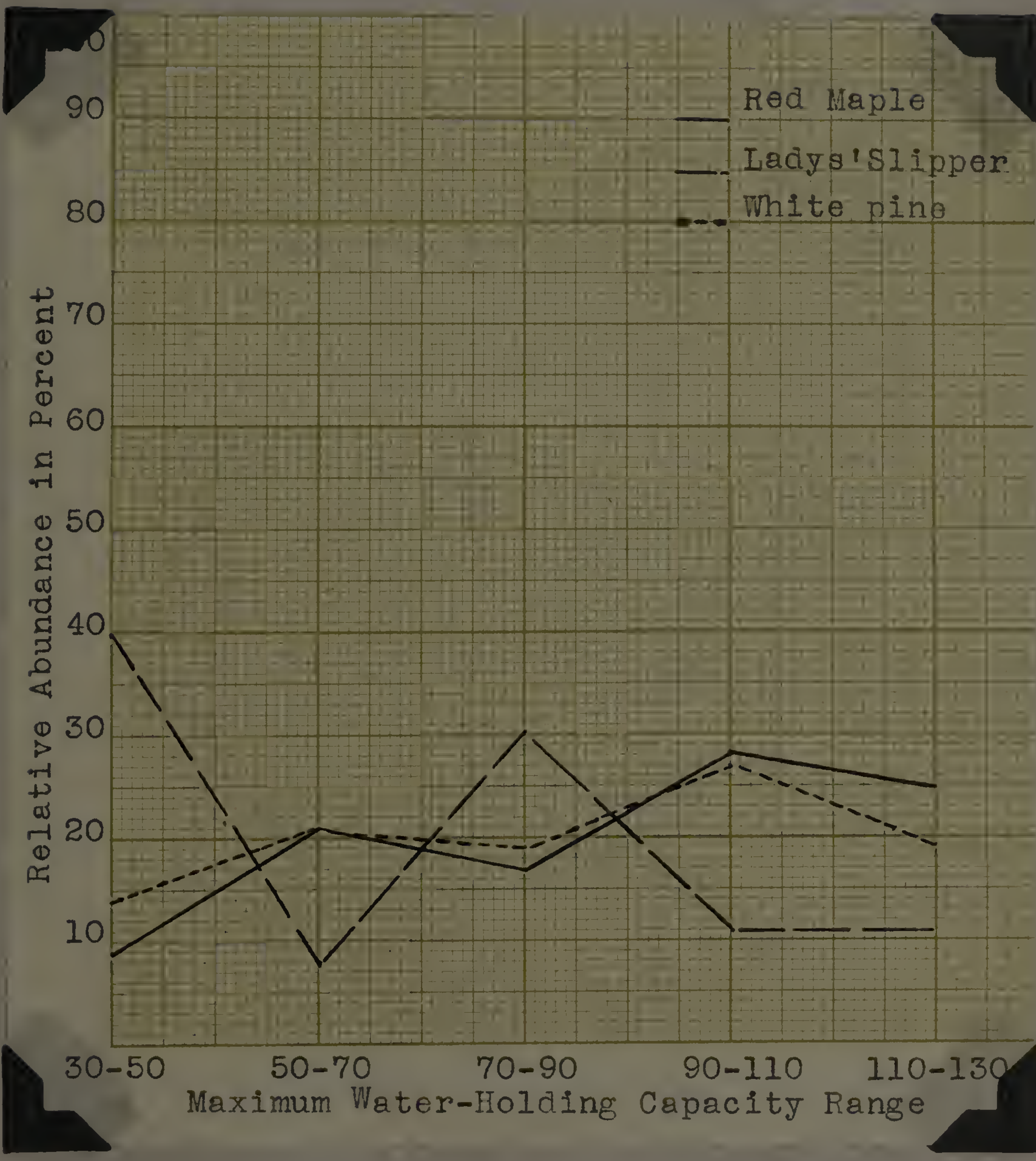
Three plant species characteristic of soil having a relatively high maximum water-holding capacity.

A considerable number of species studied were found growing on soils varying a great deal in their moisture-retaining properties. In other words, in regard to this factor, their distribution seems to be quite general. Gray birch, choke cherry, false lily of the valley, hemlock, ladys' slipper, red maple, red cedar, sarsaparilla, shad bush, spotted wintergreen, white pine, wintergreen, and witch hazel were among those of widespread occurrence. Table IV reveals that several of the above named plants are more abundant in one soil class than in another, gray birch and choke cherry for example, but in general, their range of tolerance is not a narrow one in respect to the water-holding capacity of the soil, as previously mentioned. Of course, this is not saying that they do not have a particular soil preference in regard to this and other factors. The attempt is merely to show what one finds in the field.

Wilde (35) and Hazard (12) have both demonstrated that white pine occurs on a wide variety of sods. Red maple, cherry, and false lily of the valley were classified by Hicock et al (13) as being well represented on all types of soil although red maple was more common on the poorly drained and organic soils. Lawrence (19) stated that no definite relationship exists between distribution of gray birch and soils on which the plant exists.

Figure IV presents curves for three plants which were noted as being common on several soil types.

FIGURE IV

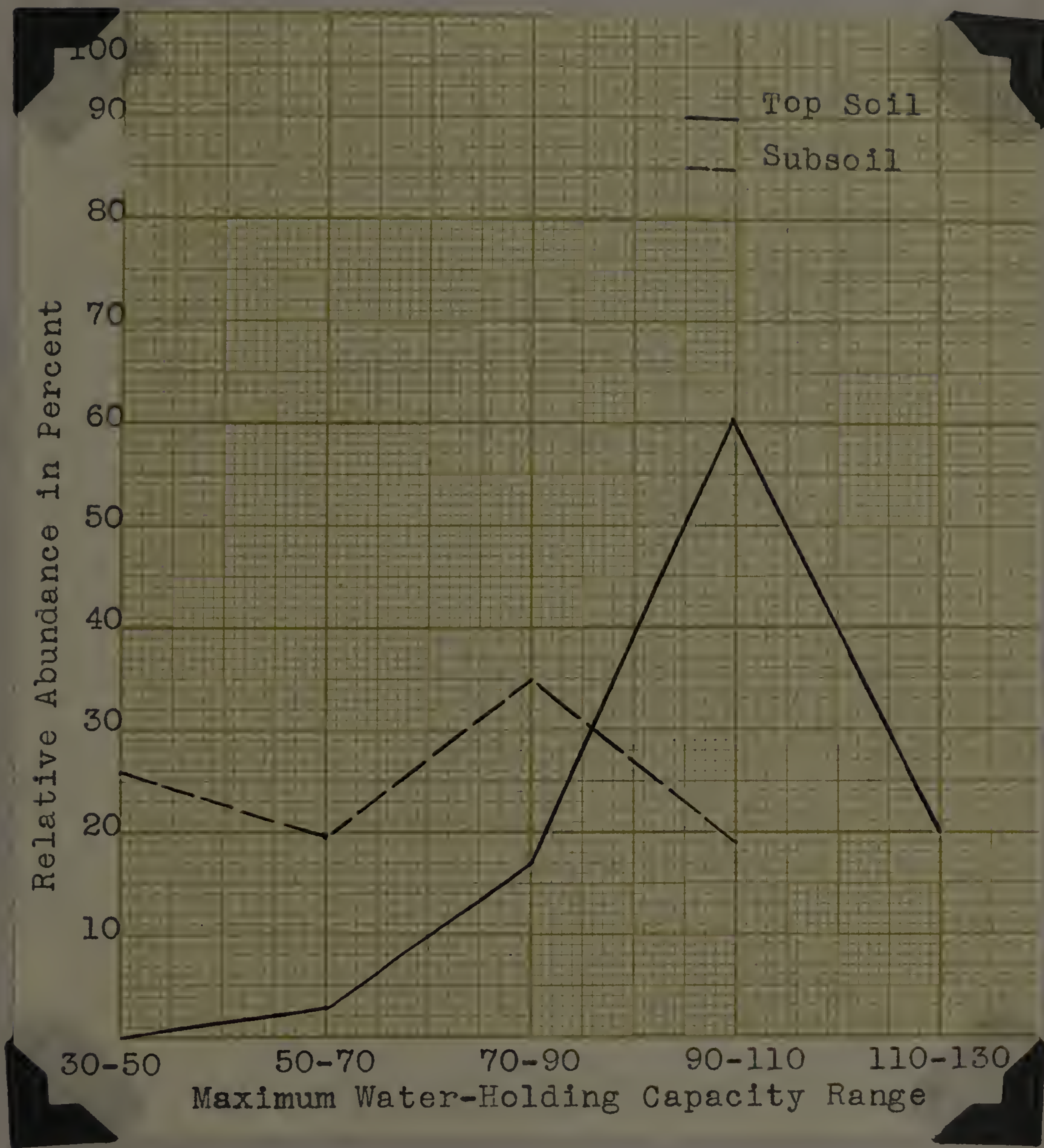


Three plant species found growing on a wide variety of soils.

Plant Distribution and Biological Equivalent Soil Types

Several plants, notably arrow-wood, elm, hardhack, skunk cabbage, sensitive fern, hemlock, red maple, cinnamon fern and yellow birch, were often found growing on soils where there was a wide variation between the maximum water-holding capacity of the top soil and subsoil, the subsoil usually holding much less water than the top soil. These plants, usually characteristic of moist soil conditions, may or may not indicate the moisture-holding capacity of the soil. However, it was noted that whenever these plants were growing on areas, especially where the subsoil had a relatively low moisture-holding capacity, there was invariably a high water table present. Hence, even though the sandy subsoils, that occur in such soil series as Whitman and Scarboro, have a comparatively low water-holding capacity, plants such as those named above occur there since we have a biological equivalent soil condition as explained by Hicock et al (13) in respect to plant distribution. In other words, the high water table, poor drainage, or whatever the case might be, compensates for the inability of the subsoil to hold water. Several plants such as ash, elm, red maple, yellow birch, willow, alder, and white pine were described by Wilde (35) as having been found in abundance on soils under permanent or partial influence of the water table. Figure V is presented to illustrate the principle of biological soil types. The graph shows arrow-wood growing abundantly on A horizon soil that has

FIGURE V



Biological equivalent soil types and its effect upon the natural distribution of arrow-wood.

a high moisture-holding capacity while its distribution is general in respect to the subsoil.

Conclusions

The maximum water-holding capacity of the solum has been found to be a factor in the natural distribution of some plants. However, exception must be made in the case of soils which are under the direct influence of the water table as previously explained by Wilde (35) and others. Results indicate that certain trees, shrubs and herbs were found growing in the greatest abundance on soils of particular maximum water-holding ranges while other species were indifferent to this soil factor as one influencing their natural distribution.

Plant Distribution and pH of the Soil.

Statistical Treatment of Data

The pH values, determined for the various top soils collected, ranged from 3.5 to 6.8. Invariably, the subsoil exhibited a higher pH value than did the top soil, the range usually being 0.3 to 0.5 pH higher. For convenience in tabulating data, the pH values were grouped into eight classes, each consisting of a pH range of 0.5. According to this classification, the number of stations represented in each pH class of soils considered are given in table V.

In finding the relative abundance of each plant in the various pH classes, the same method precisely was used as was employed in determining relative abundance of plants occurring on soils represented in the various maximum water-holding capacity classes as previously outlined with the exception that pH values were substituted for the maximum water-holding capacity values.

TABLE V

Number of Stations Represented
In Each pH Class

pH Class	Horizon A	Horizon B
3.5-4.0	15	2
4.0-4.5	26	13
4.5-5.0	68	71
5.0-5.5	57	69
5.5-6.0	15	20
6.0-6.5	8	4
6.5-7.0	1	11
7.0-7.5	0	2

Accordingly, Table VI shows the relative abundance in percent, of the various plants occurring in each designated pH class. It is interesting to note the close relationship that exists between abundance values for the A and B soil horizons.

Species Indicative of Soil Reaction

Relative abundance figures given in Table VI indicate that certain trees, shrubs and herbs were found growing the most abundantly on soils of a particular pH

TABLE VI

Relative Abundance of Certain Plants In Various pH Classes of the Soil

Plant	Soil Hor.	Range in Soil pH Values 3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5
Alder (speckled)	A	13		14	25	48			
	B			9	16	18	42	15	
Anemone	A		28	42	15	15			
	B			54	26	20			
Arrow-wood	A		24	29	17	30			
	B			22	16	62			
Ash	A		3	8	19	29	41		
	B		7	7	15	24	47		
Beech	A		36	9	9	17	29		
	B		28	26	4		42		
Bellwort	A	40	18	28	14				
	B			71	29				
Birch (black)	A	21	16	29	29	5			
	B		21	35	26	18			
Birch (canoe)	A	14	1	12	11	18	44		
	B		17	10	5	17	51		
Birch (gray)	A	6	17	25	33	19			
	B		19	23	39	19			

TABLE VI (Con't)

Plant	Soil Hor.	Range in Soil pH Values 3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5
Blueberry (low)	A	47	19	13	18	3			
	B		53	15	17	11		4	
Blueberry (high)	A	4	20	17	54	5			
	B	14	8	29	39	10			
Broomsedge	A		26	74					
	B		24	60	16				
Buttercup	A			2	8	22	68		
	B				3	5		21	71
Cherry (choke)	A		23	26	25	26			
	B		7	25	51	17			
Cinnamon fern	A	31	18	31	20				
	B		8	40	52				
Cinquefoil	A	29	13	30	26	2			
	B		3	4	66	27			
Dandelion	A				3	4	27	66	
	B				1	8	31		60
Elm (American)	A		10	6	3	33	48		
	B			11	8	14	67		
False lily the valley	A	17	13	40	12	18			
	B		28	29	43				

TABLE VI (Con't)

Plant	Soil Hor.	Range in Soil pH Values 3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5
Flowering Dogwood	A		28	28		34	10		
	B		30	51	10		9		
Hardhack	A	12	9	22	21	36			
	B		16	17	32	34		1	
Hemlock (Canadian)	A	28	3	10	36	23			
	B		43	16	11	30			
Hickory	A	6	31	25	40				
	B		6	28	28	38			
Huckleberry	A		87	10	3				
	B			78	22				
Indigo	A	74	16		10				
	B		84	4	3	9			
Ironwood	A		3	2	23	62	10		
	B			1	3	17	79		
Jack-in-the Pulpit	A		28	14	17	41			
	B			20	36	44			
Kentucky blue grass	A		1		1	3	58	37	
	B				2	1		69	28
Ladys' slipper	A		54	10	36				
	B		54	21	25				

TABLE VI (Con't)

Plant	Soil Hor.	Range in Soil pH Values							
		3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5
Lespedeza	A		53	42	5				
	B			57	23	20			
Lupine	A	78		7	15				
	B		66	2	4	28			
Maple (red)	A	21	15	24	20	20			
	B		33	28	24	15			
Maple (sugar)	A	4		4	25	10	57		
	B		7	7	7	16	35	28	
Meadow-sweet	A	4		6	23	55	12		
	B		4	7	13	23	27	26	
Mountain Laurel	A	60	1	8	31				
	B	14	59	17	7	3			
Mouse-ear Chickweed	A			1	6	23	70		
	B				3	1	47	33	16
Oak (black)	A	29	17	33	21				
	B		27	16	21	32			
Oak (red)	A	16	22	12	15	10	25		
	B		16	21	11	8	26	18	
Oak (scarlet)	A	14	47	12	19		8		
	B		39	22	21		18		

TABLE VI (Con't)

Plant	Soil Hor.	Range in Soil pH Values 3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5
Oak (scrub)	A	82	4	9	5				
	B		81	11	7	1			
Oak (white)	A	13	43	31	9	4			
	B		27	60	13				
Pitch pine	A	70	11	11	8				
	B		59	17	12	12			
Plantain (common)	A				3	15	46	36	
	B					5	24	22	49
Plantain (English)	A		14			1	85		
	B			7			4	88	
Red Cedar	A		13	11	14	62			
	B		21	12	32	35			
Sarsapa-rilla	A	31	36	26	7				
	B		45	48	7				
Sensitive fern	A		9	9	55	27			
	B			1	8	91			
Shad Bush	A	33	28	28	11				
	B		36	36	28				
Sheep Laurel	A		43	17	40				
	B			22	62	16			

TABLE VI (Con't)

Plant	Soil Hor.	Range in Soil pH Values 3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0	7.0-7.5
Shrubby Cinquefoil	A				1	10	23	66	
	B					5		28	67
Skunk Cabbage	A		11	1	4	84			
	B			2	3	19	76		
Sorrel	A		17	38	43	2			
	B		26	8	61	5			
Spotted wintergreen	A		26	34	40				
	B		31	47	22				
Spruce (Canadian)	A	18	4	30	34		14		
	B		26	43	19			12	
Strawberry	A	11	2	1	6	18	62		
	B		18		7	12		63	
Sweet fern	A	3	31	49	17				
	B		4	52	36	8			
White pine	A	4	13	6	10	13	27	27	
	B	21	10	6	7	8	7	20	21
Wild oat grass	A			71	29				
	B			20	59	21			
Wintergreen	A		52	14	34				
	B			44	47	9			

range indicated by a definite trend in abundance values with the maximum percentage being in one particular pH class. A list of such plants is presented in Table VII which shows the pH range of the top soil in which certain species occurred in the greatest abundance. It should be understood that the results shown in this table do not necessarily picture the optimum pH ranges preferred by the plants cited. The object of the table is merely to depict conditions as noted in the field under natural conditions.

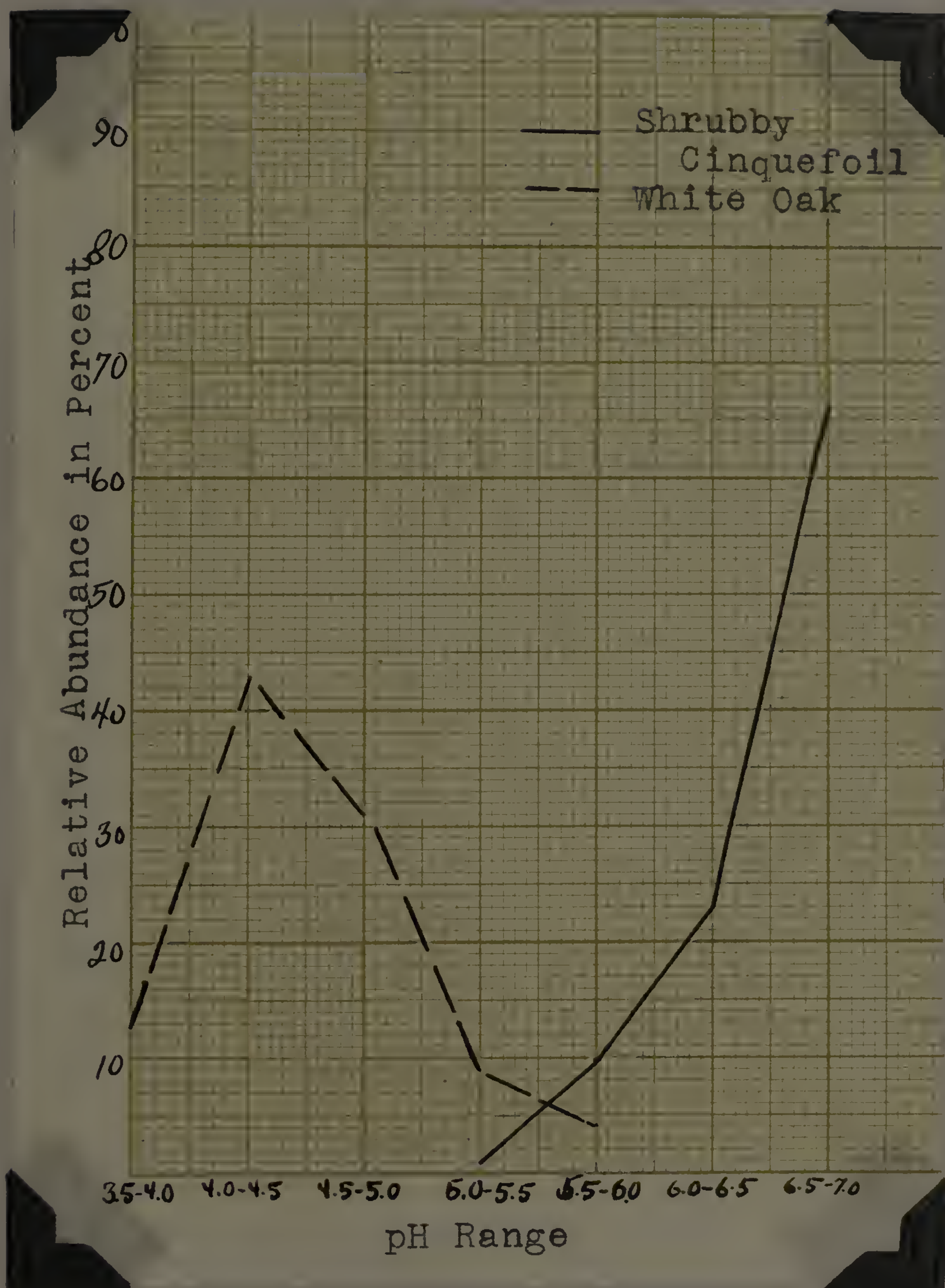
Sugar maple, beech and ash were reported by Hazard (12) as being the climax species on the better soil types having a pH range of 5.0-6.2. In the region studied by Wilde (36), it was found that spruce, hemlock, and canoe birch were well adapted to soils ranging in pH values from 3.7-4.5, while many hardwoods seemed to be doing well in localities where the soil reaction ranged between 4.5 and 5.5. Further, he observed that ash was characteristic of the alkaline soils while sugar maple grew on both acid and alkaline soils. Diebold (7) regarded beech, sugar maple and ash as characteristic of certain alkaline soils of New York while Olsen (22) cited Kentucky blue grass, English plantain and buttercup as growing the most abundantly on soils having a pH above 6.0. Members of the Ericaceae family were pointed by Wherry (30) as being abundant on soils of a pH of 4.0, common at a pH of 5.0 and rare at a pH of 6.0. In Pennsylvania, Kelley's (17)

TABLE VII

SOIL pH CLASSES IN WHICH CERTAIN PLANTS WERE FOUND GROWING IN THE GREATEST ABUNDANCE

3.5-4.0	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.0
Low Blueberry	Huckleberry	Anemone	Gray birch	Alder	Ash	Dandelion
Indigo	Lespedeza	Broomsedge	High blueberry	Ironwood	Canoe Birch	Shrubby Cinquefoil
Lupine	Ladys' Slippers	Sweet fern	Sensitive fern	Meadow Sweet	Buttercup	
Scrub Oak	Scarlet oak	Wild Oat grass		Red Cedar	Elm	
Pitch pine	White oak			Skunk Cabbage	Kentucky Blue grass	
	Witch-hazel				Sugar maple	
					Mouse-ear chickweed	
					Common Plantain	
					English plantain	
					Strawberry	

FIGURE VI



Relative abundance of shrubby cinquefoil and white oak in various pH classes.

investigation showed that many plants such as red cedar, elm, ash, blueberry, broomsedge, red maple, black oak, and red oak occurred on soils ranging around a pH of 7.0, while scrub oak, high blueberry, azalea, mountain laurel and huckleberry were found on other soils ranging from 5.75-6.2.

Figure VI shows curves for white oak and shrubby cinquefoil, the former being typical of the more acid soils while the latter was associated with the more alkaline soils.

Species Indifferent to the Soil Reaction

Several other plants, included in table VI, seemed to be indifferent to soil reaction. In other words, in regard to the pH of the soil, certain species, represented in figure VII, showed a wide range of tolerance, they being as common at one pH level as they were at another. Again, it must be emphasized that plants appearing in figure VII grew on soils of pH levels other than those given, but this chart indicates the pH ranges in which certain plants were found, under native conditions, in the greatest quantities. Further, figure VII also shows the relationship existing between abundance values for the top soil and the subsoil.

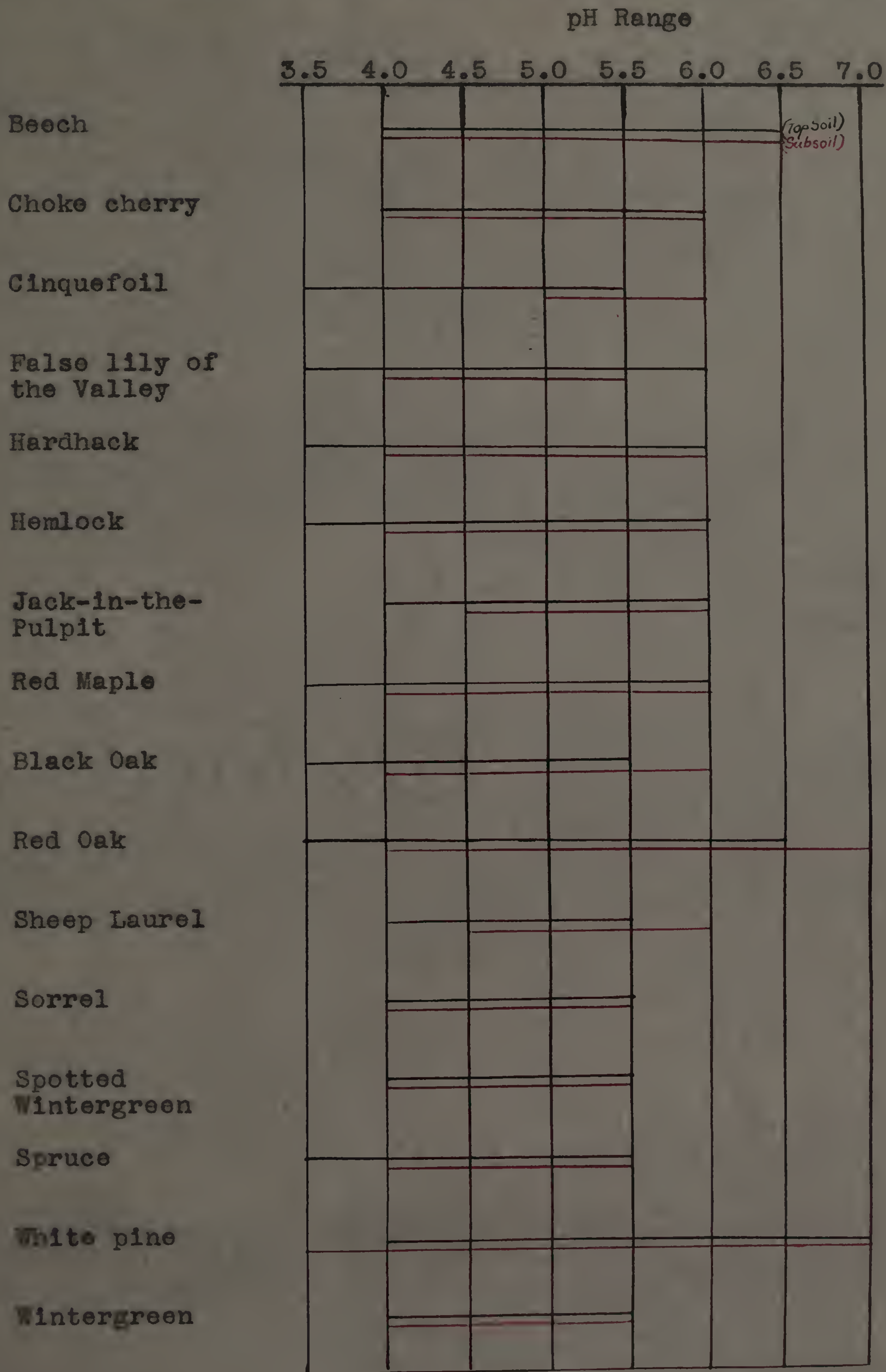
Wilde (36) stated that "white pine . . . . . may grow satisfactorily within a very wide range of reaction from 4.5 to 7.0."

Conclusions

Under natural conditions, some plants were observed

FIGURE VII

pH Range Over Which Certain Species Occur in the Greatest Abundance Under Natural Conditions.



as being more abundant at one pH level than they were at others, this being in close agreement with the work of several other investigators in this field. Still other species were noted as growing abundantly on soils varying considerably in their Hydrogen-ion concentrations. Therefore, soil reaction is not always a factor influencing the natural distribution of plants. This point was previously explained by Wherry (31), Olsen (22), Sampson (26) and others. There is also evidence to support Wilde's (36) contention that ground cover may be considered as an indicator of soil reaction although much depends upon particular herb in mind since many, apparently, have no indicator value in regard to the pH factor. Results further show that various species, within a given genus, were associated with soils having different pH values, such having been demonstrated by Atkins (1), Olsen (22) and Wherry (31).

SUMMARY

1. The maximum water-holding capacity of the A and B horizons of the soil, (solum), has been found to be an important factor in the natural distribution of some species of plants except in the case of soils under the direct influence of the water table.
2. Other plants studied seem to be indifferent to the water-retaining power of the soil as a factor in determining their natural distribution.
3. The pH of the soil has been noted to be an important

factor in the natural distribution of some plant species.

4. Other trees, shrubs, and herbs were found growing in abundance on soils varying considerably in their pH values.
5. Finally, it appears that whether plants do or do not have indicator value, in regard to soil factors studied in this investigation, rests upon individual species and not upon flora in general.

GLOSSARY

Alder (speckled)	Alnus incana (l.) Moench.
Anemone	Anemone quinquefolia L.
Arrow-wood	Viburnum dentatum L.
Ash (white)	Froxinus Americana L.
Beech	Fagus grandifolia Ehrh.
Bellwort	Uvularia perfoliata L.
Birch (black)	Betula lenta L.
Birch (canoe)	Betula alba var. papyrifera (Marsh.) Spach.
Birch (gray)	Betula populifolia Marsh.
Birch (yellow)	Betula lutea Michxf.
Blueberry (low)	Vaccinium pennsylvanicum Lam.
Blueberry (high)	Vaccinium spp.
Broomsedge	Andropogon scoparius Mishx.
Buttercup	Ranunculus bulbosus L.
Cherry (choke)	Prunus virginiana L.
Cinnamon fern	Osmunda cinnamomea L.
Cinquefoil	Potentilla canadensis L.
Dandelion	Taraxacum officinale Weber.
Elm (American)	Ulmus americana L.
False lily of the valley	Maianthemum canadense Desf.
Flowering dogwood	Cornus florida L.
Hardhack	Spiraea tomentosa L.
Hemlock	Tsuga canadensis (l.) Carr.
Hickory	Carya spp.
Huckleberry	Gaylussacia baccata (Wang.) C. Koch.

Indigo	Baptisia tinctoria (L.) R. Br.
Ironwood	Carpinus caroliniana Walt.
Jack-in-the-Pulpit	Arisaema triphyllum (L.) Schott.
Mouse-ear Chickweed	Cerastium vulgatum L.
Oak (black)	Quercus velutina Sam.
Oak (red)	Quercus rubra L.
Oak (scarlet)	Quercus coccinea Muench.
Oak (scrub)	Quercus ilicifolia Wang.
Oak (white)	Quercus alba L.
Pitch pine	Pinus rigida Mill.
Plantain (common)	Plantago major L.
Plantain (English)	Plantago lanceolata L.
Red cedar	Juniperas virginiana L.
Sarsaparilla	Aralia nudicaulis L.
Sensitive fern	Onoclea sensibilis L.
Shad bush	Amelanchier canadensis (L.) Medie.
Sheep Laurel	Kalmia angustifolia L.
Shrubby cinquefoil	Potentilla fruticosa L.
Skunk cabbage	Symplocarpus foetidus (L.) Nutt.
Sorrel	Rumex Acetosella L.
Spotted wintergreen	Chimaphila umbellata (L.)Nutt.
Spruce	Picea canadensis L.
Strawberry	Fragaria virginiana Duchesne.
Sweet fern	Myrica asplenifolia L.
White pine	Pinus Strobus L.
Wild oat grass	Danthonia spicata (L.)
Wintergreen	Gaultheria procumbens L.
Witch-hazel	Hamamelis virginiana L.

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