A Preliminary Study of Forest Succession in Central New England

by

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Introduction

In this paper an attempt has been made to describe the original forest of central New England as it appeared to the white man upon his arrival. To the most casual student it is obvious that the structure of the forest was not uniform throughout such a vast area. Due to changes in topography, soil and other causes the region was naturally divided into a good many more or less distinct forest communities. In this study eight distinct forest cover types have been described. It is, of course, realized that all the forest of the region did not fit nicely into these groups. Vast areas were undoubtedly a merger of two or more of these types.

Upon the belief that these types existed, in the virgin forest approximately as described, an effort has been made to trace the development of these various types following the action of man upon them.

It is also realized that this is not the last word but only a beginning. It is most unlikely that we will ever have an accurate description of the original forest. It is very unlikely, even, that a description of the kind needed by foresters was ever written. If such an account was written it is now nowhere to be found and the forest description has to be based on inference from what little was written plus what we can now see on the ground.

This study of the development of these tentatively described types following the action of man is just a beginning. As nearly all the stands available for study are in the earlier stages of succession we have very little more than trends to work with.

Purpose

If we are to be successful in raising forest crops on a commercial basis it is essential that we know what kind of a forest a given site will grow. Repeatedly attempts to disregard this natural capacity of sites have resulted in disaster. In central New England efforts to grow white pine in pure stands on soils not suitable for pine have resulted in failures. Another outstanding example of this sort of thing were the attempts in Germany to grow spruce in pure stands outside its natural range. (Annon. 1923) Similar failures have resulted in efforts to grow pure stands of teak in India. In both the last two cases the first rotation was successful and profitable, but in the second rotation growth rates fell rapidly and in many cases in Germany it was found desirable to cut down the spruce and to start over again with other species.

Franz Heske (Heske 1938) in his book German Forestry points out very clearly the need of avoiding this sort of thing. The following is a quotation from Heske.

"Countries newly embarked on forestry can learn much from Germany's experience during the nineteenth century with a systematic system of forestry that placed too much reliance on mathematical calculations. They can, from the start, avoid mistakes which came to be recognized as such in Germany only in the course of many decades. There is imminent danger of slipping into systematic forms of forest structure during the transition from virgin forest or forests subject to unrestricted exploitation to forests under sustained yield management. Virgin forests especially in the tropics contain innumerable trees of no present commercial value intermingled with a few that are

highly valuable. It is only too easy to make the mistake of converting these mixed uneven, virgin forests into uniform plantations of a single species (Monokulturen). This mistake has been made repeatedly. Large areas have been afforested with even-aged plantations of a single species, chosen because it is fast growing or especially valuable, and without paying heed to the biological factors that control the life of the forest. In spite of initial success of these monocultures, the fundamental error of such practices has later become evident.

"German experience confirms the biological fact that the forest is a complicated community of living things, in which each tree species is merely a member, no more and no less important for health of the whole than the other members. A single species may not be used with impunity in plantations where it is entirely isolated from its natural organic complex. The foundation and the elements of practical sylviculture are not the individual tree species, but the natural life communities of which these economically desireable species are a part. The growing of commercially less valuable, but biologically important species in mixtures with species of high economic value is equivalent to paying an insurance premium against later losses.

"The abundant German experience with these monocultures is already of value as a lesson for the rest of the world. The lesson will become even more convincing in the future, as it becomes possible to demonstrate in specific instances what caused the frequent failures of monocultures. These have been made due to pure stands as such, to the failure to adapt species to site, to the even-aged, schematic form of forest, to other factors,

or to the joint effect of several or all of these. This important problem has by no means been solved. In place of theories, we must have more experiments before a conclusive judgement is possible."

The purpose of this paper is to show what kind of a forest grows under natural conditions in central New England, and what happens when this natural forest is completely or partly destroyed. It is realized that this study is superficial and incomplete, but it is also felt that taking this into consideration it could be of considerable help as a guide to a sylviculturalist.

Scope

The description of the original forest made in this paper includes the entire transition white pine-hemlock-hardwood region of central New England. This area is bounded on the north by the northern hardwood region and on the south by the central or "sprout" hardwood region. Geographically this region consists of Massachusetts east of the Berkshires except for a strip running along the coast as far north as the mouth of the Merrimac River and south into Rhode Island and Connecticut. A portion of northern Connecticut is included in this area as well as southern New Hampshire. The region extends up the rivers of New Hampshire as far as the base of the white mountains and also includes the southern third of Maine and extends up the principal rivers of that state. The region is characterized by abandoned fields coming up in pure or nearly pure stands of white pine.

The work done on forest succession was confined to the town Petersham Massachusetts which is in the west central part of the

region. A land use history of the Harvard Forest, which is located in Petersham, prepared by Raup and Carlson, 1941, was of great value. Complete soil maps of the forest were available as well as soil maps of some of the nearby farms.

It was originally planned in making the successional studies to see if there was any relationship between the forest types and the soil types as classified by the United States Department of Agriculture and mapped on the Harvard Forest by Simmons, 1940, 1941 and 1942. It was soon found that soil types were of little value and that it was necessary to depend almost entirely on topography and exposure. On the ridge tops, however, the stands studied were confined to those on soils of the Gloucester series. The ridge tops were studied more intensively than any of the other types. This was the only part of the study where extensive sample plots were taken. In the case of these plots records were made showing the number of trees of each species per acre and where trees were over one inch in diameter at breast height basal areas are given. These tables can be found at the end of the section dealing with the oak-hickory-chestnut type.

In none of the other types was any corelation between cover and soil types found. Also on none of the other types were samples taken to illustrate the successional steps.

Climate

The climate of Petersham is humid and temperate with marked seasonal changes. The winters are usually rigorous with heavy snow falls and the summers are comparatively cool and short. The average annual precipitation is 42 inches, but has varied from 25-54 inches, and is fairly evenly distributed through out the year. The average number of frost free days is 180 and the average annual temperature is 47°F. The temperature range is from - 35°F to 103°F.

Topography and soils

Petersham is located in the so called central plateau of Worcester County, which " is so thoroughly dissected that large areas of smooth unchanged plateau surface do not exist." (Latimer et al. 1927) There are three ridges extending through the town in a generally north south direction and are lower at the south than at the north end. These ridges are separated by broad valleys. The highest points on the ridges are approximately 1300 feet above sea level. Swales and swamps are common and there are a few peat bogs.

This area is in the region of Brown Podzolic soils. (USDA yearbook 1937) The soil profiles are incompletely developed with a thin accumulation of organic matter. " In some places there is an incipient true podzol profile, with a very thin gray layer on top of a dark-brown upper sub-soil two to three inches thick." (Lutz and Cline 1947) These soils are considered young having developed but slightly since they were deposited

during the later part of the glacial period.

On the upland soils of the Brookfield,Charlton and Gloucester series are most common. Soils of the Sutton and Whitman series are common on poorly drained sites. There are some soils developed under defecient moisture conditions which have been derived from water laid materials, mainly sands and gravels. These soils are located along the present main water courses and are of the Merrimac and Hinckley series. These soils were those on which the pines grew in the original forest.

Land Use History

In order to better understand the condition of the forests of Petersham today a brief account of the land use history is given here. The imformation in this section is taken largely from Raup and Carlson, 1941, The History of Land Use on the Harvard Forest.

The original settlement of the town of Petersham took place in 1733. During the remainder of that century there was no large scale land clearing due to the fact that there was no ready market for agricultural produce. Each farm operated on a subsistance basis, and raised practically all that was needed there.

At about the turn of the century manufacturing began to become important in central Massachusetts. Now for the first time the farmers had a market for their produce in the growing industrial towns. This led to wide spread land clearing. By 1830 nearly 80 % of the total land surface of the town of Petersham was cleared and farming was a profitable business. This period of prosperity was short lived. For at about this time the opening

of the west due to the construction of the Erie Canal and the building of the railroads, caused the down fall of New England agriculture. It was cheaper to raise crops on the fertile plains soils and ship the harvest east than to raise the crops on the rocky New England hillsides. The Massachusetts farmers started moving westward , and after 1840 farm abandonment became general.

On the drier sites and on all but the most wet when grazing accompanied abandonment the old fields grew up in pure or nearly pure stands of white pine. Along the streams and swamps hardwoods were plentiful, but generally the effect was that of a " white pine region." This pine grew rapidly and in 60-70 years produced stands from 50M-70M board feet per acre. Eventually the box board industry was built up based on the use of this large quantity of low grade material. This industry reached its Zenith between 1890 and 1910, 60-70 years after farm abandonment had become a large scale proposition.

It was at the height of the boxboard industry in New England that interest in forestry was first aroused. Naturally enough in central New England the early attempts at forestry consisted of efforts to cut the white pine so that it would reproduce itself, and also to plant more white pine in open fields. This effort was a complete failure. Regardless of the method of cutting the following stands were almost entirely composed of hardwoods, except on the drier sites. At the Harvard Forest stands were cut by many different sylvicultural systems to assure pine reproduction. Although as many as 50,000 pine seedlings per acre were counted on the ground immediately after cutting repeated weedings failed to keep the hardwoods from crowding out the pine.

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except on the drier sites such as the Hinckley and Merrimac soils. (Lutz and Cline 1947)

Likewise the pine plantations were largely failures. In most cases nearly 100 % of the pines were severely damaged by the white pine weevil (Pissodes strobi). In many cases hardwoods seeded into the plantations naturally and over topped the pines.

These events have caused the forester to reconsider and plan his operations on a sounder basis. He must find what nature will produce on a given site. To do this it is necessary to discover what the original forest was on a given area. Naturally this cannot be done everywhere through out an entire region. However could one discover what the original forest was on a given soil type or topographic feature and trace the various stages of succession following various treatments it would give the forester much more to work with than he has ordinarily used in central New England.

Forest Successions

Before starting with a discussion of forest succession a few definitions are in order. The following are from Nichols, 1923.

"Succession may be broadly described simply as the replacement of one plant association by an other."

"Association- a plant community characterized by its essential homogeneous ecological structure and floristic composition at least in regard to dominant species."

"Plant community-any group of plants growing together."

"Climax-a stage of vegetational development beyond which, practically speaking, there is no further development (or successional) change.

Two types of climax are distinguished.

a) climatic climax-the most advanced type of vegetation that is capable of development under the climatic conditions which characterize the climatic region.

b) physiographic climax-the most advanced stage of vegetation capable of development in any physiographically uniform area. In physiographically favorable areas the physiographic climax corresponds to the climatic climax of the region; in physiographically unfavorable areas it represents a lower stage of development than the climatic climax."

The Society of American Foresters,(Hawley 1940) define a forest type as: "A descriptive term used to group stands of similar character as regards composition and development due to given physical and biological factors, by which they may be

differentiated from other groups of stands. The term suggests repetition of the same character under similar conditions--"--" A cover type is a forest type now occupying the ground, no implication being conveyed as to whether it is temporary or permanent."

Once we have established what the original forest types were the next step is to trace the development of the various types following various sorts of use. Succession has been defined above and we shall now discuss the causes of succession.

Gleason, 1927, lists these causes as follows:

1) reaction of vegetation on its own habitat.

2) physiographic processes.

3) climatic change.

4) arrival of additional species in the area due to migration.

5) specific evolution.

In addition to the above natural causes man has a marked effect on plant succession. Every tree he cuts, every clearing he makes, every fire he builds in the open effects the development of vegetation. The action of man may have some effect on the natural causes listed by Gleason. In our study of forest succession we are, of course, interested in both the natural and man-caused effects. In discussing the five causes listed above an effort will be made to include the effect of man.

The reaction of vegetation on its own habitat. As one type of vegetation becomes established on a given area it may change the conditions of the site in such away that it makes the site unsuitable for itself and this vegetational type is followed by another. Eventually the climax is reached which is a comparatively stable form of vegetation which can repro-

duce itself. Among these changes in site are the difference in the amount of solar radiation reaching the forest floor, the amount of rainfall actually reaching the ground, the evaporation, and the condition of the seed bed.

The physiographic processes are of minor importance in the region under discussion as far as secondary succession is concerned and need not be discussed here.

Climatic changes over long periods of time have a marked effect on vegetational development. It is, however, very difficult to evaluate this effect. Raup, 1941, has shown that over a long period of time the climate of New England has become colder and more moist than it was 2000 to 3000 years ago. He does not, however, prove that it is still getting cooler and there is some indication that the trend has reversed itself. Data from the U.S. Weather Bureau station at New Haven, Conn. indicates that the mean average temperature in this city as well as elsewhere is rising. (Kincer, 1933) Flint, 1947, points out that most glaciers in the world are becoming smaller due to a moderation of climate.

If the climate in New England had been getting colder and more most for a thousand years or so prior to the arrival of the white man and if this process were still going on it could conceivably have a marked effect on forest succession.

In our most reliable account of the original forest, Peter Whitney's History Of Worcester County, the uplands are described as being composed largely of oak, chestnut and walnut (hickory and butternut). Today the hickory though present in some stands with southern exposures is not nearly as common as Whitney's description would lead us to believe.

If this hickory were a relic from climatic conditions which no longer exist the land use history would explain the lessening of the hickory very nicely. In an area cleared and cultivated all tree species were eliminated. Following farm abandonment the successional development would be such that relics would tend to drop out. Of course, where hickory trees still existed they would tend to seed into the newly forested areas, but they would not thrive as well as under previous climatic conditions. As 80 % of the land area of central New England was once cleared, this might well have caused the amount of hickory to lessen.

The evidence which points toward a moderation of climate, of course, counteracts the above argument. However, this is an example of how change in climate effects succession in a relatively short period of time. In this particular case the conflicting evidence makes it impossible to draw definte conclussions, but when we consider that a generation of trees may last 400-500 years changes of climate could have an effect in a comparatively few generations of trees.

There is no evidence of any new tree species having arrived in the region due to migration since the arrival of the white man. Three species of tree enemies have, however, been introduced into the region in recent years. The chestnut has been eliminated due to the arrival of the chestnut blight (Endothia parasitica) . Obviously the elimination of this once common tree has had a marked effect on vegetational trends. The other two introduced enemies, the white pine blister rust and the gypsy moth, have at times done considerable damage, but there is no evidence that these pests have had a very serious effect on forest succession.

Specific evolution does not have any visible effect on our problem. The process is too slow to be recognizable. It is conconceivable, however, that due to man's interference this might in the future play an important part in successions. The breeding of a superior tree of one species could possibly upset the relationship between this species and its natural associates.

In a discussion of this sort it is necessary to consider chance. Over long periods of time and in studies of vegetation over large areas chance is probably of minor importance. However, when we are thinking in terms of restricted areas and of comparatively short periods of time chance becomes more important.

When certain changes occur in a forest, such as wind throw or fire, conditions are ordinarily created which favor the establishment of a certain species or group of species. Nevertheless these species will only become established under these conditions if there happens to be an available seed supply. If, by chance, the same disturbance took place and for some reason the seed supply of the most suitable species was below normal or entirely lacking and the seed supply of some second species was well above normal the second species would become much more important in the new stand than is ordinarily the case.

In any study of forest sucession in central New England, as opposed to succession in general, there are three points of primary importance to be considered.

1) land use history

2) the hurricane of September 21,1938

3) the chestnut blight

Because of the first two causes there are no stands left in the area that even approach the condition of the original forest. There are no stands in Petersham that even approach maturity and very few elsewhere in central New England. This situation is most acute on the ridge tops where all stands of any size where blown down by the storm of 1938. As a result a study of the ultimate forest stands can be determined only by a study of previous forest descriptions of doubtful value and by inference of the trends now visible.

The elimination of the chestnut has had a marked effect on forest succession. In the original forest this species was very important particularly on the ridges. There has been considerable competetion by other species to take the place of the chestnut. It is impossible to tell just what have and will take place, but apparently red oak has gained much of the area lost by the blight killed species and possibly red maple has also increased.

One other cause of successional change which should be considered is fire. Fire has in the past and could again in the future have a marked effect on succession. In this study there was no chance to work in fire damaged areas. However, a discussion of fire is included under the section dealing with the original forest.

Description of the Original Forest

When the white man first arrived in central New England he found a vast forest consisting of a wide variety of trees many of which were of great size. On the uplands this forest, where undisturbed by fire or wind, was very open and it was possible for men to travel through it on horse back. In the lower and more moist areas the under brush was more dense and the swamps were described as impenetrable jungles. Another feature which caught the eye of the traveler, particularly in the more northern portion of the region and in the lowlands, was the dripping wet of the forest. These people from Europe had never seen a virgin forest before and were amazed by the size of the trees and the openess of the forest which they were comparing mentally with the coppice stands of England. Equally impressive was the dampness of the forest floor in the denser stands where the sun's rays rarely reached while the leaves were on the trees.

This brief general description was written after a careful study of the records of the early travelers and settlers as well as accounts of botanists and foresters based on residual stands of old growth forests. Unfortunately there are now practically none of the original stands left. In central New England the hurricane of 1938 blew down nearly all that was left of the virgin forest. However, prior to that date, foresters and botanists through out the region had located and studied some virgin stands. The two outstanding examples of this were the Pisgah tract in Winchester, New Hampshire (Spurr and Cline, 1942) and a tract in Stonington, Connecticut. (Nichols, 1913 and Raup, 1940) The Stonington stand is outside the transition region, but is of value as an example of a virgin forest in

the central hardwood region. Undoubtedly stands similar to this grew on the drier sites with southern or south western exposures in the transition region. Hawes also described a virgin stand in North Colebrook, Connecticut which must have been typical of many of the upland stands of the region. (Hawes and Hawley 1909)

Many of the early settlers and explorers in New England wrote about the new land. Unfortunately very few of them were interested in botany. In addition to this many who did discuss the forest did so with specific views in mind, such as encouraging settlers to come to New England. Therefore all the early descriptions of the area were not disinterested and cannot be accepted at face value. Most of those who wrote of the forest simply enumerated the tree species to be found and had little to say of the make up of the forest.

There are, however, a few accounts which appear to be of real value. The most outstanding of these is Peter Whitney's, History of Worcester County. (Whitney 1793) Whitney takes each town individually and in describing it gives an account of the forest present. Although this book was not written until 1791 the history of the region shows that there were few extensive clearings before that time. Up until then farming had been on a subsist - ence basis, and very few settlers had cleared more than eight or ten acres. Raup and Carlson, 1941, went into this very thoroughly and show convincingly that Whitney's account can be accepted as a description of the original forest.

Timothy Dwight, 1821, in his Travels in New England and New York, gives some account of the forests. His book was based on travels in the late 18th and early 19th centuries. He was not as interested in the forests as Whitney and his trips were made

late enough so that there is some doubt as to when he is describing the original forest.

Another source is Jeremy Belknap's ,1813, History of New Hampshire originally published in 1793. As in the case of Dwight it is difficult to tell whether or not his description refers to the original forest. By 1793 the costal region of New Hampshire had been settled 170 years. However, as in Worcester County, it appears that the clearing in the inland sections had been done for subsistance farming only. Therefore it seems safe to consider Belknap's description as being that of the original forest, but there is some doubt as to the exact location of that forest.

William Wood, 1634, in his New England's Prospect published in London in 1634 devotes a chapter to the natural history of New England. His 5th chapter is entitled, " Of the Hearbes,Fruits, Woods, Waters,and Mineralls." Wood's description is of the area adjacent to Boston and does not reach inland or north far enough to enter our region. However, as he is discussing the " sprout " hardwood region his discussion is of considerable interest. Apparently it is from Wood as well as from Morton that the idea has arisen that large portions of southern New England was burned over annually by the indians prior to the arrival of the white man.

Capt. John Smith's, 1616, Decription of New England published in 1616 is often refered to, but does not add much to our knowledge of the original forest.

Rosier's Relation of the Weymouth Voyage to the Coast of Maine in 1605 (Burrage 1887) is of considerable interest. Historians have been squabbling among themselves for years about

the location of the river he described. Some have thought that the stream in question was the Penobscot and others the Kennebec. It is now, however, generally agreed that the George is the river in question. This being the case the territory described is in the upper limits of our region.

John Josselyn's two books, New England Rarities, 1672, and Two Voyages to New England, 1675, are confined to the central hardwood region. These are both of some interest, but the forest description is largely confined to a list of trees found.

In The New English Canaan Morton, 1632, describes the Massachusetts Bay area. Like Wood he commented on the openess of the forest which he too felt was due to burning by the indians. He believed that they burned the forest both in the fall and in the spring of the year.

Change in the Pre-Colonial Forest

In considering the forest of central New England as it was when the white man arrived it is interesting to determine to what extent it was a climax forest. There are several factors which prevent a given vegetation from arriving at or remaining in a climax condition. Some of these factors are man caused and others are natural.

Fire

Fire undoubtedly had considerable effect on the pre-colonial forest. Bromley, 1935, indicates that vast sections of southern New England were burned over annually by the indians. Apparently he came to this conclussion because he felt that the climax forest of the area was a hemlock-beech-maple type while the colonists found an oak-hickory-chestnut type. In addition to this change in type he was undoubtedly influenced by Wood, 1634 and Morton, 1632 as well as by other early writers. These people fresh from Europe were impressed by the openess of the old growth forest. They immediately came to the conclussion that this lack of brushy vegetation was due to fire. They were, of course, unaware of the fact that by shade and the use of available moisture dense stands of timber often prevent young growth from becoming established. This argument was further supported in their minds by the fact that in swamps and in other places where there was an excess of moisture under growth was plentiful. This according to Wood was due to the fact that this type of forest was too wet to burn. Bromley also considered the possibility that a change of climate might have caused a change of climax in the region he studied.

The Indians did undoubtedly burn the forest frequently, but

not to the great extent indicated by Bromley and others. Sometimes this may havebeen done to make clearings for crops by the semi-agricultural Indians of southern New England. Often, however, these fires must have been due to carelessness. Between the frequent wars the savages were careless with their camp fires and they often must have burned considerable area.

Lightning must also be considered as a cause of fire in the pre-colonial forest. Althouth lightning at the present day occasionally causes forest fires, ordinarily there is enough rain with electrical storms that lightning fires are not serious in central New England.

Periodically, in the region under discussion, excessively dry periods do occur and fires become serious. For example in the fall of 1947 there was an excessive drought throughout New England and forest fire were extensive and in many cases severe. In the year 1825 there were very serious fires in Maine and New Brunswick. (Illick 1935) These two years are mentioned to show that periodically the weather is dry enough so that fires caused by Indians or other means could have a marked effect on forests and forest succession. However, these bad fire years come very rarely and in most years the forests of central New England are toowet to burn excessively. Therefore it seems obvious that except at very rare intervals fire did not seriously effect the forest, but occassionally over extensive areas it did have some effect.

Wind

Another cause which probably upsets the course of forest succession in New England is the wind. On September 21,1938

a hurricane struck New England doing great damage. Not the least of this damage was that done to the forests. Hundreds of acres of growing timber were blown down, and naturally the older and more mature stands were most severely injured. Needless to say this has had a marked effect on forest succession. The hurricane of 1938 was not a fluke. Brooks, 1939, and others show that similar storms struck New England in 1635 and again in 1816. Other storms of less intensity and breadth have also done serious damage to localized spots in the forest. It Is evident from the above that wind has played an important part in setting back forest succession.

Other Factors

Other factors such as ice, snow, insects and disease all did considerable damage to the pre-colonial forest. There is, however, no evidence to indicate that any of these factors were responsible for changes in natural succession except possibly very locally.

Others besides Bromley (Nichols, 1913, Lutz, 1930 and Raup, 1937) have noted that there seems to be a change in the climax association of southern New England. Raup, 1937, shows that this is due in part at least to a change in climate. In southern New England the climate is becoming colder and more moist and the oak-hickory climax is gradually being replaced by the hemlock-beech-maple climax.

The above discussion shows that there were many factors working against the establishment and maintenance of the climax in the pre-colonial forest. When the original settlers arrived they must have found a forest in many stages of succession. In small limited areas probably the earliest stages of succession were in effect following blow downs and severe fires. In

other large sections more advanced stages of succession were in existance following hurricanes and fires of less severity or of greater age. In addition to all this the climate itself was in the process of change and this too was having an effect on the forest. Much of the forest that the first explorers and early settlers found was in a condition of great change.

Individual Species

In this paper an effort has been made to describe the original forest on a community basis as it seems evident that the forest community is the basic unit of all sylvicultural operations. However, as the study progressed, it became apparent that some species appeared in a different light in different communities. Also it was felt that because of the commercial importatance some trees deserved special attention. Therefore in this section several species have been discussed individually.

Red Maple

The red maple is now one of the, if not the most common tree in the region. Some of the swales are comprised of nearly pure stands of this species and in others it plays a predominat part as it also does in the swamps. This species is not, however, confined to damp places, but is also prominent on the ridge tops. As we have no remnants of the original ridge top stands, and as it is not mentioned in the early descriptions of these it is impossible to know for sure whether or not it remains in the stands indefinitely.

Due to the tolerence of this species it is quite conceivable that it may have been in the original ridge top forest. Undoubtedly if this were true it was not one of the dominant species. It was over topped by the oak and other species present, but due to the openess of this kind of forest it could probably have survived under it. Coile, 1941, found that in the piedmont region of North Carolina red maple survived in a healthy condition under a mixed oak stand of 125 years in

age. Spurr and Cline, 1942, found that in the Pisgah tract that red maple was prominant on the higher elevations and in the low wet sites, but that it was rare on the mid-slopes.

It seems that the red maple is much more common now than before the arrival of the white man. This is due to the ability of the species to sprout which it does more vigorously than any other species of the region. The red maple is also a light seeded and prolific seeder. The tree grows well in the open and under partial shade. For this reason it has gained at the expense of the less aggresive species. Still another reason for the abundance of this species at the present is the chestnut blight. Although it is likely that the red oak gained more by the demise of the chestnut than any other species the red maple must have gained some of the territory lost by this species.

Hemlock

The part that hemlock played in the original forest and is likely to play in the stands of the future is obscure. Some observers in recent years have felt that this species is increasing in frequency and that it is going to play a more important role in the future than it has in the past.

The apparent increase in the hemlock could be explained by the land use history. As the farm lands reverted to forest, the hemlock, as it ordinarily grows in dense forests and is usually found in shady moist sites, would be one of the last species to become established in the new forest.

In addition to its prevalence there is also considerable doubt as to the part played by the hemlock in the forest. It

has often been noticed that in mixed stands where hemlock is present the other species are of higher quality than when the hemlock is absent. That is, in the stands where hemlock is present both the hardwoods and white pine have longer branch free stems and also straighter ones than where the hemlock is lacking. Whether this is simply the mechanical action of pruning by the hemlock or whether the hemlock has some other effect on the site which promotes better form and growth is not known.

White Pine

In the history of the transition region white pine has always played an important part commercially. When the first settlers arrived there was considerable white pine in central New England especially in the northern part of the region. Even in the southern section there was enough white pine to cause considerable interest. It was the most useful for all around purposes of any of the species found in the area. The early saw mills were set up to handle the pine and it was of great value for the masts of ships. In addition to its value it was noticed by every one because of its great size. The white pine was the outstanding tree of the primeval forest even if well down the list of species in numerical occurrence. In New Hampshire where it was more prevalent than in the southern part of the region Belknap has this to say.

" Another thing worthy of observation is the aged and majestic appearance of the trees, of which the most noble is the mast pine. This tree often grows to the height of 150 and sometimes 250 feet. It is as straight as an arrow and has no branches, but very near the top. It is from 20-40 inches in diameter at its base and appears like a stately pillar adorned with a ver-

dant capital, in form of a cone. Interspersed among these are common forest trees, of various kinds, whose height is generally about60 to 80 feet."

Along the coast of Maine the early explorers noted it, but even there it apparently was not outstanding numerically speaking. In the Rosier account of the Weymouth expedition the forest of am islend in George's Bay is described; " The Iland is woody, grouen with Firre,Birch,Oke and Beech as farre as we saw along the shore; and likely within." Rosier's Firre is without doubt white pine.

Further south where white pine was of comparatively minor importance numerically it attracted attention because of its usefulness and great size. Hawes in describing a remaining stand of virgin timber in Connecticut says. " It is for the most part a mixture of immense hemlock,beech,yellow birch, sugar maple, fine black cherry, ash, chestnut with a few giant white pines--" (Hawes and Hawley 1909)

In Worcester County it was frequently noted by Whitney. There, in some of the towns a large percentage of the white pine had been cut before large scale land clearing began. A few quotations from Whitney:

Westborough p.124

" There is at this day, but little white pine--"

Lunenburg p.146

" --white and yellow pines were plenty in the infancy of population but from great and long consumption of both a scarcity is felt."

Harvard p.156

" They have some white pine land in northerly part--"

Upton p.173

" There is much pitch pine in the place and also considerable white pine remaining even at this date."

Charlton p.124

"--; some white pine and some pitch pine."

Athol p.246

"--; there is also considerable white pine remaining in the northern part of the place;"

Dwight, 1821, had comparatively little to say about the pine, but did point out in the following quotation that it was of minor importance south pf Maine. " That the pine south of the district of Maine, if it were all collected in one spot would scarcely cover the county of Hampshire."

Students of remnant stands in New England and elsewhere in the eastern United States have been puzzled by even-aged stands of pure or nearly pure white pine. In Pennsylvania Hpugh and Forbes, 1942, stated that these stands were due to catastrophes of some sort presumably fire or wind or both.

In the Pisgah tract in south western New Hampshire Spurr and Cline,1942, described a physiographic climax of white pine and hemlock on the higher slopes. In addition to these stands they found even-aged stands of a high percentage of white pine plus hemlock and hardwoods. They say, " At all elevations, the destructive action of wind and fire resulted in a more or less even-aged stand of white pine with about half as much hemlock and smaller amounts of red oak and red maple." They go on to point out that in the middle stories of these stands white pine is lacking and that apparently the areas involved will revert to something closer to the climatic climax of the region.

In the Petersham area undoubtedly the hurricane of 1938 will cause even-aged stands of pine on those sites which are

naturally pine lands. However, on areas which are predominantly hardwood the effect of the hurricane has been to lessen rather than increase the percentage of pine although 1938 was good white pine seed year. The great wind hastened the natural course of succession by blowing down the remaining old field pine and allowing the hardwoods to take over. Even in the case of comparatively young pine plantations the same thing happened. It is difficult to understand how catastrophes, wind at least, could increase the amount of pine on lands in which pine is not an important part of the climax. Fire by itself, or following a hurricane, might conceivably increase the amount of pine. Following a severe fire which destroyed all trees on the area light seeded species aspen, fire cherry and gray birch would first occupy the area. If due to chance white pine seeded in and became established before the other hardwoods it might well hold an important place in the stands for many years to come before giving way to the climatic climax.

Red Oak

Red oak is an other species that warrants special attention. From the early accounts it is apparent that this species was one of the major components of the ridge top communities and of considerable importance on all sites except the wettest.

Today in many of the ridge top stands nearly 100 % of the dominant trees are red oak. In the younger stands of this type the red oak is present in large numbers. It soon shares dominance with the red maple and by middle life over-tops this species.

It is believed that this species has taken over much of the

area lost by the chestnut. Because of the short time since the loss of the chestnut and due to the interference of man it is impossible to tell just what the exact position of the species would be in the ultimate forest. However, it is obvious that this will be the most important species numerically and commercially in the upland stands of the future.

Forest Types

In a transition region such as the one under discussion there is naturally a wide range of forest types. In the southern part of this region the types are similar to those of the " sprout " hardwood region with the oaks and to a lesser extent the hickories being plentiful. As we move to the north and noetheast the types more closely resemble those of the northern hardwood region with beech, birch and maple becoming more common as well as white pine and hemlock. There is ,nevertheless, through out the region a mixture of types from both the northern and southern regions. Of course topography as well as geography plays an important part in the distribution of types. Therefore on the north and north eastern facing slopes in the southern section of the region stands of the northern types are found and in the northern section on the southern and south western exposures central hardwood types are found.

Oak-Chestnut-Hickory Type

Through out the region the ridges especially those facing toward the south and southwest were covered with an oak-chestnut-hickory forest. Naturally there was considerable variation within this type. In the warmer drier sited the hickory was more common that elsewhere. The oaks involved in this type are red, white and black most frequently, and occasionally the chestnut and possibly a small amount of scarlet. The hickory consisted primarily of the shagbarck with small amounts of the bitternut and pignut. Peter Whitney found this type to be more common in Worcester County than any other type and describes it repeatedly. the following quotations are from him.

In the town of Mendon p.60

" The groves of wood here are in general very thrifty and tall, consistingfor the most part of walnut and oak. There are fine forests of most excellent chesnut suitable for building or fences."

Brookfield p.68

" The growth of wood is principally chesnut,white, red oak and some walnut--"

Oxford p.88

"--on higher lands are oak of all kinds, walnut and chesnut-"

Rutland p. 109

"The growth of wood in Rutland is oak of all sorts,chesnut, walnut--"

Westborough p.124

" The higher lands bear plenty of oak and chesnut and some walnut;-"

Southbridge p. 133

"The growth of wood is sufficient for the town if prudently used and consists of white, red and black oak, some walnut and more chesnut."

Hardwick p.176

" The principal growth of wood is oak of all sorts, chesnut and walnut:--"

Harvard p. 159

"Chesnut, oak of all sorts and walnut constitute the principal part on the highlands. "

Western p.210

"On the highlands grow chesnut, oak and walnut:--"

Through out the county he describes the type over and over

again. Only in a few towns in the northern and more hilly section of the region does he fail to note this type.

In addition to Whitney other early travelers found these species common through out southern New England. William Wood, 1634, in his New England's Prospect speaking of the area near Boston which is in the sprout hardwood region says: " The chiefe and common timber for ordinary use is Oake and Walnut: Of Oakes there be three kinds, the red the white and the blacke--"

The ridge tops, where these stands originally occurred,in the Petersham area are generally covered with soils of the gloucester series particularly Gloucester stony loam. It is impossible at this late date to tell the exact composition of the stands on these sites but the preceding quotations show that an oak-chestnut-hickory forest grew here.

These ridges were some of the land first cleared by the settlers for agriculture and only those at considerable distance from dwellings failed to be cleared. As in the case of must types in central New England following farm abandonment these areas grew up in pure or nearly pure stands of white pine. Following the cutting of these stands the areas invariably returned to stands of mixed hardwoods.

As these areas have returned to hardwoods they have not gone back to exactly the type described by Whitney. In the early part of the 20 th century the chestnut blight (Endothia parasitica) killed all the chestnut in the Petersham area and eliminated this species from the forest. Whitney's walnut is also largely missing from present stands. Raup, 1937, has brought out the point that the climate in New England is changing and becoming cooler and more moist. This would of course work against the hickory. If the hickory made up a part of the virgin forest

because of climatic conditions which existed 400-600 years ago and no longer exist naturally the hickory would not return to these stands. However, we have some stands which have always been in woodland and in these cases too the hickory is scarce.

Of course, none of the stands now in existance have gone through the whole stage from climax forest through clearing and back to climax forest. It is apparent, however, on these ridges there is going to be little or no hickory except on southern exposures and no chestnut. The forests of the ridge tops if left to nature will be largely an oak forest.

Table I shows the composition of a stand that has always been in woods. This stand has been cut over frequently but has never been entirely cleared. As all the hardwoods in this region sprout profusely it is reasonable to assume that none of the original hardwood species have been eliminated by man. Excessive opening of the stand might have permitted less tolerent trees than were present in the virgin forest to enter the stand. This seems to have been the case in this stand. Red oak is numerically by far the most important species in the stand. Not only does it make up 90 % of the trees in the dominant crown class, but is apparently crowding out the black birch which to a slight degree shares this dominance. Red maple is also present in this stand in considerable numbers but all trees of this species are over-topped. There are no softwoods of any species present in this stand.

Tables II and III show an area that has been through the white pine stage. In 1909 this was a partially stocked old field pine stand. The openings in this stand were filled in by planting white pine transplants (2-2). In 1938 this stand was completely destroyed by the hurricane of September 21. Those trees

which were large enough to produce saw logs were salvaged and the others were left on the ground. There is now some white pine present which is growing vigorously, but which is completely over-topped by hardwoods. The two plots were taken in this st-and to show the effect of different exposures. In the stand with the northern exposure the only oak is red oak, while in tha t section with the southern exposure there is some white and black oak present. The gray birch, fire cherry and other species with the exception of the red maple will be largely eliminated b y competetion by the time this stand gets to the table I stage.

Table IV shows a stand whose history is somewhat similar to that of the stand illustrated in tables II and III. In this case an old field occupied by sweet fern was planted in 1915 to red pine. The hurricane of 1938 completely destroyed this stand. This area is now largely occupied by sumac, gray b irch and fire cherry. However, both red oak and red maple are enter-ing the stand.There is one lone red pine present and a scatter-ing of over-topped white pine. Although this stand is very sim-ilar in history to the last stand described it is behind it in successional development. There is a much higher represent-ation of pioneer species and a much lower percentage of oak in the stand.

Table V shows a stand on an area that was cleared but never cultivated. This area was at one time a pasture and upon abandon-ment grew up to white pine and gray birch. The gray birch has now completely died out and only the stumps and a few logs re-main. Apparently soon after the arrival of the pine and birch, oak both red and white as well as hickory entered the stand. At present these species share the dominance with the pine. This is one of the few areas examined where hickory plays a

substantial part in the stand.

Table VI shows a stand with similar history to that shown in table V. This abandoned pasture came up to white pine and there is no evidence of any gray birch having been present. In this stand as in the preceding case hickory entered the stand with or immediately after the pine. There is very little oak of any kind present. The hurricane of 1938 destroyed the pine, but left the hickory virtually undamaged. At the present time this stand is almost 100 % hickory in the upper crown classes. In this stand as in those illustrated in tables, II, III and IV the hurricane speeded up the process of succession by decades if not more.

Table VII shows an old field pine stand blown down in 1938. This stand is now a mixed hardwood stand with a few white pine trees. At the present time red maple is the most important tree numerically followed by gray birch. Next in frequency to these two species come black birch, fire cherry and white and red oak. This is typical of what happens to young white pine stands when blown down or clear cut. Had reproduction become well established prior to the removal of the stand the gray birch and fire cherry would be much less common and the red oak and black birch would be more prevalent.

Table VIII shows an old field white pine stand about 50 years old. The pines are coarsely branched and wide spreading. This area was once a pasture, and upon abandonment gray birch seeded in with the white pine and is now being crowded out. This stand has a better variety of hardwoods in the understory than is usually found on these sites. The comparatively large amount of ash is rare. This was the only area examined where

any hickory was found on a northern exposure.

Table IX illustrates an old field pine stand partially blown down in 1938. This stand was recorded to show the composition of the reproduction under pine stands as they approach maturity. As elsewhere in Petersham all the pine on the actual ridge tops has been blown down. This stand was approximately 150 feet below the crest of the ridge. The residual stand on the top of the ridge was completely dominated by red oak with a lesser amount of red maple. It is interesting here to note the rather wide range of species closely resembling the hemlock-northern hardwood type. This plot is in the lower edge of the ridge top type and has some of the characteristics of the area immediately below it. In this same stand a little lower down the hill approximately 80 % of the reproduction was black birch and the red oak was negligible.

The stand recorded in table X was taken to illustrate an abandoned area just coming into old field pine. Prior to abandonment this area was being used for a pasture and juniper was becoming established. The pine trees are very thick immediately adjacent to the seed trees and 30 yards away there are still gaps in the new stand which are not occupied by any tree growth. In addition to the white pine there is a small amount of gray birch present which will remain in the stand a comparatively short period of time.

Table XI shows the next stage in development following that illustrated in table X. We now have a closed canopy of pine and the birch is rapidly being crowded out. The canopy is too dense in this stage of development to allow hardwoods to become established. It will be 20 years or so before hardwood reproduction appears in any quantity.

Table XII illustrates an old field white pine stand which was cut 25 years ago. This stand now consists of a mixture of red and white oak, red maple, gray and black birch and hemlock. This is the only ridge top studied that contained any hemlock. Apparently the hemlock entered the stand with or soon after the pine. When the pine was cut the hemlock was left and these few trees are now the largest on the area.

In the following tables the composition of the stands is shown on an acre basis. The number of trees per acre are broken into two classes, those up to 15 feet in height and those over 15 feet in height. In case where more than an occassional tree was above two inches in diameter the average dbh per species was given as well as the basal area per acre in square feet. The basal area and diameters are given in two sections. The first section includes trees in the dominant and co-dominant crown classes, the second section includes the overtopped trees and those in the intermediate crown classes.

TABLE I

Mixed hardwood association. This stand has always been in woodland. Soil type: Gloucester stony loam. Aspect: ridge top, level. Based on one .025 acre plot.

Species	Height 0-15'	Height 15/	Basal Area in square feet for trees 15/ Dom.& Co.	Ave.DBH	Int. & Ov.	Ave.DBH
Red Oak	120	320	91.84	8.0		
Red Maple	960	120			6.48	3.1
White Pine	120	40			7.76	3.3
Beech					1.76	3.0
Chestnut	120					
Black Birch	120	80	11.84	6.5	5.44	5.0
Gray Birch	20				0.24	1.0
Vaccinium sp.	scattered					
Viburnum sp.	scattered					

The dominant trees in this stand are approximately 35' tall and are all red oak except for one black birch.

TABLE II

Mixed hardwood association following old field white pine blow n down by the hurricane. Soil type: Gloucester stony loam. Aspect: north to northwest. Based on one 0.025 acre plot.

Species	Height 0-15'	15/
White Pine	92	
Gray Birch	800	400
Red Oak		320
Fire Cherry		200
Red Maple	1000	2280
Sweet Fern, Common		
Vaccinium, common		
Viburnum, common		

This was at one time an old field pine stand. As the area was only partially stocked the openings were filled in with white pine transplants (2-2) The stand was completely destroyed by the hurricane of September 21, 1938. The dominant red maple, red oak and gray birch are now 20' tall. The white pine is all over-topped, but is still growing vigorously, and has enough light and space. Average height of the pines is 12'.

TABLE III

Mixed hardwood association following old field pine blown down by the hurricane. Soil type: Gloucester stony loam. Aspect south. Based on one 0.025 acre plot.

Species	Height 0-15'	15' +
Red Oak	700	80
White Oak	800	110
Black Oak	300	50
Red Maple	500	280
Gray Birch	700	600
White Pine	260	
Willow sp.	130	
Shumac		260

This was at one time an old field white pine stand. As the area was only partially stocked the openings were filled in with white pine transplants (2-2). This stand was completely destroyed by the hurricane of September 21, 1938. The dominant oak and red maple are about 20' tall and the pine averages 12'. This is the same stand as that in table II this section of the stand has a southern exposure. This change has apparently been responsible for the black and white oak.

TABLE IV

Mixed hardwood association following the blow down of a red pine plantation. Soil type: Gloucester stony loam. Aspect: north to northwest. Based on one 0.10 a cre plot.

Species	Height 0-15'	15' -/
White Pine	150	
Red Pine	10	
Gray Birch	560	50
Red Oak	80	20
Fire Cherry	260	60
Red Maple	30	
Aspen	60	
White Ash	30	
Black Birch	40	
Sumac		980

The average height of the white pine is 5'. The cherry and birch average 12' and the red oak 10' The ground is covered with black berries and raspberries. In 1915 this was an old field with a scattering of sweet fern and at that time was planted to red pine with (2-2) transplants.

TABLE V

White pine hardwood association. This area was once an old pasture and upon abandonment white pine and gray birch seeded in. The birch has died out and oak and hickory now share the dominance with the pine. Soil type: Gloucester stony loam shallow phase. Aspect: west to southwest. Based on one 0.10 acre plot.

Species	Height 0-15'	15'/	Basal area in square feet for trees 15/ Dom.&Co.	Ave.DBH	Int.&Ov.	Ave. DBH
White Pine	190	190	47.28	12.5	15.99	4.5
Red Oak	90	10	15.76	17.0		
Hickory	50	80	9.28	6.5	2.43	4.0
White Oak	60	60	18.87	10.0	4.19	5.0
Hemlock	100					
Chestnut	30					
Black Birch	40					
Fire Cherry	50					
Gray Birch	60					
Paper Birch		20	8.84	9.0		

The average height of the dominant trees is 55 feet.

TABLE VI

Hickory Association. This stand was at one time a pasture which seeded into white pine with hickory entering the stand soon afterward. The hurricane of 1938 blew down the pine and now practically all the dominant trees are hickory. Soil type: Gloucester stony loam shallow phase. Aspect: south. Based on one 0.10 acre plot.

Species	Height 0-15'/	15'/	Basal area in square feet for trees 15/ Dom.&Co	Ave.DBH	Int.&Ov.	Ave. DBH
White Pine	290	20			2.23	3.0
Red Oak	200	10	6.60	10.5		
Hickory	40	330	59.61	6.0	5.23	3.5
White Oak	50					
Red Maple	130	10	1.96	6.0		
Fire Cherry	10					

The dominant trees in this stand are 35 feet tall.

TABLE VII

Mixed hardwood association following the blow down of an old field stand of white pine. Soil type: Gloucester stony loam. Aspect: west. Basdd on one 0.025 acre plot.

Species	Height 0-15'/	15'/
Gray Birch	1160	
Red Maple	1440	
Red Oak	120	
White Pine	80	
Sugar Maple	40	
Fire Cherry	520	
Black Birch	680	
Paper Birch	80	
White Oak	320	

Raspberries, blackberries and sumac are plentiful and there is also some sweet fern present.

TABLE VIII

White pine association. Soil type: Unknown. Aspect: north to northwest. Based on one 0.10 acre plot.

Species	Height 0-15'	15'/	Basal area in square feet for trees 15'/ Dom.&Co.	Ave.DBH	Int.&Ov.	Ave.DBH
White Pine		200	92.26	10.7	5.95	4.0
Gray Birch	20	50			2.51	3.0
Red Oak	30					
White Ash	40					
Black Birch	20					
Hickory	20					

In this 50 year old white pine stand the average height of the dominant trees is 50 feet.

TABLE IX

Old field white pine association partially blown down by the hurricane. Soil type: Gloucester stony loam. Aspect: northwest. Based on one 0.10 acre plot.

Species	Height 0-15'	15%	Basal area square feet for trees 15% Dom.&Co.	Ave. DBH	Int.& Ov.	Ave.DBH
White Pine	320	120	125.64	13.5		
Black Birch	200	40	15.80	8.5		
Red Maple	840	160			2.96	2.0
Red Oak	440	40			0.48	2.0
White Ash	120	80			0.48	1.0
Chestnut	120					
Basswood	40					
Sugar Maple	40					

The average height of the dominant trees all of which are white pine is 65 feet.

TABLE X

Old field pine association. Soil type: unknown. Aspect: level, ridge top. Based on one 0.10 acre plot.

Species	Height 0-15'	15'/
White Pine	1120	
Gray Birch	130	
Juniper	110	

This stand was an old field and has just started to seed into white pine. The oldest pines are 11 years old and about 8 feet tall.

TABLE XI

White pine association. This area was an abandoned field which grew up to white pine and gray birch. The gray birch has been nearly crowded out by the pine. Soil type: unknown. Aspect: north west.

Species	Height 0-15'	15'/	Basal area in square feet for trees 15'/ Dom.&Co. Ave. DBH		Int.& Ov. Ave.DBH	
White Pine		480	94.08	5.5		
Gray Birch		10			.34	2.5

The dominant trees in this stand are 30 feet tall.

TABLE XII

Mixed hardwood association. This area was at one time a pasture, and upon abandonment it grew up to white pine and a few hemlocks were also present. Approximately 25 years ago the pine was cut and there is now a young hardwood stand. Soil type: Gloucester stony loam. Aspect: level. Based on one 0.10 acre plot.

Species	Height 0-15'	15'/	Basal area in square feet for trees 15'/ Dom.&co.	Ave. DBH	Int.& Ov.	Ave. DBH
Red Oak	80	40	4.08	5.0	.22	2.0
White Oak	30	30	2.20	4.5	.49	3.0
Red Maple	200	60	2.68	3.5	.24	1.4
Hemlock	10	30	5.88	6.0		
Gray Birch	40	30	[illegible]		1.02	2.5
Black Birch	70	50	1.47	3.0	.44	2.0

The hemlocks are the dominant trees and average 35 feet in height.

Swamps and Swales

In the swamps and swales grew a forest very different from the oak-chestnut-hickory type of the ridges. This forest was also described repeatedly by Whitney, but with more variation than in the oak-chestnut-hickory type. This type was characterized by a large number of hardwood species and occasionally some hemlock and white pine. This type of forest contained many bushes and was not free from under brush as were the ridges. Wood, 1634, noticed this difference and felt that it was due to fire; the swamp forest being too wet to burn. "-- there is no underbrush saving swamps and low ground that are wet." Belknap also noted the underbrush in this type of forest and stated; " In swamps and near rivers there is thick growth of under wood which renders traveling difficult."

This type consists of a mixture of birch,both yellow and black, red and sugar maple, both black and white ash as well as elm, beech, hornbeam amd some hemlock.

Whitney's descriptions of it are as follows.

Brookfield p. 81

" The swamps and swales yield maple, black birch,ash and some hemlock."

Oxford p.88

": On the lower ground grow ash, birch, elm of all sorts maple-- "

Sutton p. 139

" In the lowlands the wood is ash, birch, maple &c."

Shrewsbury p. 159

"--, and the lowlands bear ash, birch, maple &c."

Upton p. 173

" The low lands have beach, elm and alder &c. "

Western p. 201

"--, and in the lower lands grow ash, birch, maple, elm, pine and hemlock."

Spencer p. 214

" The swamps are covered generally with maple, birch and elm."

Petersham p. 221

" In the swamps and low lands there is beach, maple, ash, elm and hemlock."

Westminster p. 229

" The low lands are stored with ash, beach, birch, ma ple a nd hemlock."

Today swales on the Harvard Forest are much the same in composition as they were in the 18th century. These areas were too damp for cultivation and when cleared were used as pastures. When these sites were abandoned they did not develop into pure stands of white pine as did the ridge tops, but rather to stands of mixed hardwoods with red maple being the most common. The other most common species present were white ash, black a nd yellow birch, sugar maple, elm and basswood. White pine when present at all was of minor importance. The composition depended largely on the available seed supply.

Not all of these areas were ever cleared. Many of them were used as farm woodlots and many of those which were cleared have been cut over several times since abandonment. The effect of these cuttings has been to increase the percentage of red

maple. The vigorous sprouting ability of this species plus its ability to grow in the open and its light seededness give it an advantage over its rivals. Apparently the heavier these swales are cut the more important the red maple becomes.

In the future by judicious management it should be possible to increase the percentage of the commercially more valuable species at the expense of the red maple. However, due to the vigor of the red maple this will be a long slow process.

The swamps in the Petersham region have had much the same treatment as the swales. Apparently few of the swamps were ever cleared and they have been used as woodlots. In the original forest there must have been a slightly wider range of species than in the swales. Hemlock and white pine both must have been more common here than in the swales.

The frequent cuttings have been more detremental to these conifers than to the sprouting hardwoods. As in the case of the swales red maple seems to have gained at the expense of the other species due both to increased light and to its sprouting ability. The sylvicultural treatment in this case will have to be similar to that of the swales.

Cedar Swamps

In addition to the hardwood swamps Whitney also reported cedar swamps in the southern part of Worcester County. This type was apparently rare in the transition region. To quote from Whitney once again.

Oxford p. 88

" There are some small cedar swamps, which yield cedar for shingles and other valuable uses."

Westborough p. 124

" Here also they have large and excellent cedar swamps, which afford the people with shingles and other important necessary uses."

These swamps usually consisted of stands of southern white cedar only occasionally mixed with other swamp species. Sphagnum moss and heath plants were characteristic of this type and there was also an accumulation of peat. As there are no areas of this type in Petersham no successional studies were made of the cedar swamp type.

Spruce Bog

Today there is clearly disernable a spruce bog type distinctly different from the cedar swamp and from the hardwood swamp types. This type is characterized by a growth of black spruce. As in the case of the cedar swamp type sphagnum moss is present as well as heath plants a nd there is an accumulation of peat. In the less boggy ground around the spruce is found larch and sometimes red maple and white pine.

Whitney does not describe this type, but in several towns he suggests it.

New Braintree p. 209

"--, in the low swamps and marshes there is maple, ash, beach, hornbeam and some spruce and hackmatav." Here he is apparently describing the swamp type and also the spruce bog.

Royalston p. 263

"--, as pine, hackmatac and spruce &c."

These spruce bog still exist today in about the same form as in Whitney's day. These lands were never cleared as they were not suitable for agriculture. Presumably there has been

some cutting, but it is inconceivable that there has been any marked change in the composition of such stands.

The Pine Plains

Among the forest types definitely recognizable from the old accounts is the " pine plains " or more commonly the " pitch pine plains". In the drier sand and gravel soils of outwash origin this was and still is a commomn type. The driest sites of this sort were occupied by pitch pine in pure or nearly pure stands. In the more moist areas white pine entered the stands and in the even more moist areas the pitch pine was almost entirely lacking and hemlock joined with the white pine. As the sites became still wetter the plains lost their distinctive character and more closely resembled the surrounding uplands. Therefore it was the pitch pine plains that caught the eye of the early travelers and many of them remarked on it. Timothy Dwight, 1821, in his Travels in New England and New York noticed them along the Connecticut River.

Further north in New Hampshire Belknap, 1813, remarked on them. While on the subject of roads he says; " The best kind of lands for roads is where the pitch pine grows, this is generally level, or if not perfectly so, yet always dry; the trees are sparce and the undergrowth consists of braken, fern and wortlebushes, which are easily subdued; but this kind of land is not profitable-- "

Needless to say, our old friend Peter Whitney also noted and commented on the pitch pine plains:

Rutland p. 119

" In the westerly part of town is an extensive plain which is still covered with pitch pine. This is rather light land."

Grafton p. 169

" There is some pine plain land in this town near the rivers."

Leominster p. 197

" In the south part of town there is a very large body of plain land covered with pitch pine."

New Braintree p. 209

" On the westerly side of town is what is commonly called a plain though not very level, its natural growth of wood is pitch pine."

Athol p. 216

" There is some pitch pine plain in the north part of town."

The pitch pine plains are still recognizable today and have been all through the history of central New England. In 1891 Joseph B.Wheeler in speaking to a meeting of the New Hampshire Board of Agriculture said of the pitch pine plains;

" Fifty years ago, heavy growths of pitch pine trees (Pinus rigida) were to be found on sand formatioms along some of the rivers of the state. Specimens were not uncommon which compared quite favorably with the hard pines (Pinus Australis) of the south. But such forests have mostly disappeared. Those pine trees have been cut for lumber and the inferior ones used for wood, much of which has been consumed by locomotive engines.

" Where forests of this wood have been removed, they have shown a disposition to return with similar growth, but in many cases, particularly in the vicinity of large towns, fires have destroyed the second growth before they had attained a size sufficient to endure their ravages. This remark applies with particular force to hard pine woods in the vicinity of Concord and Manchester. The dark plains, so well known to the people of the former city, a half century ago, is to be found

only in history."

On the Harvard Forest there are no examples of pitch pine plains. However, pitch pine plains that Dwight noted along the Connecticut River are still there. In this study there was no oppurtunity to study them thoroughly. The stands that were looked at were nearly 90 % pitch pine. The remainder of the stands were made up of over-topped gray birch and a few scattered oaks. Apparently following clear cutting or farm abandonment gray birch comes in heavily along with the pitch pine. Eventually as the gray birch dies out the pine gains nearly complete control of the area. An occassional oak also survives with the pine. The sites of this type are unusually dry and are therefore particularly subject to fire. Unfortunately there was no chance to study the effect of fire upon succession.

In the Harvard Forest there is a tract which according to Marshall, 1927, has always been a stand of white pine and hemlock. Lutz and Cline, 1947, describe this area in the thirty year report. This was the one site listed where they believed it was feasible to produce continuous crops with a high percentage of white pine,

All trees of any size on the area were destroyed by the hurricane of 1938. From studies of tree growth now on the ground it is difficult to get a clear picture of what is happening. On one section of the area a rather dense stand of hemlock and white pine has already gained possession of the site. However, close by an area that seems to be exactly the same the tree growth is composed of red maple, red and white oak and small amounts of gray birch, fire cherry and some aspen. Here the stand looks almost exactly like those of similar age on the ridge tops and it seems as if pine and hemlock will never be im-

portant elements of the stand. Adjoining both these areas is one which is sparcely stocked with gray birch, fire cherry and aspen with a few scattered white pines. In this section the oaks and red maple have not entered the picture and it is conceivable that white pine might gain dominance. All three of these areas are on soils of the Hinckley and Merrimac soil series.

From this it can readily be seem that the successional trends are not clear. From a sylvicultural stand point it would be possible by proper cuttings to bring through a substantial amount of white pine. However, it seems obvious that left to its own devices only a relatively small portion of the total area would revert to pine and hemlock and that the remainder would become a mixed hardwood stand with an occassional pine.

The Ravine Type

In the transition region the ravines were occupied by a type very distinct from that found on the ridge tops and also from those found in swamps and swales. This ravine type is very similar to the hemlock northern hardwood type so common further north and also present in the transition region. Hemlock is the most characteristic species and with it is found black birch and some yellow birch, beech and both red and sugar maple. Red oak was present in this type as was ash and to a limited extent white pine. It was a variation of this type that Hawes described.(Hawes and Hawley, 1909) " It is for the most part a mixture of immense hemlock, beech, yellow birch, sugar maple, fine black cherry, ash, chestnut and oak with a few giant white pines--" The black cherry which Hawes mentions is rather uncommon in the transition region, and in the southern part of the region the yellow birch is usually not as common

as the black.

This type was obviously common in Whitney's day, but as he lumped his low land species together it is difficult to distinguish between the swamps and swales types and the ravine type. However, he suggests this type at several points.

Western p. 201

"-;and in the low lands grow ash, birch, elm, pine, hemlock &c.-" Apparently he is describing both the ravine and swamp and swale types.

Petersham p. 221

" In the swamps and low lands there is beach, maple,ash, elm and hemlock." Both types again.

Westminster p. 229

" The low lands are stored with ash, beach, birch, maple and hemlock."

Athol p. 284

"-:but oak, chestnut, ash, beach, birch and hemlock and maple constitute the principal growth of wood."

Hubbardston p. 284

" The growth of wood in this place is chiefly white pine and pitch pine in great plenty, hemlock, beach and maple and oak there is little of any sort." The last section seems to indicate the ravine type."

Because of the rockiness and steepness of the slopes it seems unlikely that any very great amount of this type of land was ever cultivated. Apparently this land was cleared or partially cleared and used for pasture. Often these stands must have been used less and less until finially abandoned completely. This resulted in a smaller portion of hardwoods in the new stands than in the original forest. Areas of this type are now

rather common in central New England and consist of nearly pure stands of hemlock or hemlock and white pine. In stands where the hardwoods have not been eliminated there are specimens of yellow birch, red oak, black birch, white ash, sugar maple and in some of the younger stands paper birch. Hemlock is the characteristic species of this type and usually makes up more than 50 % of the total number of trees present.

It is in these stands that much of the best timber in the region is found. The trees are taller and straighter and the form much better than in surrounding stands. It is here also, that the longest branch free stems are found.

Hemlock Northern Hardwood Type

In the northern part of the transition region the uplands are covered with a mixture of hemlock and the northern hardwoods. This type covers an immense area and varies a good deal in composition. The following species are commonly found in this type: hemlock, black and yellow birch, red and sugar maple, beach, ash, red oak, basswood and white pine. Whitney described this type very nicely in the town of Winchendon. " The general growth of woods on the highlands, is red oak, beach, rock maple and black birch interspersed with white pine and hemlock."

This type is also described by Cline and Spurr, 1942, in their study of The Virgin Upland Forest of Central New England. They found the climatic climax in the Pisgah area on the low slopes and mid-slopes to consist [illegible], "-- primarily of hemlock, beech and sugar maple, with black birch and white ash as other major components and yellow birch, basswood and red spruce as species of minor importance. This hemlock-beech-sugar maple association is essentially the same hemlock-northern hardwood

climax recognized by the majority of field investigators as existing throughout the northeastern United States."

As can readily be seen this upland type is made up of practically the same composition as the ravine type previously described. It is interesting once again to quote Hawes. " It is for the most part a mixture of immense hemlocks, beech, yellow birch, sugar maple, fine black cherry, ash, chestnut and oak with a few giant white pines--" These two stands are very similar. The cherry and chestnut of Hawes are missing on the Pisgah tract while the basswood is absent in Connecticut as well as the spruce and the black birch. Another apparent variation is the oak. In the Pisgah tract the red oak was the only oak found. Hawes simply lists oak implying that more than one species was present.

A variation of this type was found by the early explorers along the coast of Maine. In Weymouth's trip up the George River he found(Rosier, 1605); " The wood she beareth is not shrubbish fit only for fewell, but goodly tall, Firre, Spruce, Beech, Oke, which is in many places not so thick--" There is a good deal of confusion about which species the early authors had in mind, but apparently Rosier's Firre was white pine. In the summary of what had been seen on the shores of Maine Rosier on page 159 tabulates the trees found.

" A Briefe note of what profits we saw the country yield in the small time of our stay.

Trees

Oke, of an excellent grain, straight and great timber.

Beech

Birch, very tall and great, of whose bark they make their canoes.

Wich-hazel

Hazel

Alder

Cherry-tree

Ash

Maple

Yew Hemlock ?

Spruce

Aspe Aspen?

Firre White Pine?

Many fruit which we knew not."

This type described so completely by Cline and Spurr, 1942, must have occupied a greater area than any other type in central New England. It is believed that in the Petersham area this type must have occupied vast areas between the swales, swamps bogs, and ravines and the ridge tops. Undoubtedly there was, is now and will be in the future a great variation in this type.

Apparently as we go up the slopes the hemlock becomes less important and the red oak more so. It is believed that on the mid-slopes the black birch becomes more important than elsewhere in the forest. In all old field white pine stands investigated on these mid-slopes the black birch was the species most prominant in the reproduction. In the Petersham area the yellow birch is not very important but may well be so only slightly furtner north. Beech and sugar maple are present in small numbers and the ubiquitous red maple is prominent particularly in the younger stands.

It was on these sites that many of the old field pine stands occurred. These areas were abandoned early and except in the

most moist areas grew up to nearly pure stands of white pine. Presumably if these stands are left undisturbed the beech and the sugar maple will gain at the expense of the birch and oak. However, on any conceivable plan of forest management the rotation would be too short to allow these species to fully develop. Therefore on a commercial basis the hardwoods grown here would be primarily birch and oak with possibly a small amount of ash and of course red maple with the sugar maple and beech being of minor importance.

White Pine- Hemlock Type

In the Pisgah tract Cine and Spurr, 1942, found a hemlock white pine physiographic climax at the higher elevations and on the ridge tops. This type consisted primarily of hemlock and white pine with lesser amounts of beech, black birch and red maple. This type is similar to that white pine-hemlock association described under the pine plains. The existance of such a type is brought about by light dry soils which are comparatively infertile. No examples of these type were found at Petersham and no effort has been made to trace the successional trends.

Summary

In this paper an attempt has been made to describe the forest types as they appeared in the pre-colonial forest of central New England, and to trace the development of these types following their use by man. It was possible to describe eight distinct types in the original forest. It is, of course, realized that all the forest did not fall into these types and much of the total area must have been a combination of two or more of these types.

The eight types are as follows:

1) An oak-hickory-chestnut forest occurred on the ridge tops. Most of this land was cleared and much of it was later abandoned. Upon abandonment this type of land became a pure or nearly pure stand of white pine. Following the cutting of these pine stands a mixed hardwood forest gains possession of the area. These sites will never return to the original oak-hickory-chestnut type. The chestnut has been eliminated by the chestnut blight (Endothia parasitica) and the hickory does not seem to be as plentiful as in the early descriptions. In the future these areas will be occupied by forest primarily of oak. On sites with southern and southwestern exposures there will also be some hickory present.

2)The swamps and swales were originally occupied by a mixed hardwood forest with some hemlock. These areas were not always cleared, and when cleared were used as pastures rather than cultivated.Those areas which were not cleared were used as farm wood lots. The treatment these areas have had has tended to reduce the amount of hemlock and increase the amount of red maple. In the future these areas should produce valuable stands of mixed hardwoods.

3) Cedar swamps occurred in the original forest of the region. However, none of these areas were studied and no attempt has been made to trace the successional development of these.

4) Spruce bogs also exist in central New England. They do not occupy a large area and are of little commercial importance. No successional studies were made of this type.

5) In this region there are considerable areas of sandy plains which were originally occupied by pine forests. On the driest sites these areas supported pure stands of pitch pine. In the damper section white pine occurred with the pitch pine and in the still more moist areas the pitch pine dropped out and hemlock grew with the white pine. When these forests are cut they tend to return to forests of the same composition as the original forest. These areas are dry and fire is more of a menace here than elsewhere in central New England. In this study there was no opportunity to study the fire successions.

6) Through out the region ravines were occupied by a mixed hemlock hardwood forest with some white pine. These areas are too steep and rocky to be cultivated and when cleared were used as pastures. Upon abandonment they came back into white pine and pine and hemlock. It takes many years for the hardwoods to get back into these stands, but cuttings of any sort speeds this process. These areas now support some of the best timber of the region.

7) Much of the region is occupied by a mixed hemlock-northern hardwood forest. This type varies a great deal in composition including hemlock, beech, sugar maple and yellow birch in its most typical form. Other species present are red oak,

red maple, white ash, white pine, black birch and paper birch. In the Petersham area red oak and black birch are important in this type. Further north yellow birch, beech and sugar maple are the important hardwood species. These areas when cleared and abandoned grew up into nearly pure stands of white pine. Following the cutting of the pine they revert to mixed hardwood forest and eventually to a mixed hardwood hemlock forest with a very small amount of white pine.

8) Studies of old growth forests have revealed that there is also a hemlock-white pine physiographic climax on some of the higher ridges in the region where the soil is thin and well drained. None of these sites were found in Petersham and no studies of succession were made.

This study was made with the belief that to obtain success in sylvicultural operations it is necessary on a given site to raise the type of forest that is best adapted to that site. In the past this idea has not been carried out in central New England. Repeatedly foresters have tried to raise pure stands of white pine on sites not suited for white pine and almost as often the result has been complete failure. This paper was written with the hope that it would be of some value as a guide for future sylvicultural work in the region.

A list of the species of plants refered to with the scientific names as given by Harlow and Harrow in Textbook of Dendrology secend edtion. New York. 1941.

White or mast pine	Pinus strobus
Red pine	Pinus resinosa
Pitch pine	Pinus rigida
Larch, tamarch, hackmatac	Larix laricina
Red spruce	Picea rubens
Black spruce	Picea mariana
Hemlock	Tsuga canadensis
Southern white cedar	Chamaecyparis thydoides
Aspen	Populus tremuloides
Shagbarck hickory	Carya ovata
Pignut hickory	Carya glabra
Bitternut hickory	Carya cordiformis
Yellow birch	Betula lutea
Black birch	Betula lenta
White or paper birch	Betula papyrifera
Gray birch	Betulapopulifolia
Alder	Alnus incana
Hormbeam	Ostrya virginiana
Hazel	Corylus americana
Beech	Fagus grandifolia
Chestnut	Castanea dentata
White oak	Quercus alba
Red oak	Quercus borealis var. maxima
Black oak	Quercus velutina
Scarlet oak	Quercus coccinea
Chestnut oak	Quercus montana

Elm	Ulmus americana
Witch-hazel	Hamamelis virginiana
Black cherry	Prunus serotina
Sugar,rock or hard maple	Acer saccharum
Red maple	Acer rubrum
Basswood	Tilia americana
White ash	Fraxinus americana
Black ash	Fraxinus nigra
Staghorn sumac	Rhus typhina
Sweet fern	Comptonia perigrina
Blueberry sp.	Vaccinium
Viburnum sp.	Viburnum

Bibliography

Annon. 1923. Observations on the Results of Artificial forestry in Germany. Journ.of For. 21:717-722

Bray, William l. 1915. The Development of the Vegetation of New York State. N.Y.state Col.of For. Tech. Pub. 29.

Brierly, William B. 1936. The effect of Paxton and Sutton soils upon vegetation types in Worcester County, Massachusetts. Clark Univ. Abstracts of Dissertations and theses, 8:75-78.

Brooks, C.F. 1939. Hurricanes into New England. Meteorology of the storm of September 21,1938. Geog. Rev.,29:119-127.

Bromley, Stanley W. 1935. The original forest types of southern New England. Ecol. Monog., 5:61-89

Burrage, Henry S. 1887. Rosier's relation of Weymouths voyage to the coast of Maine 1605. Portland, Maine.

Cline, A.C. and S.H.Spurr. 1942. The Virgin upland forest of central New England. Harv. For. Bull. No. 21.

Cline, A.C. and C.R.Lockard. 1925. Mixed white pine and hardwood. Harv. For. Bull. No. 8.

Cunningham, Floyd E. 1930. The relation of forest invasion and succession to the major soil types of the central Massachusetts uplands. Unpublished manuscript in the library at Clark Univ. Worcester, Mass.

Defebaug, James Elliot. 1906. History of the lumber industry in America. Chicago.

Dwight, Timothy. 1821. Travels in New England and Nwe York. New York.

Flint, R.F. 1947. Glacial geology and the pleistocene epoch. New York.

Fisher, R.T. 1933. New England Forests; biological factors. New England Prospect. Am. Geog. Soc. Spec. Publ. No. 16 : 213-223.

Flag, Wilson. 1890. A year among the trees. New York.

Gordon, Robert F. 1940. The primeval forest types of southwestern New York. N.Y. State Museum Bull. No. 321.

Gorges, Ferdinando Sir. 1622. A brief relation of the discovery and plantation of New England. Reprinted by the Prince Society. Boston. 1890.

Gleason, H.A. 1927. Further views on the succession concept. Ecology 8:299-326

Kincer, J.B. 1933. Is our climate changing? A study of log term temperature trends. Mon. Weather Rev. 61:251-259.

Harlow, W.M. and E.S. Harrar. 1941. Textbook of dendrology. second edition. New York.

Hawes, Austin F. 1923. New England forest in retrospect. Jour. of For. 21:209-224

Hawes, A.F. and R.C.Hawley. 1909. Forest survey of Litchfield and New Haven counties. Conn.Agri. Exp. Sta. Bull. No.162.

Hawes, A.F. and R.C. Hawley. 1912. Forestry in New England. New York.

Heske, Franz. 1938. German Forestry. New Haven, Conn.

Hough, A.F. 1936. A climax forest community on East Tionesta Creek in northwestern Pennsylvania. Ecology 17:1-28.

Hough, A.F. and R.D.Forbes. 1943. The ecology and sylvics of forests in the high plateau of Pennsylvannia. Ecol. Monog. 13:299-320.

Illick, J.S. 1935. Outline of general forestry. New York.

Josselyn, John, 1672. New England Rarities. London

Josselyn, John. 1675. Two voyages to New England. London.

Lutz, H.J. 1930. Vegetation of Heart's Content, a virgin forest in northwestern Pennsylvania. Ecology 15:295-297

Lutz, H.J. 1928. Trends and significance of upland forest successions in southern New England. Yale Univ. School of For. Bull. No. 22.

Lutz, H.J. 1934. Additions to the flora of Heart's Content,a virgin forest in northwestern Pennsylvania. Ecology 11: 1-29.

Lutz, R.J. and A.C.Cline. 1947. Results of the first thirty years of experience in sylviculture in the Harvard Forest, 1908-1938. Part I The conversion of stands of old field origin by various methods of cutting and subsequent cultural treatments. Harv, For. Bull. No. 23.

Marshall, Robert. 1927. The growth of hemlock before and after release from suppression. Harv. For. Bull. No. 11.

Morton, Thomas. 1632. The New English Canaan. London.

Nichols, G.E. 1913. The vegetation of Connecticut II. virgin forests. Torreya 13:199-215.

Nichols, G.E. 1923. A working basis for ecological classifications of plant communities. Ecology 4:11-23, 154-179.

Latimer, W.J. et.al. 1927. Soil survey of Worcester County, Massachusetts. U.S. Department of Agriculture Bureau of soils. Washington, D.C.

Nichols, G.E. 1935. The hemlock-white pine-hardwood region of eastern North America. Ecology 16:403-422.

Raup, Hugh M. 1937. Recent changes in climate and vegetation in southern New England and adjacent New York, Jour, Arn. Arb. 18:78-117.

Raup, Hugh M. 1940. Old field forests of southern New England. Journ. Arn. Arb. 21:266-273.

Raup, Hugh M. and R.E.Carlson. 1941. The history of land use in the Harvard Forest. Harv. For. Bull. No. 20.

Roberts, E.A. 1914. The plant successions of the Holyoke Range. Bot. Gaz.

Smith, John. 1616. A description of New England. London.

Spurr, S.H. and A.C.Cline. 1947. Ecological forestry in central New England. Jour. of For. 40:418420.

Whitney, Peter. 1793. The history of the county of Worcester. Worcester.

Walker, Joseph B. 1891. Our New Hampshire Forests. Concord,N.H.

Wood, William. 1634. New England's Prospect. London.

U.S.Department of Agriculture Yearbook 1937. Washington D.C.

Simmons, C.S. 1939. Soil survey of the Harvard Forest- Tom Swamp Block. Petersham, Mass.

Simmons, C.S. 1940. Soil survey of the Harvard Forest- Slab City Block. Petersham, Mass.

Simmons, C.S. 1941. Soil survey of the Harvard Forest- Prospect Hill Block. Petersham, Mass.