

NATURAL RESTOCKING OF HURRICANE DAMAGED "OLD FIELD"  
WHITE PINE AREAS IN NORTH CENTRAL MASSACHUSETTS

by

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#### A. INTRODUCTION

The area covered by the present study includes the towns of Petersham, Athol, Royalston, Winchendon, Phillipston, Templeton, Hubbardston, Barre, Hardwick, and New Braintree in north central Massachusetts (See Fig. 1). These towns were directly in the path of the hurricane which swept through New England in September 1938, and their forests were severely damaged. "Old field" white pine (*Pinus strobus* L.) was especially susceptible to windthrow. Stands of this type were almost completely destroyed throughout the hurricane area.

The widespread destruction of "old field" pine stands has caused much concern as to what should be done to rehabilitate these areas. Because many local wood-using industries, such as those making boxes, woodenware, and toys, depend to a large extent upon white pine for their raw material, the economic loss, as well as the scenic and aesthetic loss, is of great moment. A shortage of this once very abundant species was becoming noticeable even before the hurricane, but now this condition is critical. It seems likely that many industries relying upon white pine for production will be forced to suspend operations unless the present drain can be reduced by supplementing the supply from other sources.

The future productivity of central New England's forests depends in a large measure upon the restocking of the pine blowdown areas. While it was observed that many of these areas were being naturally restocked with young trees, the degree to which this stocking was taking place and its suitability for timber production was not known. Without such knowledge, it is impossible to determine a policy of forest rehabilitation for this region.

It was known that such factors as soil fertility, the composition, density and age of the previous stand, and the kind and amount of ground plants, litter, and slash influence the composition and distribution of volunteer stocking. The first step in the study, therefore, was to obtain a measure of the influence of these various factors on the reproduction coming in on pine blowdowns, so as to provide a guide for planning forest restoration, more especially to determine to what extent dependence might be placed on volunteer stocking, or, on the other hand, to what extent artificial regeneration might be required. Furthermore, it was intended that this study should disclose the most effective measures which could be applied to improve the new stands in the course of their early development.

## B. HISTORY OF "OLD FIELD" WHITE PINE

As this study is confined wholly to windthrown "old field" white pine stands, it is important to know their origin and history before considering their present condition.

### Land Use History

The initial settlement of central Massachusetts began about 1700 and was largely completed in most of the towns by 1750. Throughout this entire area the better lands were cleared and used for crops and pasturage, and between 1830 and 1850 agriculture reached its full development. During this period of intensive farming activity, probably as much as 85 per cent of certain towns and 60 to 65 per cent of others was cleared for agricultural purposes.

Soon after 1830, however, the increase in manufacturing, the opening to settlement of new, more fertile lands farther west, the discovery of gold in California, and the development of the trans-continental railroad caused many rural people to move into the rapidly growing industrial centers or to join the westward movement. Farms began to be abandoned about 1830, and the movement from the farms persisted until the early 1900's. At the present time, not more than 30 per cent of the region to which this study applies is open land. The remainder, removed from agriculture, through abandonment, reverted naturally to forest.

### Origin and Character of "Old Field" White Pine Stands

At the time the farm lands were abandoned, the few surrounding woodlands were composed of a large variety of hardwood species together with white pine and hemlock. On the heavier soils, white pine occurred in varying quantities, its distribution depending



upon the presence of openings made by some catastrophic agency such as a fire, or a severe ice or wind storm. On the light, sandy soils where competition from hardwoods was less, conifers, such as white, pitch, and red pine and hemlock, formed nearly pure stands (Cline and Lockard, '25). In the pastures, bushy, open-grown white pines were common. These were left to provide shade for the livestock.

The grass cover, and in some instances the exposed mineral soil of the abandoned fields and pastures, presented ideal seedbeds for white pine. These conditions, combined with the prolific seeding habits of pine and the mode of dissemination by wind, gave the pine a great advantage over most of the hardwoods. There were usually sufficient white pine scattered throughout the woodlots and along the fence rows, in addition to the pasture pines, to heavily seed in the lands immediately following abandonment. On the heavier soils the results were numerous, pure<sup>1</sup>, well-stocked, even-aged

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<sup>1</sup> The study was confined to pure "old field" white pine stands. "Pure" is taken to mean at least 80 per cent pine by volume. It is therefore possible to have pure stands with less than 80 per cent by stem count.

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stands of pine. However, on the lightest soils the seeding was more sporadic, being influenced by certain ground plants characteristic of these soils. Here, the form of stand was usually uneven-aged by groups. Where the supply of seed was not sufficient to establish a dense stand of pine, the trees ultimately developed the characteristic open grown form with extreme branchiness, and wide crowns. A small representation of hardwoods, usually associated with wet areas, was commonly present in the pine stands.

namely, gray birch, pin cherry and poplar, have greatly increased in abundance owing to clear cutting practices and fires. Fisher ('31, p. 9) states it is probable that forest weed species have increased a thousand fold since the day of the early settler.

In logging the "old field" white pine stands, it was the common practice of the choppers to cut the hardwood advance growth back to the ground in order to facilitate their work. This practice resulted in sprouts (from small stools), rather than seedlings, forming the bulk of the next stand. This practice had a favorable effect upon the succeeding crop because, with few exceptions, hardwood stems starting under conditions of long suppression do not produce high quality trees unless cut back at the time of removing the parent stand.

In spite of the increase in forest weeds and the presence of multiple-stemmed stump sprouts from stumps of mainstory hardwoods, the representation of valuable species of good growth form was usually sufficient to provide a satisfactory stocking of crop trees in these new stands on cutover pine land (Cline and Lockard, '25). Additions to this valuable sprout stocking were accomplished by subsequent natural seeding, usually of paper birch, white ash and hard maple.

#### THE HURRICANE AND ITS EFFECT ON "OLD FIELD" PINE STANDS

##### The Hurricane

Meteorologists have explained that storms of tropical origin affect New England every year, and that on an average of three times during a five-year period these storms may reach gale proportions. Storms of a more intense nature have caused great damage over wide areas and have occurred as often as five times in fifty years. However, tropical storms which reach hurricane proportions in New

England, such as the one which caused widespread destruction in September 1938, do not occur more often than once during a century and a half (Tannehill, '39).

Amount and Character of Forest Damage

Heavy torrential rains preceding the hurricane made the ground soggy, thus reducing the windfirmness of trees. This soft condition of the soil, coincident with full foliage, greatly increased the ease with which the trees were blown over. Windthrow was common although a certain few stands occurring on quickly-drained soils suffered more breakage than windthrow. Elsewhere, individual trees, with the advantage of strong anchorage because of location and peculiar root formation, were also broken rather than windthrown. However, for all areas, the greatest numbers of trees were completely windthrown or were left leaning.

Occasionally a few trees were left upright, and these were generally hardwoods in the interior of the stand, or firmly rooted, marginal pines which had developed a high resistance to windthrow by virtue of their location. With few exceptions, standing trees were severely broken in the crown or barked along the bole. Any hardwood advance growth beneath the stand suffered heavy damage in the form of breakage or bending (See Fig. 2).

In general, the oldest stands were most heavily damaged; however, practically all merchantable stands exposed to the full force of the wind suffered complete blowdown. Even stands as young as 25 to 30 years of age were destroyed.

Rowlands<sup>2</sup> ('40), in studying the factors influencing the

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<sup>2</sup> W. Rowlands, Unpublished Thesis, Harvard Forest, Petersham, Mass. Harvard University. Rowlands' study was limited to the Town of Petersham and included only even-aged white pine, mixed hardwood and mixed white pine-hardwood stands which were fully exposed to the full force of the hurricane on well-drained upland soils.

windfirmness of forest trees during the hurricane, rated damage to even-aged stands of white pine as follows:

1. In the 11 to 20-year age group damage was light -- 13 per cent windthrow.
2. In the 21 to 25-year age group damage was moderate -- 19 per cent windthrow.
3. Windthrow was complete in white pine stands 26 years of age and beyond.

Nine of the most commonly occurring species of the region were shown by Rowlands in decreasing order of their susceptibility to windthrow, as follows: white pine, paper birch and poplar (largetooth and trembling aspen) were most susceptible; red oak, red maple and white ash were intermediate; and black oak, white oak and hickory (shagbark and pignut) were least susceptible.

D. POST HURRICANE SALVAGE AND TREATMENT

Following the hurricane, the possibilities of fire and the urge for immediate salvage presented a pressing problem to the woodland owners and the public--a problem that demanded immediate attention. The U. S. Forest Service was appointed to direct the work, and the New England Forest Emergency office and the New England Timber Salvage Administration were set up. N.E.T.S.A. worked with salvaging logs while N.E.F.E. was primarily concerned with fire hazard reduction work.

W.P.A. forces and available C.C.C. camps began work at once on fire hazard reduction under the direction of N.E.F.E. N.E.T.S.A. purchased logs but did no logging, depending instead upon the initiative of the individual woodland owner to cut, extract, and deliver logs to designated receiving stations. The immediate result of this combined effort of logging and fire hazard reduction

work was the timely salvage and clearance of merchantable logs from most blowdown areas, thus securing an economic return of some degree and lessening the danger from forest fire to a great extent.

#### Intensity of Logging

Salvage possibilities varied in different localities, depending upon the availability of labor, logging equipment, and transportation facilities. However, logging in windthrown pine stands did not approach the completeness of that in normal clear-cutting operations, even where labor and transportation were both readily available. It was necessary for logs taken to government receiving stations to meet the minimum scaling specifications of third grade logs; and these restrictions in regard to knots, log length and straightness, necessitated leaving behind many logs which might have been accepted by a private operator (See Fig. 3). In addition, logs with extreme defects such as rot, shake, split or excessive knottiness were left, as well as those that were inaccessible.

The limbing and topping of fallen trees during salvage operations left the slash much more manageable for fire hazard reduction crews, thus expediting the disposal of slash.

#### Disposal of Hardwood and Softwood Slash

After the hurricane, the New England Forest Emergency Office began a program of work for reducing the fire hazard. This program was organized on a priority basis, determined by the urgency for immediate attention.

Softwood slash on areas treated by fire hazard reduction crews was ordinarily piled and burned, while hardwood slash was usually lopped and scattered. Light amounts of slash were left in place.

Material causing a high fire hazard near dwellings, cities, villages and along roadsides was thoroughly disposed of. As a further fire prevention measure, approximately 30 to 40 per cent of those areas not directly adjacent to public highways, villages, cities, etc., were rendered less hazardous either by complete cleanup or by gridironing.

#### Affect of Logging Upon the Understory

Only a few advance growth stems were left uninjured following logging. A great majority were cut back to the ground because they interfered with the cutting and extraction of logs. This practice, though not intentional, has resulted in many rapid-growing sprouts (produced from small stools) on all blowdown areas. Many others were left bent, broken or prostrated beneath the logs and slash and these gave rise to stem suckers.

#### REVIEW OF LITERATURE

Many investigators have studied regeneration and successional trends following the cutting of white pine in both natural and "old field" stands. Fisher was one of the very first foresters to see that an undergrowth of desirable hardwoods invariably became established under the pine canopy in advance of logging, and that, with equal certainty, this hardwood formed the bulk of the next volunteer crop. Fisher ('18) in writing on the yield of volunteer second growth, and Fisher and Terry ('20), on the management of "old field" pine in central New England, stated that good natural reproduction of mixed pine-hardwood follows clear cutting of 70 per cent of the white pine stands.

Fifteen years later, McKinnon, Hyde and Cline ('35, p. 67) disclosed even more clearly the extensive reversion of pine to

hardwoods. They found in their study that cutover "old field" pine lots in central New England have been largely reclaimed by even-aged mixed hardwoods, and in 83 per cent of the cases studied, pine was completely replaced by hardwoods.

Studies concerning natural regeneration after the hurricane are few. Baldwin ('40), in a limited study made in New Hampshire, found that at the end of the second growing season following the hurricane the stocking of tree seedlings and sprouts (2,000 to over 13,000 stems per acre) on white pine blowdowns appears to be ample to restock the areas. Irregularities and spottiness of distribution occurred in areas up to one-half acre in size, notwithstanding the great number of stems per acre. But, in general, Baldwin found that hardwoods were reclaiming the "old field" white pine areas naturally and successfully, and recommended cultural treatment to aid in restoring the blowdowns to productive forest.

Lutz ('40) studying the disturbance of soils resulting from windthrowing and uprooting of forest trees found that changes of ecological significance had occurred in the disturbed soils. Lutz likened this natural disturbance of the soil to the plowing of agricultural land. He found that in some areas nearly every mound of soil was occupied by young seedlings or large trees, depending upon the length of time since the disturbance of the soil had occurred. This indicated that the disturbed soil afforded particularly favorable conditions for germination and subsequent plant development.

Raup and Carlson ('41) point out that the composition and distribution of the hardwoods following "old field" pine are directly related to topography, soil and exposure. McKinnon et al

('35) show the importance of soil and other site factors on the composition, density and distribution of volunteer growth following white pine.

Altpeter ('26) in a study of the relation of white pine slash to the development of reproduction on clear-cut areas found that slash affects natural regeneration in two ways: in dense, heavy slash growth is inhibited, while in light slash, moisture conditions are favorable and growth of reproduction is improved. He concludes (p. 16) that, "Windrows, physically and chemically, are inimical to reproduction, ... Reproduction occurring in windrows is largely of weed or undesirable character." He states (p. 18) that, "Pine especially, is tolerant to slash ... The better hardwoods are the most tolerant of any class to slash, but even they were not found at all where slash was closely piled at one foot depth." Altpeter also noted that, "There is one situation which suggests the possibility of benefits to be derived from the scattering of slash over clear-cut areas ... I refer to those sites of the better quality (good Quality II and Quality I), on which there is adequate advance reproduction of desirable hardwoods, ... On these sites the desirable hardwood sprouts push vigorously through slash thinly and loosely piled, and they grow more rapidly than those individuals in the open."

#### METHOD OF PROCEDURE OF COLLECTING DATA

##### Method of Sampling

Sample areas were limited to pure "old field" white pine stands--those stands in which 80% or more of the volume was white pine. Location of these sample stands was simplified by the use of U. S. Forest Service maps showing blowdown areas. In addition,



soil types for the areas sampled were obtained from the Worcester County soil survey map of 1922 (Latimer, et al). Both blowdown areas and soil types were transposed to separate small-scale maps of each individual town published by the Massachusetts Department of Conservation in 1932. From these maps it was possible to select arbitrarily a representative distribution of pine blowdowns over the proposed area of study, prior to extensive field work. Selected sample areas most often bordered roadsides, but a few were taken well back in the forest.

Within each blowdown, additional limitations were imposed by sampling only that portion which had uniform aspect, slope, and soil type, in order to insure a sample representative of the natural regeneration on the area as influenced by a group of constant site factors. When irregularities in distribution of reproduction occurred within a stand, notes were taken as to the probable cause, such as kind of ground cover, condition of forest floor, occurrence of burns, and presence and amount of slash. In making reproduction counts, slash was not avoided, because its distribution appeared to be uniform on both logged and non-logged areas. Also, because the study was intended to present data on the restocking of the entire blow-down areas, portions which were covered with slash were necessarily sampled as part of the existing conditions.

Mil-acre sample plots (quadrats 6.6 feet square) were taken at spacings of either one-half or one chain (33 or 66 feet) with strips at intervals of one-half, one, or two chains, depending on the size and shape of each stand. A minimum number of 15 to a maximum of 50 plots was taken in each stand. A light, folding frame with an inside area of one milacre was used to define the boundaries of each quadrat and to facilitate reproduction counts

Arbitrary classes were established for the abundance and distribution of slash as follows:

Light slash - 0-20% of area covered  
 Medium slash - 20-40% of area covered  
 Heavy slash - 40-100% of area covered

Notes were taken on the amount and kind of available seed trees in bordering stands. Within the sampled areas themselves, general information was recorded on frost and insect damage affecting the new reproduction. Additional notes were taken on observed differences in rate of growth of valuable and inferior species, and the influences of ground cover plants on reproduction.

#### Site Classification

The basis for site classification was patterned after that used in a study of composition and stocking of volunteer stands following cutting of "old field" pine (McKinnon, Hyde, and Cline, '35, p. 24) in which the classes Site II and Better, Site II-, and Site III were used.

Site classifications are generally based on height of dominant and co-dominant trees at a certain age, or as a function of age, average diameter, and volume. Since these measurements were not available, other criteria had to be used. Some measure of site quality may be had by observing what species are growing on a given area. Therefore, the composition of the former stand and of the present stand was considered. The presence of certain indicator species of trees and ground cover plants has been used by other investigators to classify site, and this factor was also given consideration.

Soil is an important factor of site, for soil composition and structure directly affect the moisture relationship and the

supply of nutrients available to the plants. Aspect and topographic position are factors also in determining site quality. The south and southwest facing slopes are the warmest and, therefore, moisture conditions are often least favorable there for best growth. Topography influences the rate of drainage, depending upon the degree of slope. Shallow and rapid draining soils on high slopes, and poorly drained soils as well as sandy outwash soils at lower elevations are usually associated with slow growth. All of these factors affecting site were considered for each blowdown area sampled.

Site II and Better included the most favorable situations, with well-drained, loamy soils. Basswood and white ash are the two principal indicator species for this site. Site II- includes areas located on the drier and more-exposed aspects. Chief indicator hardwood species here are the oaks, particularly white and black, and the hickories. Site III includes mostly those areas of light outwash soil, found along old glacial stream beds. Here pine frequently follows pine, and the hardwood element is confined to a few of the less exacting hardwoods, such as the oaks, aspen, and gray birch.

#### Definition of Growth Forms

The principal growth forms recognized are seedling, sprout, and sucker. These are defined as follows:

#### Seedling Growth Forms

Seedling growth forms include seedlings (stems direct from seed) and single- or multiple-stem seedling sprouts (stems arising at or below the root collar from stools 2" or less in diameter).<sup>3</sup>

<sup>3</sup> A single-stem seedling sprout was taken to be one stem arising from a stool 2" or less in diameter, while a multiple-stem seedling sprout was two or more stems arising from a stool 2" or less in diameter.

In general, these growth forms are the most desirable.

#### Sprout Growth Forms

Sprout growth forms include single- and multiple-stem stump sprouts (stems arising at or below the root collar from stumps larger than 2"). The former was not recognized as a separate class in this study because it was rarely found. The latter was divided into three classes according to size of parent stump -- 2 to 4 inches, 4 to 8 inches, and 8 inches and over. This distinction was made to determine the future quality on a relative basis. It is generally recognized that because of the greater incidence of decay sprouts from the largest stumps do not produce high quality trees, and that chances for good quality increase with a decrease in stump size.

#### Sucker Growth Forms

Sucker growth forms include stems arising from roots or from the main bole (See Fig. 5). The latter is sometimes referred to as epicormic branching. Neither of these forms of suckering can be expected to develop into crop trees (trees suitable for forming the final crop).

#### Discussion of Valuable and Inferior Elements

Because of the difficulties of recognizing separate stand elements (crop trees, trainers, and weeds)<sup>4</sup> at this early age, the

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<sup>4</sup> The stand elements used by McKinnon, Hyde, and Cline ('35) were defined as follows: (1) crop trees, those trees suitable for forming the final crop; (2) trainers, those trees forming the subordinate element; (3) weeds, those trees interfering with the growth of crop trees.

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determination of quality of growing stock was accomplished in a

relative manner. All reproduction was classed as valuable or inferior, and these classes were distinguished solely on the basis of species, growth form, and anticipated or potential future quality.

#### Valuable Elements

Valuable elements include those individuals having desirable growth forms and of species having potential market values. Among the desirable species are red oak, white oak, paper birch, yellow birch, black birch, white ash, basswood, hard maple, black cherry, hickory, beech, white pine, red spruce, and hemlock. Red maple occurring as seedlings or single-stem seedling sprouts was also considered valuable.

Seedling and single-stem seedling sprouts of good form were considered the most desirable elements (See Fig. 6). Multiple-stem seedling sprouts were considered valuable when there was at least one straight, strong, free-to-grow stem of low origin (at or below the root collar) per stool. Multiple-stem stump sprouts from stumps less than 8" in diameter were considered desirable, provided at least one well-formed stem of low origin was present. Sleeth and Roth ('39) in a study of second growth oak forest emphasized low origin as important to the development of valuable stems. They found that an abrupt and large increase in decay hazard occurs from one inch below the ground level to three inches above.<sup>5</sup>

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<sup>5</sup> Decay incidence based on height of sprout origin was as follows: from 4 to 2 inches below the ground level, the average was about 4 per cent; from 2 to 0 inches below ground level, the average was about 7 per cent; from 0 to 1 inch above ground level, the average was about 25 per cent; and from 1 to 3 inches above ground level, the average was approximately 34 per cent.

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### Inferior Elements

Inferior elements include: (1) weed species, such as pin cherry, gray birch, aspen, and choke cherry, and (2) trees of valuable species having poor origin or poor form. The weed elements are characterized by small size, short life, and low quality wood products, while the latter are considered inferior on a relative basis only, i.e., they are not suitable crop tree material as defined by valuable elements. However, these inferior elements might serve a very useful function in a stand in the role of trainers or fillers or as soil improvers.

### Definition of Residual Classes

For the purpose of this study, those trees or stems left standing after the hurricane were divided into two groups -- main-story residuals and advance growth residuals. The former is distinctive by name. The latter includes those trees which had established themselves beneath the former stand.

### ANALYSIS OF DATA

The initial step was to separate individual stand records according to site quality. This division made it possible to distinguish differences in amount, kind, and quality of reproduction attributable to the basic environmental factors of site. A second separation was made according to the age of the previous stand. This was done in order to determine those differences in the composition and stocking of the new stand attributable to the influence of the former stand.

No attempt was made to separate the data according to specific forest types, since species characteristic to both the northern forest and central hardwood forest were generally well-represented

over the entire area studied. Certain species, such as red spruce, balsam fir, beech, and red pine in the northern part of the area and scrub oak in the southern part, were the chief exceptions. These were found only rarely, and did not warrant special consideration. Therefore, all sampled areas were considered characteristic of the so-called transition zone, a zone of gradual change or intermixing between the northern and central hardwood types.

#### Distribution of the Stands Studied

The representation of stands sampled according to site and age class, shown in Table 1, is considered representative of the area covered and fairly representative of the entire transition zone. Most of the stands were sampled in the central and northern portions of the area studied (See Fig. 1) because towns within this area were more heavily timbered with "old field" white pine than those in the southern portion. This resulted chiefly from the fact that land abandonment in the former was considerably more extensive than in the latter.

A total of 137 stands was sampled. These varied in size from a minimum of one-half acre to a maximum of 25 acres. Most were small, 72 per cent of them containing less than five acres. The actual area covered by the sampled plots was 527 acres (See Table 1).

Table 1 further shows that 77 per cent of the sample areas on Site II and Better, 87 per cent on Site II-, and 100 per cent on Site III were 60 years of age or less. The representation of ages indicates that most older "old field" pine stands were cut prior to the hurricane and that farm abandonment was greater during the period 1875 to 1895 than it was during the period of 1895 to 1915.

TABLE 1

NUMBER AND ACREAGE OF BLOWDOWN AREAS SAMPLED, ACCORDING  
TO AGE CLASS OF PREVIOUS STAND AND SITE

Age <sup>1</sup> Class	Site II and Better No. areas Sampled	Better Acres	Site II Minus No. areas sampled	Acres	Site III No. areas sampled	Acres
30	2	2	2	2		
40	10	13	13	27	5	9
50	20	76	23	78	8	22
60	11	34	16	84	6	20
70	5	39	8	49		
80	4	24				
90	4	48				
Total	56	236	62	240	19	51

<sup>1</sup> Age of previous stand.



TABLE 2  
DISTRIBUTION OF SAMPLE AREAS ACCORDING  
TO SOIL TYPE AND SITE

Soil Type	Site II and Better Number of sample areas	Site II Minus Number of sample areas	Site III	Total
Gloucester	32	48	1	81
Charlton	16	6		22
Hinckley	2	4	9	15
Merrimac	2	3	9	14
Paxton	2	1		3
Brookfield	1			1
Whitman )				
Sutton )	1			1
Basis No. Sample Areas	56	62	19	137

TABLE 3

PERCENTAGE DISTRIBUTION OF SAMPLE AREAS ACCORDING  
TO ELEVATION AND SITE

Elevation	Site II and Better	Site II Minus	Site III
600- 700	5%	7%	26%
700- 800	9	13	16
800- 900	11	11	21
900-1000	25	21	32
1000-1100	30	36	5
1100-1200	13	10	
1200-1300	7	2	
Basis No. Sample Areas	56	62	19

In general, the distribution of sample areas according to specific soil types and site quality is also significant. Table 2 shows that the great majority of the sample areas were on Gloucester and Charlton soils. These soil types, except in one case, were associated exclusively with Sites II and Better and II-. Most of the remaining sample areas were found on Hinckley and Merrimac soils. These soil types were generally associated with Site III.

Table 3 shows the relationship between site quality and elevation. The great majority of sample areas on the better sites occurred at the higher elevations. Seventy-five per cent of the sample areas on Site II and Better and 69 per cent of the stands on Site III were at elevations below 900 feet. These findings agree with those in an earlier study of cutover "old field" pine lands in central New England by McKinnon, Hyde, and Cline ('35). These authors found that the best sites occurred on the slopes and ridge tops; whereas, the poorest sites occurred in the valley bottoms.

#### Composition and Stocking of the Volunteer Stand

A detailed analysis of the amount, kind and form of reproduction in the volunteer stands is basic to the establishment of guides for planning forest rehabilitation and for determining specific actions to be taken. Of chief importance, therefore, is the composition and stocking of the new stands as influenced by environmental factors summed up in site classes and by the age of the previous stand.

#### Relation of Composition to Site

The composition of volunteer stands varied directly with site quality. Certain species common to the best sites, namely, white ash, paper birch, hard maple, yellow birch, black birch, beech,

hickory, and hemlock, were either rare or absent on the poorest sites. Species common to all sites were black cherry, pin cherry, white oak, aspen, choke cherry, gray birch, red maple, red oak, and white pine. Other species were encountered too infrequently to warrant specific classification.

Fig. 7 shows graphically the frequency of occurrence of all species encountered according to site and percentage of the total number of sample areas in which a given species was found. Most outstanding is the fact that certain species show a direct relationship of frequency of occurrence to site quality; whereas, others show either very little or no relationship. In order to analyze these relationships more closely, species are segregated into three classes according to the apparent relationship of site quality to frequency of occurrence.

A. Species which show a close relationship to site quality.

Species	Sites		
	II+	II-	III
Paper birch	48%	26%	--
White ash	57	21	5
Hard maple	41	18	--
Black birch	30	24	--
Yellow birch	16	6	--
Hickory	11	10	--
Beech	11	5	--
Basswood	4	--	--

But site quality is defined by competition - see p. 18-16

The percentages indicate that these species occur most frequently on the better sites and that their occurrence is, therefore, most directly influenced by specific favorable factors of site, specifically, protected aspects, fertile soils, and better moisture conditions.

Although environmental factors chiefly influence the location of the species concerned, their distribution on a given site may be

attributed to dissemination of seed by agencies such as wind and animals. Paper birch, white ash, hard maple, black birch, yellow birch, and basswood seeds are widely disseminated by winds to all sites where final establishment is ultimately determined by site factors. Beech and hickory are disseminated by gravity and, in part, by animals, and their less frequent occurrence is therefore influenced by both site and distribution of seed. Of these species, the first four were most evenly distributed and most abundant.

B. Species which show an intermediate relationship to site quality.

<u>Species</u>	<u>Sites</u>		
	II+	II-	III
Red oak	88%	87%	42%
Hemlock	16	8	5
Chestnut	54	29	11

The percentages indicate that these species are only moderately influenced by site quality, and that the best site conditions are not demanded in full for their occurrence and development. This is concluded from the fact that such species is represented on the poorest sites but not as commonly as on the best sites.

The greater frequency of occurrence of red oak must be attributed, in part, to its inherent "aggressive", "space-demanding" characteristics and, also, to the wide distribution of its seed by small animals. The growth characteristics helped secure a dominant position in most forest stands for red oak, thereby, increasing its potentialities as a seed source. The animals dispersed and buried the red oak seed beneath "old field" white pine stands, where they became established as advance growth or seedlings.

Hemlock owes its relatively low frequency of occurrence chiefly to the effect of overly exposed seedbeds and, possibly, to

the lack of a sufficient seed supply. Chestnut, once a major commercial species, now rarely becomes large enough to reproduce by seed because of the action of the chestnut blight (*Endothia parasitica* L.). Practically all chestnut reproduction encountered was of sprout origin. It was asserted by McKinnon, Hyde, and Cline ('35) that this species seldom attains an age beyond seven years.

C. Species which show either a low or no relationship to site quality.

<u>Species</u>	<u>Sites</u>		
	II+	II-	III
Pin cherry	93%	85%	79%
Black cherry	96	92	95
Gray birch	91	85	84
White pine	91	87	95
Red maple	100	100	89
Choke cherry	23	27	21
White oak	25	24	26
Aspen	36	39	37

The percentages indicate that these species are, at most, only slightly influenced by site quality and that they occur almost equally on all sites. In contrast to those species more directly related to site, the site location and distribution of these species is chiefly influenced by the activities of disseminating agencies, such as animals, wind, birds, and humans.

Pin cherry, black cherry, and choke cherry owe their widespread distribution, particularly, to the dissemination of their heavy seed by birds. This is pointed out by the fact that neither choke cherry nor pin cherry stumps or residuals were found within a single blowdown area, while black cherry was found in less than 20 per cent of the areas studied. With the exception of choke cherry, these species were usually uniform in distribution and abundant on all sites.

Gray birch, red maple, white pine, and aspen owe their wide-

spread distribution chiefly to the dissemination of their light seed by wind. Of these, the more prolific seeding gray birch probably has the greater range, being often found in great abundance considerable distances from the immediate proximity of a seed source. Red maple and white pine seed sources were readily available to all blowdown areas and were, therefore, usually well distributed and abundant on all sites. Aspen owes its lower frequency of occurrence to a lack of seed supply. This is concluded from the fact that it was almost invariably found in considerable abundance in volunteer stands having a nearby aspen seed source.

Species which occurred too infrequently to warrant specific classification include balsam fir, red spruce, black ash, and scrub oak. Balsam fir and red spruce were only rarely encountered, except in the northern range of the study and scrub oak in the southern part. Black ash favors a more moist habitat than "old field" pine and, therefore, seldom appeared on the sites studied.

#### Relation of Stocking to Site

The stocking on "old field" pine blowdown areas also varied directly with site quality (See Table 5). The total average per acre stocking ranges from 8517 stems on Site II and Better to 8146 on Site II- to 3913 on Site III. This total represents 2836 valuable stems per acre on the best sites to 1643 valuable stems per acre on the poorest sites.

Table 4 shows the percentage distribution of sample areas according to stocking classes and site. On Site II and Better 88 per cent of the sample areas contained 1000 to 10,000 valuable stems per acre; 10 per cent 500 to 1000; and 2 per cent less than 500. Ninety-one per cent of the areas studied contained 2000 to 20,000

TABLE 4

PERCENTAGE DISTRIBUTION OF SAMPLE AREAS ACCORDING TO DEGREE  
OF STOCKING, SITE, AND VALUABLE AND INFERIOR ELEMENTS

Stocking (No. stems per acre)	Site II and Better			Site II-			Site III		
	Val. *	Inf. *	Total	Val.	Inf.	Total	Val.	Inf.	Total
0- 250	2								
250- 500				2			5		
500- 750	6			5			11		
750- 1,000	4			8			26		
1,000- 2,000		7		8	2		5	16	5
2,000- 3,000	22			36	16	7	21	16	26
3,000- 4,000	25	20	2	25	18	8	16	21	11
4,000- 5,000	16	14	7	12	16	7	11	16	16
5,000- 10,000	16	21	2	2	13	12	10	10	37
10,000- 20,000	9	25	46	2	24	48	5	5	
20,000- 30,000		11	28		3	10			
30,000- 45,000		2	3		3	5			5
		100%	100%	100%	100%	100%	100%	100%	100%
Basis No. Sample Areas	56			62			19		

\*Valuable - Desirable as crop tree.

\*Inferior - Not desirable as crop tree.



inferior stems per acre; 7 per cent 1000 to 2000; and 2 per cent 20,000 to 30,000.

On Site II- 77 per cent of the sample areas contained 1000 to 10,000 valuable stems per acre; 16 per cent 500 to 1000; and 7 per cent less than 500. Eighty-three per cent of the areas studied contained 2000 to 45,000 inferior stems per acre, and 17 per cent contained less than 2000.

On Site III 48 per cent of the sample areas contained 1000 to 4000 valuable stems per acre; 31 per cent 500 to 1000; and 16 per cent less than 500. Only 69 per cent contained 2000 or more inferior stems per acre. This decrease in numbers of inferior elements is largely attributable to the sharp decline in abundance of gray birch as well as in the number of species represented.

These findings indicate that the greatest majority of the blowdown areas on Sites II and Better and II- are being desirably restocked. Both hardwoods and conifers are sufficiently represented in most of the volunteer stands to assure the development of full-stocked, profitable stands of commercial sawtimber.

On Site III there is an apparent lack of desirable restocking on many of the areas studied. This lack of stocking is definitely associated with the drier and more sterile Site III because, with few exceptions, the more desirable species cannot endure such an environment. White pine is the chief exception, being particularly able to sustain itself under the poorer site conditions. As a result, this species, alone, accounts for an average per acre stocking of 1647 valuable stems or approximately two-thirds of the valuable stems on Site III. Furthermore, it is free from much of the severe hardwood competition which it encounters on the better sites.

The data do not indicate significant variations in total amounts of reproduction according to a division of the samples by age classes; however, with an increase in age of the previous stand, the ratio of valuable to inferior stems becomes generally more favorable (See Table 6). This indicates a trend towards a greater number of valuable stems and fewer inferior stems in volunteer reproduction which follows the oldest pine stands.

Stocking of desirable species -- never abundant on blowdown areas of the youngest stands -- usually showed a marked increase from age class 30 to age class 40. Beyond this age the change in proportion of valuable to inferior stems was chiefly due to a decrease in numbers of weed species. Relatively few weed species were found on blowdown areas of the oldest pine stands.

#### Analysis of Growth Forms

Table 5 shows the average per acre stocking and composition according to site, growth form, and valuable and inferior elements. In order that the relative importance of the growth forms may receive greater emphasis, a separate analysis is given to each. The individual forms are considered in the same order in which they rank in abundance.

#### Seedlings

According to Table 5 the greatest number of both valuable and inferior elements occurred in the seedling form. Their percentage of the total stocking per acre for each site is as follows:

<u>Site</u>	<u>Val. Elements</u>	<u>Inf. Elements</u>
Site II & Better	72%	71%
Site II-	78	77
Site III	88	61

These percentages indicate that seedlings will be by far the most important growth form in the restocking of "old field" pine blowdown areas, especially on Site III.

Valuable stems chiefly include white pine, black cherry, red maple, paper birch, red oak, white ash, black birch, hemlock, and hard maple on Sites II and Better and II-; and white pine, black cherry, red maple, red oak, and white oak on Site III. Inferior stems chiefly include gray birch, pin cherry, red maple, black cherry, aspen, and choke cherry.

Stocking of valuable seedlings on Site II and Better was nearly 600 per acre more than that on either Site II- or Site III. However, the difference between average number of seedlings for the latter sites is very slight. This is because of the greatly increased number of white pine seedlings on Site III. Actually, the number of valuable hardwood seedlings alone varies radically from an average of 1388 on Site II and Better to 804 on Site II- to 387 on Site III. This decrease in number is due to limiting influences of site on less site-tolerant species, namely, white ash, hard maple, black birch, red oak, and paper birch. The former three are entirely absent and the latter two are greatly reduced in occurrence on the poorer sites.

All of the species encountered except scrub oak and black ash occurred as seedlings on the better sites but not more than one-half were represented on Site III. Species which did appear on Site III, with the exception of white pine and the oaks, were generally of poor form and quality.

Although the reproduction was only two years of age, certain differentiations in height growth were apparent. Hardwood seedlings

grew faster than coniferous seedlings; and pin cherry, aspen, and white ash grew faster than other hardwoods. This observation was particularly noticeable on the poorer sites, where weed species, such as pin cherry, aspen, and gray birch, tend to suppress the most desirable stand element, white pine, almost from the beginning.

#### Multiple-Stem Seedling Sprouts

Second to seedlings in numbers of valuable and inferior elements were multiple-stem seedling sprouts. For each site, the per cent of the total stocking per acre is as follows:

<u>Site</u>	<u>Val. Elements</u>	<u>Inf. Elements</u>
Site II & Better	18%	15%
Site II-	12	12
Site III	6	25

These percentages indicate that this growth form is most desirable on the better sites. On the poorer sites, it becomes a major inferior or weed element.

Valuable stems chiefly include white ash, black cherry, red oak, hard maple, black birch, and white oak on Sites II and Better and II-; and white oak, red oak, and black cherry on Site III. Inferior stems chiefly include red maple, black cherry, gray birch, choke cherry, aspen, pin cherry, and chestnut.<sup>6</sup> Of these, red maple

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<sup>6</sup> Because aspen, gray birch and pin cherry are intolerant and were seldom established as advance growth, the appearance of these species as multiple-stem seedling sprouts apparently resulted from their establishment as seedlings and also root suckers (in the case of aspen) after the hurricane, but prior to logging. These were mowed back during the extraction of logs. The resulting small stools produced single- and multiple-stem seedling sprouts and were thus recorded during the collection of field data.

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was by far the most abundant.

With the exception of scrub oak and black ash, all hardwood species encountered were found in this growth form on the better sites. On the poorer sites both the stocking and number of species were reduced at least 50 per cent. Multiple-stem seedling sprouts which did appear on Site III were most often of poor form and quality.

Differentiations in height growth of multiple-stem seedling sprouts were even more apparent than that of seedlings. Every individual under this form grew faster than any one species under seedlings, i.e., where both occurred within uniform environmental conditions. (See Fig. 6). Of the species concerned, white ash, aspen, black cherry, pin cherry, and chestnut showed a more vigorous initial rate of growth than others.

#### Single-Stem Seedling Sprouts

Third in numbers of valuable and inferior elements were single-stem seedling sprouts. For each site, the per cent of the total stocking per acre is as follows:

<u>Site</u>	<u>Val. Elements</u>	<u>Inf. Elements</u>
Site II & Better	9%	4%
Site II-	9	4
Site III	5	7

These percentages indicate that the relative desirability of this growth form is greater than that of either of the two preceding forms but that it is also less common than other desirable forms. Actually 47 per cent of all single-stem seedling sprouts were considered valuable as compared to 30 per cent for seedlings and 28 per cent for multiple-stem seedling sprouts. This fact must be largely attributed to the absence of gray birch and the rare occurrence of pin cherry, aspen, and choke cherry weed species in this form.

Valuable stems chiefly include white ash, red oak, red maple, black cherry, and hard maple on Sites II and Better and II-; and black cherry, red maple, and red oak on Site III. Inferior stems chiefly include black cherry and red maple for all sites.

Differentiations in height growth of species found in this growth form were very similar to that of multiple-stem seedling sprouts. In general, all single-stem seedling sprouts showed a more vigorous initial growth than seedlings.

Stem Suckers

This growth form ranked fourth in abundance. However, because of its high origin, all stems concerned were considered inferior. The per cent of the total stocking was as follows:

<u>Site</u>	<u>Inf. Elements</u>
Site II & Better	8%
Site II-	6
Site III	6

These percentages indicate that stem suckers are of minor importance on all sites. Furthermore, since this growth form resulted primarily from the affects of the hurricane and logging (chiefly bent over and prostrated advance growth and high cut stumps), it will tend to decrease in relative abundance rather than increase in the future stand. Therefore, it does not warrant special consideration in the volunteer stand.

Species recorded as stem suckers chiefly include red maple, black cherry, red oak, white ash, and black birch on Sites II and Better and II-; and choke cherry, red maple, black cherry, pin cherry, and aspen on Site III. Red maple was the most prevalent of all species encountered.

The better sites invariably supported a much greater number of stem suckers than the poorer sites. Whereas 15 species were found in this form on the best sites, only 5 of these were represented on the poorest sites. This condition was probably due to the fact that advance growth was more abundant under pine stands on the better sites, as indicated by Table 9 showing number of advance growth residuals.

Stem suckers showed a vigorous initial height growth similar to that of sprouts. In general, they grow faster than seedlings; and white ash, aspen, and black cherry grew more rapidly than other stem suckers.

#### Multiple-Stem Stump Sprouts

This growth form was the least abundant encountered. The per cent of the total stocking per acre for each site is as follows:

<u>Site</u>	<u>Val. Elements</u>	<u>Inf. Elements</u>
Site II & Better	1%	2%
Site II-	1	1
Site III	-	1

These percentages would seem to indicate that multiple-stem stump sprouts are relatively unimportant on all sites either as valuable or inferior elements. However, this growth class is important because the occurrence of clumps of sprouts will demand much space and will create serious weed problems.

Valuable stems chiefly include red oak, white ash, white oak, and black birch on Sites II and Better and II-; and red oak on Site III. Inferior stems chiefly include red maple, black birch, gray birch on Sites II and Better and II-; and red maple and gray birch on Site III.

Thirty-one per cent of the sprouts from stumps 2" to 4" in diameter, 20 per cent from stumps 4" to 8" in diameter, and 22 per cent of all stump sprouts were considered valuable. Sprouts from stumps over 8" in diameter were considered inferior, because they are less likely to develop into desirable crop trees (see def. growth forms). However, according to Table 9, there were few associated hardwoods and therefore few stumps over 8" diameter.

Stump sprouts showed an initial vigorous height growth similar to that of stem suckers and sprouts originating from smaller stools. In general, sprouts from stumps below 8" in diameter grew faster than those above 8".

#### Summation of Stocking and Composition

The most conspicuous feature of the tables showing average per acre stocking and composition (See Tables 5 & 6) is the great diversity of species and the large numbers of stems on the best sites as compared to the poorest sites. Site III has only 50 per cent as many species and stems as the better sites.

Also, age of the previous stand has affected stocking and composition for, with an increase in age, the ratio of valuable to inferior stems does become generally smaller. This is explained chiefly by the fact that desirable species, such as white pine, red oak, and yellow birch, show specific increases in stocking with an increase in age, while inferior species, such as gray birch and aspen, show specific decreases (See Table 6).

Black cherry, red maple, paper birch, white pine, red oak, and white ash have the greatest representation of valuable stems and will be important species in the new stand. Stocking with these species and others was found entirely adequate to provide a basis



for a future timber crop on most areas. This is substantiated by the fact that whether the data were combined in tables according to age class, site, average per acre figures, or in dispersion of actual per acre figures (See Table 4), the results show that on 127 areas, or 91 per cent of the blowdowns, stocking of valuable stems was above 500 per acre. On 124 areas, or 89 per cent of the blowdowns, stocking of inferior stems was above 1000 per acre.

Table 5 shows that three growth forms -- seedlings, single-stem seedling sprouts, and multiple-stem seedling sprouts -- include 99 per cent of the valuable stems on each of the three sites and will furnish the valuable stems in the future stand. Of these, seedlings are by far the most abundant. Thirty per cent of all seedlings, 28 per cent of all multiple-stem seedling sprouts, and 47 per cent of all single-stem seedling sprouts were recorded as valuable.

#### Influence of the Former Stand on the Volunteer Stand

It was expected, from results of previous studies, that the composition, density (stocking), and age of the previous stand would affect the composition and density of the new stand, and especially, that the number of hardwood sprouts (those originating from advance growth) would increase in quantity with an increase in age of the previous stand. In order to measure and determine this influence, the composition of the former stand was summarized according to site in Table 7, and stocking of sprouts was summarized according to site and age and density of the former stand in Table 8.

#### Influence of Composition

Table 7 shows the composition of hardwoods found in "old field" pine stands sampled, and their frequency of occurrence

TABLE 7

OCCURRENCE OF ASSOCIATED SPECIES IN "OLD FIELD" PINE STANDS BY SITE

Species	Frequency Distribution According to Stands			Average Number Trees Per Acre
	Site I	Site II	Site III	
Black cherry	20%*	21%	11%	2
Red oak	20	15	7	2
Red maple	43	44	21	7
White ash	9	2	..	1
Hemlock	9	3	..	1
Black oak	..	2	..	..
White oak	7	..	5	..
Black birch	9	8	..	1
Yellow birch	2	..	..	..
Hard maple	2	..	..	..
Basswood	2	2	..	..
Hickory	2	..	..	..
Paper birch	7	3	..	1
Aspen	2	2	5	..
Red spruce	4	3	5	..
Gray birch	14	23	26	3
Elm	4	..	..	..
Ironwood	2	..	..	..
Red pine	..	5	11	..
Pitch pine	..	2	..	..
Total Per Acre	19	22	16	19
Basis No. Stands	56	62	19	56

\*Example: Twenty per cent of the stands on Site II and Better contained black cherry.

according to site. It is indicated, from a study of this table, that certain hardwood associates have influenced the composition of the volunteer stand. Red maple is by far the most prevalent hardwood associate on all sites with gray birch, black cherry, and red oak in respective order. The influence of these species is evidenced by the fact that, with the exception of pin cherry, they are also the most abundant hardwoods in the new stands (See Fig. 7 & Table 5).

Other associated species, such as white ash, black birch, hard maple, hickory, and paper birch, while present on the better sites, are entirely absent on the poorer sites. These species show a similar representation in the volunteer stand, i.e., they occur most frequently on Site II and Better, less frequently on Site II-, and are entirely absent on Site III. This would indicate that the frequency of occurrence of these species as a seed source must certainly have influenced, in part, their respective occurrence in the ensuing volunteer stand.

Influence of Stocking

A second factor affecting the volunteer reproduction is the relatively open character of the white pine stands present at the time of the hurricane as compared to those previously clear-cut. By 1938 practically all of the good stands of high quality pine (high quality is associated with good density and full stocking) had been cut, and understocked stands of limby, short, scrubby trees were left. Tarbox ('24) studied the stocking in unthinned natural stands of white pine and found that 30-year-old stands had a maximum average stocking per acre of 1070 trees on Site I and 1230 trees on Site II, and that at 70 years there were 310 trees on Site I and 315 on Site II. At

the time of the hurricane (Sept., 1939), (See Table 8) it was found that 30-year-old stands on Site II and Better had 705 trees per acre and that Site II- had 244 trees per acre; also, that at 70 years there were 244 trees on Site II and Better and 217 trees on Site II-.

This marked reduction and the small differences in stocking among the various age classes of "old field" pine in 1938 as compared to 1924 must certainly have had a direct influence upon the amount of advance growth and, therefore, upon the subsequent stocking of hardwood sprouts. This is pointed out conclusively by the fact that stocking of sprouts increases with a decrease in density of the previous stand (See Table 8). Furthermore, the relatively open character of present-day pine stands must have aided favorable seedbed conditions for the establishment of advance growth under stands of all ages. That this is true is indicated by the large number of sprouts (from stools of the advance growth) encountered in stands at all ages.

#### Influence of Age

On Sites II and Better and II- there was a marked increase in abundance of sprouts (from stools of the advance growth) of all kinds with an increase in age of the previous stand from 30 to 40 years; whereas, on Site III a similar marked increase occurred from 40 to 50 years. With an increase in age of the former stand beyond age class 40 on the better sites more gradual increases in stocking of sprouts took place. This would indicate that seedbed conditions beneath most pine stands become much more favorable for the establishment of advance growth after the stands had passed the 30-year age class. However, the ultimate in good seedbed conditions was not reached until the older age classes were attained.

Influence of Mainstory and Advance Growth Residuals on the Volunteer Stand

Influence of Mainstory Residuals

Forty-two per cent of the stands on the poorer sites to 71 per cent on the better sites contained mainstory residuals. In general, the blowdown areas contained only a few residuals -- the average being 2 to 4 per acre for all sites (See Table 9). Of these, red maple, red oak, and gray birch were most common.

Residuals of desirable species will provide a valuable source of seed for additional restocking of volunteer stands. Especially valuable will be the residuals less severely damaged by the hurricane and the ones showing a greater evidence of recovery. Other residuals will be non-desirable, so-called because of the species or because of the occurrence of severe crown breakage. These will be a detriment to the volunteer stand for they will compete with and suppress the young stand. Non-desirable residuals should be eliminated prior to their development into coarse, wide-spreading wolf trees, and desirable residuals should be removed subsequent to the establishment of a satisfactory volunteer stand.

Influence of Advance Growth Residuals

Forty-two per cent of the stands on the poorer sites to 58 per cent on the better sites contained advance growth residuals. No one of these areas was heavily stocked -- the average being 7 per acre on Site III to 26 per acre on Site II and Better (See Table 9). These figures serve to indicate the relative abundance of advance growth residuals according to site; however, they cannot be used as a final criterion of occurrence for a given site. Actually the number of stems found on any given area was due to chance, i.e., logging

TABLE 9

AVERAGE PER ACRE STOCKING OF MAINSTORY AND ADVANCE GROWTH RESIDUALS  
ACCORDING TO SITE

Species	Mainstory Residuals			Site	Advance Growth Residuals		
	II+	II-	III		II+	II-	III
White pine	..	..	..	..	4	5	3
Black cherry	..	..	..	..	..	1	..
Red oak	..	1	..	..	2	1	..
Red maple	.1	2	.1	..	5	4	1
White ash	..	..	..	..	5	..	..
Hemlock	..	..	..	..	5	3	1
Beech	..	..	..	..	1	..	..
White oak	..	..	..	..	..	..	..
Red pine	..	..	..	..	..	..	1
Black birch	..	..	..	..	2	2	..
Yellow birch	..	..	..	..	1	..	..
Hard maple	..	..	..	..	1	..	..
Gray birch	..	1	1	..	..	1	1
Total per acre	2	4	4	..	26	16	7
Basis No. stands	56	62	19	..	56	62	19

and fire hazard reduction crews failed to cut back as much advance growth on some areas as on others. The original abundance of advance growth is reflected in the occurrence of sprouts -- chiefly the occurrence of multiple-stem sprouts.

White pine, red maple, and hemlock were considerably more common for all sites than were other species. White ash and black birch, while frequent on the best sites, were entirely absent on the poorest sites. The rare occurrence or absence of paper birch, aspen, pin cherry, and gray birch concurs with the assertion that these species are intolerant of an overstory.

It was observed that many advance growth residuals are already showing signs of developing into large-crowned, heavy-limbed trees. Most of these are in a dominant, free-to-grow position. This fact is of immediate as well as future importance because such trees will compete with and suppress the more valuable stems in the volunteer stand. In addition, these advance growth trees can rarely be expected to develop into anything other than coarse, low-quality timber.

Other Factors Affecting the Character of the Volunteer Stand

Ground Cover

Table 10 gives a comparison of the relative abundance of ground cover plants on the various sites. Species most common to the poorest sites were low-bush blueberry, wintergreen, dwarf raspberry, and polytrichum moss. Grasses were abundant on all sites. Other species, such as blackberry, hypnum moss, partridge berry, and sweet fern, were considered sparse in occurrence on all sites.

Ground cover types proved to be inimical to seedling reproduction only where they occurred in heavy densities. Chief among the plants found in such densities were hay-scented fern on the best sites;

TABLE 10

RELATIVE ABUNDANCE OF GROUND COVER PLANTS ACCORDING TO SITE

Species	Site II and Better	Site II Minns	Site III
Low-bush blueberry	Sparse <sup>1</sup>	Frequent	Frequent
Wintergreen	Sparse	Frequent	Frequent
Lycopodium	Frequent <sup>2</sup>	Frequent	Sparse
Sweet fern	Sparse	Sparse	Sparse
Ground raspberry	Frequent	Abundant	Abundant
Blackberry	Sparse	Sparse	Sparse
Hay-acented fern	Abundant <sup>3</sup>	Abundant	Sparse
Polytrichum moss	Sparse	Frequent	Abundant
Hypnum moss	Sparse	Sparse	Sparse
Grasses	Abundant	Abundant	Abundant
Partridgeberry	Sparse	Sparse	Sparse
Basis No. Stands	56	62	19

<sup>1</sup> Sparse: Found in 0-20% of stands studied and usually occurred in light densities.

<sup>2</sup> Frequent: Found in 20-40% of stands studied and usually occurred in light to heavy densities.

<sup>3</sup> Abundant: Found in 40-100% of stands studied and usually occurred in medium to heavy densities.



low-bush blueberry and dwarf raspberry on the poorest sites; and grasses on all sites. These species, on the respective sites given above, occasionally occurred in heavy, uniform densities over small areas and caused the reproduction on a certain few blowdowns to be spotty or scattered in occurrence. Only rarely did they exclude reproduction over an extensive, widespread area.

Ground cover types in light to medium densities were not inimical to seedling reproduction on any site. In fact, certain ground cover plants encountered in such densities apparently presented more favorable seedbed conditions for the establishment of tree species. In light to medium densities of grass, seedlings, such as white pine, gray birch, yellow birch, and paper birch, were generally more abundant than elsewhere. Beds of polytrichum moss and hypnum moss, in any density, were particularly favorable to the establishment of white pine.

#### Litter

The presence of thick, widespread covers of litter did not appear to have any relationship to site classification or age of previous stand. Examples of variations in density of litter layers from "light" to "very heavy" were found in all three site classes. Seedling reproduction was practically excluded from areas of heavy litter cover, and stems of sprout origin were generally few in number. Such areas showed evidences of being extremely dry on the surface and seedling roots were not often able to penetrate to a good moisture supply rapidly enough to survive. White pine seedlings found on heavy litter covers were most generally desiccated and dying. Those seedlings most often found surviving in heavy litter were pin cherry

and black cherry, the seeds of which had been buried beneath the litter and duff by rodents.

On areas of light to medium densities of litter, reproduction was satisfactorily and uniformly established. All species were present to some extent under these litter conditions, but red maple, red oak, pin and black cherry, and white pine were by far the most abundant.

#### Exposed Mineral Soil

Because the majority of trees damaged in the hurricane were uprooted, many small areas of mineral soil 2 to 10 feet in diameter were exposed (See Fig. 8). In addition, the extraction of logs from the blowdowns exposed the mineral soil along skid trails and truck trails. These exposed areas are being largely restocked with white pine, pin cherry, and light-seeded hardwoods such as the birches and aspen. They often contain a denser stocking of seedling reproduction than adjacent undisturbed areas. Light covers of grass became established on some of the exposed soil, and white pine and paper birch were commonly found in abundance on such areas.

#### Slash Burning

An intensive program of fire hazard reduction was carried on after the hurricane, and the slash on a great percentage of the areas sampled had been piled and burned. After the burning of the slash piles, 10 to 15 charred areas of from 5 to 10 feet in diameter were left per acre. These burned, charcoal-covered areas were almost invariably covered with pin cherry, gray birch, sumac, aspen, or paper birch (See Fig. 4). The first three species, however, were always most abundant.

### Slash

During fire hazard reduction activities most of the slash on 75 per cent of the areas studied had been piled and burned, and slash on 25 per cent of the sample areas was piled, windrowed, or partially piled and burned. Light to medium amounts of slash remaining on the "slash-burned" areas showed no appreciable unfavorable affect upon the establishment of seedlings and sprouts, and seedlings were abundant on light slash, where they were shaded and moisture conditions were favorable.

Dense piles of slash were found on only about 15 per cent of the samples and, where found, very rarely covered more than 30 per cent of the area. Under conditions of densely piled slash, seedlings were entirely absent and sprouts were few. The sprouts present were most often deformed and mishappen and were classed as inferior elements. Scattering or burning of the denser slash piles should greatly improve conditions for uniform seedling establishment and survival.

### Additional Seed Source

In addition to the main story residuals present on some areas, border trees in adjacent stands should provide seed of desirable species to supplement present stocking of the blowdown areas. The neighboring stands, rarely more than 150 feet from the blowdowns, are mostly hardwoods with, not uncommonly, a mixture of white pine. In the border of adjacent stands on the better sites (including the cases in Site II and Better and most cases in Site II-) desirable species, such as red oak, white ash, hard maple, paper birch, black birch, black cherry, and white pine, were often recorded as being present. On the poorer sites red maple, gray birch, and white pine predominate as a seed source.

As shown in Table 1, the blowdown areas are mostly small in size and seldom exceed five or six acres. Under such conditions practically every part of a blowdown area is within reach of wind disseminated seed. Also, many heavier seeds, disseminated by gravity, are available along the borders of adjacent stands. Because of this, a better and more desirable stocking, in general, may be expected on the blowdown areas than on the previously clear-cut larger and more extensive "old field" white pine areas.

#### Post-Hurricane Treatment

In spite of the fact that, in a preliminary study, no appreciable differences in amount and quality of reproduction were found between logged and non-logged areas, there is reason to expect significant differences in the future. The trees on non-logged areas are mostly off the ground and are lying in much the same order as immediately after the hurricane, with only the limbs looped and burned. As the seedlings and sprouts become large and come in direct contact with this windthrown material, it is believed that many will develop poor form. Favorable observations were made that fallen trees shaded the ground and tended to bring about desirable moisture conditions for the establishment of certain reproduction. Extreme conditions of shading especially favored hemlock, while less extreme shading appeared to favor red maple, black cherry, and white pine. It is believed by the authors that both favorable and unfavorable effects of fallen trees will become more apparent and more positive within a few years.

## SUMMARY

A total of 137 stands was sampled. Most of these were small, 72 per cent of them containing less than five acres. The actual area covered by the sample plots was 527 acres.

Gloucester and Charlton soils, except in one case, were exclusively associated with Sites II and Better and II-, while Hinckley and Merrimac soils were generally associated with Site III. The first two soils were encountered in 75 per cent of the areas sampled and the latter two in 21 per cent.

The great majority of sample areas on the better sites occurred at the higher elevations; whereas, a majority on the poorer sites occurred at the lower elevations, which were generally valley bottoms.

The present stocking found in the volunteer stands on "old field" white pine blowdown areas varies directly according to Site quality, with the greatest density of stocking occurring on Site II and Better.

In general, the number of species represented on sample areas decreases from the better sites to the poorer sites. The only significant exceptions to this were white pine and scrub oak, both of which were present most often on areas of Site III.

The more exacting species commonly found on the better sites, such as white ash, paper birch, hard maple, yellow birch, black birch, beech, hickory, hemlock, and balsam fir, were either poorly represented or entirely absent on Site III.

In general, with an increase in age of the previous stand, the number of valuable stems to the number of inferior stems becomes proportionately greater (See Table 6). This is largely accounted for

by specific increases in stocking of white pine, red oak, and yellow birch from the youngest to the oldest stands; whereas, gray birch and aspen generally show a decrease. Also, in the older stands, the number of sprouts (from small stools or stumps) in proportion to seedlings generally becomes larger. This is important in that the sprouts often come of much better stock than the seedlings and thus increase the desirability of the volunteer stand. These conditions are more especially true of Sites II and Better and II- where environmental factors are most favorable to the establishment of hardwoods.

Whether the samples were combined in the tables according to age class, site, average per acre figures (See Table 4), or in dispersions of actual per acre figures, the results show that stocking is quite generally satisfactory. On 127 areas, or 91 per cent of blowdowns, stocking of valuable stems is above 500 per acre, while on 124 areas, or 89 per cent of blowdowns, stocking of inferior stems was above 1000 per acre. It is felt that a base of 500 valuable stems per acre is sufficient to establish an adequate stand of trees to provide a desirable crop of timber in the future. At least five hundred additional stems (these may be inferior in quality) should be present to act as filler and trainers of the crop trees.

For all ages and sites, an average per acre stocking of 2928 to 10,126 stems was found. This represents 950 to 5530 valuable stems and 1739 to 7651 inferior stems per acre on all sites (See Table 5). The valuable are largely accounted for by black cherry, white pine, red maple, red oak, white ash, and paper birch on Site II and Better; and white pine, black cherry, red maple, and red oak on Sites II- and III. The inferior are largely accounted for by gray birch, red maple, pin cherry, black cherry, and aspen on all sites.

Three growth forms -- seedlings, single-stem seedling sprouts, and multiple-stem seedling sprouts -- will furnish the valuable stems in the future stand. Of these, seedlings are by far the most abundant. Thirty per cent of all seedlings, 28 per cent of all multiple-stem seedling sprouts, and 47 per cent of all single-stem seedling sprouts were recorded as valuable.

Although the reproduction was only two years old, differentiation in height growth among species and growth forms was already evident: hardwood seedlings grew faster than white pine and other coniferous seedlings; and hardwood suckers and sprouts grew faster than hardwood seedlings.

Red maple was by far the most prevalent hardwood species associated with the former "old field" white pine on all sites. Gray birch, black cherry, and red oak follow in respective order. A direct relationship between hardwood associates of the former stand and the present reproduction is indicated by these four species, for they are also the most abundantly represented species in the volunteer stand, except in the case of pin cherry.

In general, a marked increase in the abundance of sprouts (from small stools of the advance growth) occurred with an increase in age of the previous stand from 30 to 40 years, with only a gradual increase thereafter. The early influx of advance growth (before age 30) must be largely attributed to the small size and relatively open character of most "old field" white pine stands remaining in 1938 as compared to more extensive and less open stands of the past.

Few residuals were encountered on any one blowdown -- the average being 2 to 4 per acre for all sites. Of these, red maple, red oak, and gray birch were most abundant.

Advance growth residuals averaged from 7 per acre on Site III to 26 per acre on Site II and Better. For all sites, white pine, red maple, and hemlock were considerably more common than other species.

Many advance growth residuals already show signs of becoming large-crowned, heavy-limbed individuals. Most of these are in dominant positions where they may cause considerable harm to the natural or volunteer stand.

In general, ground cover types occurred in light to medium densities; however, a few types, usually associated with a specific site class, such as hay-scented fern and lycopodium on the better sites, and low-bush blueberry and dwarf raspberry on the poorer sites, did appear in heavy densities. Spotty and irregular reproduction was usually associated with high densities of ground cover, whereas, light or medium densities apparently had a negligible affect on reproduction.

On areas of light to medium litter, reproduction was satisfactorily and uniformly established. On areas of heavy litter, seedling reproduction was practically excluded, and stems of sprout origin were generally few in number and inferior in quality.

Burned, charcoal-covered areas from slash burnings were almost invariably stocked with pin cherry, gray birch, sumac, aspen, or paper birch.

Seedlings were abundant among light to medium amounts of slash where they were shaded and moisture conditions were favorable. Under conditions of densely piled slash, seedlings were entirely absent and sprouts were few.



On the better sites desirable species, such as red oak, white ash, hard maple, paper birch, black birch, black cherry, and white pine were most often recorded as a seed source in the border of adjacent stands. On the poorer sites white pine, red oak, and red maple predominated as a seed source in the border of adjacent stands.

## DISCUSSION

### Rehabilitation of Blowdown Areas

#### Dependence on Natural Reproduction

For the past half century the attitude of a majority of the woodland owners in the so-called "pine region" of Massachusetts has been that pine is the only practical and profitable forest tree species to be grown and utilized in the wood-using industries of the state. Species other than pine have been considered to be of specific value only as cordwood. Because the white pine has dominated the local forest products market over so long a span of years, the belief persists that it will continue to do so, and that hurricane-devastated areas ought to be restocked with stands of pine. This study, however, has shown that 90 per cent or more of the growing stock on areas classified as Site II and Better or II- is hardwood reproduction, and that even on Site III more than 70 per cent of the stocking is of hardwood species. These conclusions agree with those of Fisher, Cline, Lockard, Baldwin, Raup and Carlson, and others who have found that "old field" white pine in central New England was replaced in at least 75 per cent to 80 per cent of the cases by hardwoods or mixed pine-hardwoods.

In addition, it has been found that most of the present areas of timber are progressing towards a uniform, simple and natural pattern with the elimination of a majority of the unnatural pine

groups. The complex mosaic of types prevailing in the past was very largely due to the wide variation in conditions which resulted from the varying land uses and subsequent land abandonment and which influenced the establishment of new stands. The concept of a progressively simpler forest arrangement involving a mixture of naturally reproduced deciduous and coniferous species, with the deciduous species predominantly greater in numbers, is supported by the fact that the present composition is now reverting to one similar to that of the precolonial forest. The aspects of this concept of reversion to the original forest pattern were largely developed through the observations and deductions made over a period of a quarter of a century by R. T. Fisher, late director of Harvard Forest.

Because this study has shown that the hurricane damaged areas are being so very satisfactorily stocked with hardwoods and some pine, the authors have concluded, in general, that a policy of forest rehabilitation should place its chief dependence on natural regeneration and upon the protection of the growing stock and young growth now becoming established.

#### Dependence on Planting

Although, in the past, one of the first and most loudly acclaimed recommendations has been to plant white pine regardless of cost or natural factors involved, studies have shown, that, if only from the one viewpoint of cost, it is impracticable to plant white pine on sites where hardwoods are abundant. The initial cost of planting is necessarily greater than the free establishment of a natural stand, and as pointed out by McKinnon, Hyde, and Cline ('35), Fisher ('18, '20, and '31), Cline and

Lockard ('25), and others, numerous and expensive weeding, release cuttings, and improvement cuttings must be made in order to bring pine through the severe competition from hardwoods. And when white pine does become established in a free-to-grow position, the attacks of the white pine weevil injures and distorts the form to such a degree that, generally, only low grade products can be cut.

Fisher ('31) particularly regretted the widespread emphasis on the planting of white pine to the point where, "...forestry in the public mind of New England has been generally thought to begin and end with reforestation by planting". He also stated that natural regeneration on cutover pine lands was abundant, that the hardwoods or mixed pine-hardwood types which followed the pine were increasing the depth of the top soil and improving the general condition.

Some form of reforestation other than "natural" may be demanded: (1) in specific situations where quantity and distribution of reproduction have been influenced by the presence of extensive beds of heavy ground cover, litter or slash causing excessive spottiness of restocking, and (2) on the poorer, drier, sterile sites where both hardwoods and conifers are lacking in abundance enough to provide a well-stocked stand. However, since natural regeneration and good stocking may gradually take place over a span of several years, the authors only recommend planting if, after a period of five years, the area is not satisfactorily stocked by natural reproduction.<sup>7</sup>

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<sup>7</sup> See page 45. It is felt ...

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A recent report by the committee on silviculture for the New England section, Society of American Foresters ('41) deplores the

great emphasis in the past on the planting of "idle" acres and substantiates the above recommendations. The committee states that, "It appears now that, from the beginning of the practice of private forestry in New England, the care and treatment of existing wild stands of good stocking should have received greater emphasis".

Other special considerations for planting include aesthetical desires, recreational considerations or ownership satisfaction where monetary values are not primarily important. Groups or persons interested in planting for purely personal reasons might be sportsmen, civic-minded organizations, summer residents, or estate owners.

#### General Recommendations for Aiding the Establishment of a Natural Forest Crop

Early inspection of the hurricane damaged areas should be made, and, keeping in mind the number of growing seasons since the hurricane, the reproduction should be examined closely. In order to visualize and understand the exact nature and potentialities of the reproduction on an area, the approximate site classification and stocking, composition, and quality of that reproduction should be determined by following general procedures such as outlined in this study. As indicated in the explanation of site determination, the presence of certain species of trees and ground cover, the moisture supply, the aspect and the topographic position will aid in determining the site quality. If the factors considered would seem to indicate a good site (Site II and Better), a more rapid and vigorous growth and denser stocking can be anticipated and treatments will vary from those applied on a poor site.

After determining the extent of stocking, the composition and growth forms, a plan for treatment should be outlined. The species to be included in the future stand should be determined from a consideration of the theory of the simple forest pattern and natural association of species. This theory implies protection of the natural reproduction and favoring of the certain specific classes of individuals and species which were indicated in the conclusions. These species and forms should be most valuable in the final crop chiefly because, by taking advantage of the natural associations, partially determined by growth trends, more rapid growth will be secured in the favored species and quicker returns realized.

At the present time the most urgent requirement in the development of the new stand is to give the young reproduction an opportunity to grow. The important initial steps to be considered are fire protection, freeing young trees by lopping and scattering slash, cutting bent over advance growth, and, later, weeding to hasten development of desirable, well-stocked young stands.

It has been generally recognized among foresters that the composition of any wild or volunteer stand is greatly influenced later in life by specific and inherent growth habits of the species included. Studies of growth characteristics of important crop tree species by McKinnon, Hyde, and Cline ('35) show the importance of specific growth habits on the control of composition, and their findings indicated the necessity for early weedings. The first of such treatments should be given near or soon after the age five, in order to develop the best possible forest crop before there is an appreciable decline in the number of available valuable elements. (The great proportion of inferior stems present on blowdown areas

will introduce serious and adverse competition if silvicultural treatment is not given). On the best sites where the most rapid and vigorous growth and densest stocking can be anticipated, it will be essential to cut back the rank sprout clumps, suckers, and trees of weed species soon after age three to allow the more valuable elements an opportunity to become well established. In general, if it is found that upon inspection valuable stems are being overtopped and suppressed by less valuable individuals, a treatment should be given within a year of that time.

Mainstory residuals, if of valuable species, may be left to provide a source of seed for a few years but should be cut before they suppress the younger trees or before their removal would seriously break or damage the smaller trees.

It should not be believed that white pine will be entirely eliminated from the new stands. As shown in the findings, pine was abundant in many cases and especially on the drier, lighter soils of Site III. In many instances, therefore, the final stand may well be a mixture of white pine and hardwoods, but with the hardwoods predominating in number. During weeding treatments, groups of pine should be favored and released from overtopping or suppressing hardwoods. A modification of the "hole" method of releasing pine would aid in the protection of pine from white pine weevil attacks and, also, lower weeding costs because less cutting would be required.<sup>8</sup>

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<sup>8</sup> The modified "hole" method of releasing pine is one in which only branches directly interfering with and causing abrasion to the pine leader are removed. Branches providing shade but not in immediate contact with the pine leader are left to partially suppress and keep the leader slender and thus less attractive to the white pine weevil.

From the results of this study it is seen that the hurricane devastated white pine areas may be expected to be reforested naturally. With early inspection and application of simple treatments, a stand potentially more valuable than the naturally developed one may be established. Through later improvement cuttings at about age 10 years or soon after and, through thinnings made at even later dates, when the stems removed may be utilized for cordwood, posts, and other small products, returns should exceed the original costs incurred in establishing the stands. Finally, cooperation with and furtherance of the natural trends in forest associations being established on the "old field" white pine blowdown areas in the northeast will result in a satisfactory financial and aesthetic rehabilitation of the areas.

## APPENDIX

## List of Tree Species Mentioned

<u>Scientific Name*</u>	<u>Common Name</u>
<u>Abies balsamea</u> (L.) Miller	Balsam fir
<u>Acer pennsylvanicum</u> L.	Striped maple (Moosewood)
<u>Acer rubrum</u> L.	Red maple
<u>Acer saccharum</u> Marshall	Hard maple
<u>Acer spicatum</u> Lamarek	Mountain maple
<u>Alnus incana</u> (L.) Koench	Alder
<u>Betula lenta</u> L.	Black birch
<u>Betula lutea</u> Michaux	Yellow birch
<u>Betula papyrifera</u> Marshall	Paper birch
<u>Betula populifolia</u> Marshall	Gray birch
<u>Castanea dentata</u> (Marsh) Borkhausen	Chestnut
<u>Fagus grandifolia</u> Ehrhart	Beech
<u>Fraxinus americana</u> L.	White ash
<u>Fraxinus nigra</u> Marshall	Black ash
<u>Hicoria glabra</u> (Mill.) Sweet	Pignut hickory
<u>Hicoria ovata</u> (Mill.) Britton	Shagbark hickory
<u>Ostrya virginiana</u> (Mill.) Koch	Hornbeam (Ironwood)
<u>Picea rubra</u> Link	Red spruce
<u>Pinus resinosa</u> Solander	Red pine
<u>Pinus rigida</u> Miller	Pitch pine
<u>Pinus strobus</u> L.	White pine
<u>Populus grandidentata</u> Michaux	Poplar (Large-toothed aspen)
<u>Populus tremuloides</u> Michaux	Poplar (Trembling aspen)
<u>Prunus pennsylvanica</u> L.	Pin cherry
<u>Prunus serotina</u> Ehrhart	Black cherry
<u>Prunus virginiana</u> L.	Choke cherry
<u>Rhus</u> spp.	Sumac
<u>Quercus alba</u> L.	White oak
<u>Quercus borealis</u> Michaux	Red oak
<u>Quercus ilicifolia</u> Wang.	Scrub oak
<u>Salix</u> spp.	Willow
<u>Tilia glabra</u> Ventenat	Basswood
<u>Taxus canadensis</u> (L.) Carriere	Hemlock
<u>Ulmus americana</u> L.	Elm

\*From Check List of the Forest Trees of the United States: Their Names and Ranges by George B. Sudworth. U. S. Department of Agriculture Miscellaneous Circular 92. 1927.



APPENDIX

List of Shrubby and Herbaceous Species Mentioned

<u>Scientific Name*</u>	<u>Common Name</u>
Dicksonia punctilobula (Michx.) Gray	Hay-scented fern
Gaultheria procumbens L.	Wintergreen (Checkerberry)
Gramineae	Grasses
Hypnum spp.	Hypnum moss
Lycopodium lucidulum Michaux	Lycopodium
Lycopodium complanatum L.	Lycopodium
Mitchella repens L.	Partridgeberry
Nyrica asplenifolia L.	Sweet fern
Polytrichum spp.	Polytrichum moss
Pteris aquilina L.	Bracken fern
Rubus hispidus L.	Dwarf raspberry
Vaccinium pennsylvanicum Lamarck	Low-bush blueberry
Rubus allegheniensis Porter	Blackberry

\*From Gray's New Manual of Botany: A Handbook of the Flowering Plants and Ferns of the Central and Northeastern United States and Adjacent Canada. Seventh Edition. Revised by Benjamin L. Robinson and Merritt L. Fernald.

APPENDIX

List of Abbreviations Used for Tree Species Mentioned

<u>Abbreviation</u>	<u>Tree Species</u>
P. C.	Pin cherry
R. M.	Red maple
Mis.	Miscellaneous*
G. B.	Gray birch
P. B.	Paper birch
W. P.	White pine
R. O.	Red oak
W. A.	White ash
H. M.	Hard maple
Y. B.	Yellow birch
B. B.	Black birch
Chest.	Chestnut
W. O.	White oak
Hem.	Hemlock
C. C.	Choke cherry
Bal. fir	Balsam fir
Red spr.	Red spruce
Hick.	Hickory
Bass.	Basswood
Bl. ash	Black ash

\*Miscellaneous includes sumac, willow, mountain maple, ironwood, and striped maple.

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Fig. 2. "Old Field" white pine stand destroyed by the hurricane.

Much of the hardwood advance growth was broken or bent over by the falling trees.



Fig. 3. Hurricane damaged "Old Field"  
pine stand showing amount of unmerchant-  
able material left after logging. Note  
background of windfirm conifers and hard-  
woods along the border of the stand. These  
will serve as a source of seed.



Fig. 4. Method of sampling with light, folding frame enclosing an inside area of one milacre. Note abundance of Gray Birch seedlings on burned area in foreground, and the heavy cover of ground raspberry in the background inhibiting all reproduction.



Fig. 5. High hardwood stump and bent over advance growth with stem suckers along the boles and vigorous sprouting at the root collars.





Fig. 6. A volunteer stand at end of second growing season showing fast-growing White Ash sprouts with many potentially valuable stems present.



Fig. 8. A white pine blowdown cleaned up by logging and subsequent slash disposal. The exposed mineral soil caused by uprooting furnishes ideal seed beds.