Natural harvesting of trees

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INTRODUCTION

The William L. Hutcheson Memorial Forest is a mature oak-hickory forest (Buell 1957). It remains as an isolated variant of previous vegetation which once covered the New Jersey Piedmont (Monk 1961 a). The Forest is located on the Piedmont Plateau only a few miles west of the fall line. White oak (*Quercus alba*), red oak (*Q. rubra*), and black oak (*Q. velutina*) are the dominant tree species with red hickory (*Carya ovalis*) next in importance in the canopy. Occasional trees of shagbark hickory (*C. ovata*) also occur in the canopy. Scattered white ash (*Fraxinus americana*), beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), red maple (*A. rubrum*), Norway maple (*A. platanoides*) and sweet cherry (*Prunus avium*) represent a large number of transgressives. Flowering dogwood (*Cornus florida*) forms an almost unbroken subcanopy layer. Shrub species, including maple-leaved viburnum (*Viburnum acerifolium*), blackhaw (*V. prunifolium*), black cherry (*Prunus serotina*) and choke-cherry (*P. virginiana*) in the well-drained areas and arrow wood (*V. dentatum*), spicebush (*Lindera benzoin*), greenbriar (*Smilax rotundifolia*), swamp fetterbush (*Leucothoe racemosa*) and poison ivy (*Rhus radicans*) in the poorly-drained areas, form a pronounced shrub layer. Bard (1952) considers this forest to "approximate climax." However, oak and hickory are not reproducing very successfully, and sugar maple, a principal northern hardwood element, is increasing in importance (Monk 1961b).

Edlin and Nemmo (1956) write, "Everyone who tends trees . . . soon becomes aware that they face many perils." Fire, wind, man and disease are four such perils which have befallen Hutcheson Memorial Forest. It is the object of this study to show by means of a survey of the eastern portion of the Forest (Fig. 1) how the trees in this portion have been, for the past 15 or more years, "naturally harvested."

The term "natural harvest" is defined as follows. In the sense that trees are the crop of a forest, the killing of these trees represents harvest. Further, because Hutcheson Memorial Forest has for a long time been protected from human interference, the only recent harvesting has been done by the forces of nature (i.e., wind and disease) — thus the term "natural harvest."

Fire is in the Forest's history. Indians practiced intentional, regular burning for many purposes such as clearing for villages and agriculture, hunting, facilitating travel, driving away insects, increasing the supply of grass and berries and for offense and defense in war (Day 1953). Carelessness may have resulted in unintentional burning at times, too. One large white oak which was destroyed in the windstorm of 1950 exhibited fire scars approximately every ten years from 1641 to 1711. Since 1711, it seems that there have been no serious fires (Buell, Buell and Small 1954). The Forest remained under the ownership of a single family from colonial days until 1955 when it was acquired by Rutgers - The State University as an ecological preserve (Monk 19-

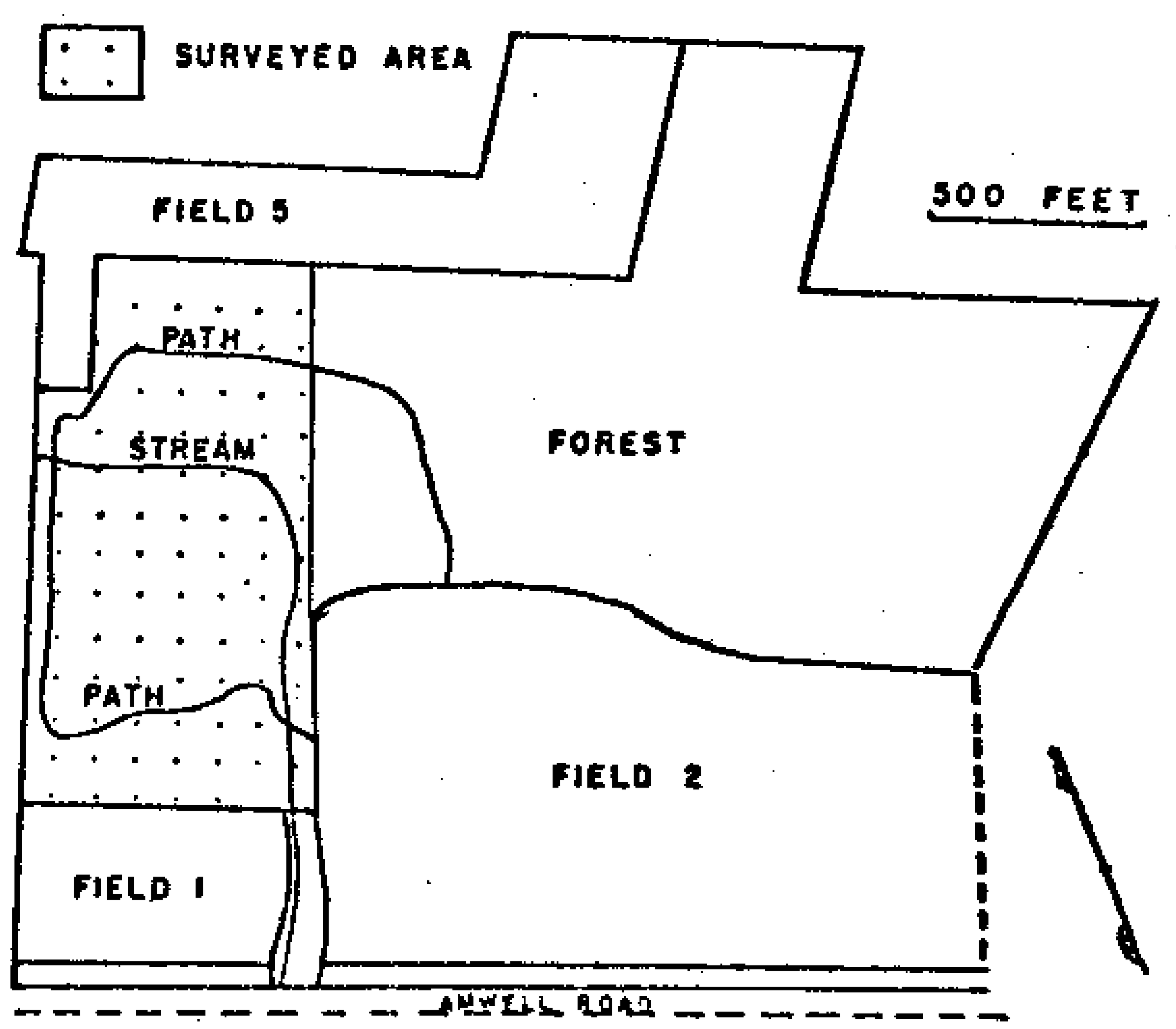

Fig. 1. Surveyed portion of the William L. Hutcheson Memorial Forest (from Monk 1957).

57). This ownership history has assured longstanding protection of the Forest from fires and other human interferences.

Perhaps the most catastrophic factor acting on this Forest is wind. In November of 1950, a severe storm toppled or broke more than 300 large trees (Monk 1957). Since 1950, three storms, hurricane Hazel in 1954, and hurricanes Connie and Dianne in 1955, have caused extensive damage to the Forest (Adjemovitch 1958).

Man has augmented the natural disturbance of wind. Prior to 1950, an occasional wind-damaged tree was removed by the original proprietors. The greatest human influence, however, was in 1951 when loggers salvaged 299 trees damaged in the November 1950 storm (Monk 1957). None of the injured trees were removed following the 1954-55 storms.

The extent of disease injury to a forest is difficult to determine. It is known that the fungus *Armillaria mellea* (Vahl) Quel. is present in Hutcheson Memorial Forest. Frequently, the "shoestring" mycelium of the fungus can be seen on upturned roots and logs. *A. mellea* is a basidiomycete infecting and decaying both sapwood and heartwood. Generally, the fungus lives as a saprophyte on stumps and roots of dead trees. Often, however, it becomes parasitic and may kill the infected tree (Boyce 1961). This fungus is particularly active in oaks and chestnuts (Long 1914) and causes the most serious damage to trees growing under sub-optimal conditions — including trees growing on poor or badly drained soil (Boyce 1961).

Drought, considered a disease in this study according to the definition of disease given by Walker (1957), has taken its toll of trees in Hutcheson Memorial Forest. The effect of this single factor is again difficult to evaluate. Small (1961) in his study indicated 114 trees were very obviously damaged and 74 trees were killed in the summer drought of 1957. Twelve per cent of those injured and 32% of those killed were dogwood, the understory species. Further, red maple comprised 19% of those injured and 14% of those killed. White oak, red oak and black oak totaled 32% of those injured and 20% of those killed.

Insect damage may be of some importance but nothing is known about this aspect of the Forest.

Natural harvesting of canopy trees is probably never the result of any factor operating independently, but is the result of an interaction of factors. The soil profile in Hutcheson Memorial Forest is commonly less than half a meter in depth. Bedrock, red Triassic shale, is fequently 60 cm below the surface (Bard 1952) thereby inhibiting internal drainage and waterlogging the solum wherever external drainage is limited. Where water accumulates, root spread is checked and at the same time soil is kept soft (Edlin and Nemmo 1956). The shallow solum also promotes spreading, shallow root systems in the trees as shown in Fig. 2. These factors undoubtedly promote wind-throws during storms, especially storms accompanied by heavy precipitation. Furthermore, one wind-thrown tree opens the canopy layer thereby rendering other trees liable to wind-throw or wind-snap.

A possible principal interaction may be that between the soil and *Armillaria mellea.* This fungus, which grows particularly well in trees on poorly-draned sites, weakens the roots and stems thus contributing to a greater likelihood of wind-throws.

Wind-snaps, frequent in Hutcheson Memorial Forest, are sometimes caused by an uprooted tree, as it falls, striking a neighboring tree (Fig. 3). Often, boles are hollow and weakened by disease and are easily snapped off.

Finally, interrelationships may exist between the effects of drought and other diseases. Severe drought may render a tree extremely susceptible to *Armillaria mellea* by injuring its roots. Thomas (1934), while presenting evidence that presumably healthy roots are penetrated by invading *A. mellea* rhizomorphs as easily as diseased roots, suggests further that wounds may have a secondary effect in facilitating establishment of the fungus by affording it saprophytic nourishment. Wound areas on tree parts above and below ground provide easy access for other pathogens as well, including heart-wood rotters.

Conversely, if we assume that healthy roots are attacked and injured by decay and are therefore unable to function optimally, this may intensify the effects of drought. Christensen and Hodson (1954), however, referring to *Armillaria mellea* state that, "from a practical forest management standpoint in the area studied, it would seem that fungus can be more or less dismissed from consideration as a damaging factor." This does not dismiss the possibility of other strains of *A. mellea* functioning more aggressively elsewhere.

Fig. 2. Typical shallow root system exposed by a wind-throw.

Fig. 3. Wind-snapped tree which as it fell struck and broke a neighboring tree.

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The nomenclature follows Gray's Manual (Fernald 1950) unless otherwise indicated.

METHODS

In the fall of 1963, a survey was made of all dead trees in 7.89 ha (hectares) of the eastern portion of Hutcheson Memorial Forest (Fig. 1). For convenience. the area was divided into contiguous 20 x 20 m plots. Excluding dogwood, each dead tree stump or trunk with a d. b. h. (diameter at breast height) of 6 in. or over was located on a plot map and the following data recorded: tree portion present (stump or trunk), decay stage, genus and species. diameter at 1 ft or 4.5 ft from the base of the tree, direct cause of death as near as could be determined (wind. disease or cut). direction of fall, and approximate date of fall in the case of wind-throws.

Genus and species determinations were made immediately when bark was present. However, the majority of specimens had no bark, and wood structure served as the basis for identifications. A small wood sample was taken from each unknown specimen. The sample was labeled and identified in the laboratory with the aid of a hand lens and razor blade. Twenty samples were sent to the Forest Service Laboratory in Madison. Wisconsin. for accurate identification. These "knowns" were used as references for the remaining sample identifications. Maple, hickory and cherry determinations could be made to genus only. Oaks could be separated into two groups: white oak group including *Quercus alba* and *Q. bicolor* and red oak group including *Q. rubra, Q. velutina, Q. coccinea* and *Q. palustris*. A few specimens had no sound wood and were left unidentified.

Since it was desirable to have basal area measurements at breast height, stump measurements, necessarily taken at the 1 ft level, had to be converted to 4.5 ft values. Conversions were then made from a correlation of the two diameter measurements. D. b. h. measurements, in inches, were placed on the y axis and 1 ft level measurements on the x axis. The straight-line slope between points, drawn by eye, had an equation of $y = .85x$ plus .20. Most canopy species were included in these measurements. D.b. h. measurements were then converted to basal area with a U. S. Forest Service table (Galant and Roy 1962).

Direct cause of death fitted into one of three classifications: wind, cut or disease. A wind-killed tree was recognized as wind-thrown by a mound of soil on upturned or loosened roots (Figs. 4 and 5) and as wind-snapped by a broken bole.

An attempt was made to approximate the year in which a wind-throw occurred by an examination of the remaining tree portion and the mound where bare soil had been exposed. Dr. John A. Small, who had records on many trees, visited several wind-throw sites with the authors to aid in the dating determinations. Condition of the wood, stage of vegetational succession on the mound and general weathering con-

Fig. 4. This tree with upturned roots was wind-thrown in 1950 and removed from the Forest in 1951.

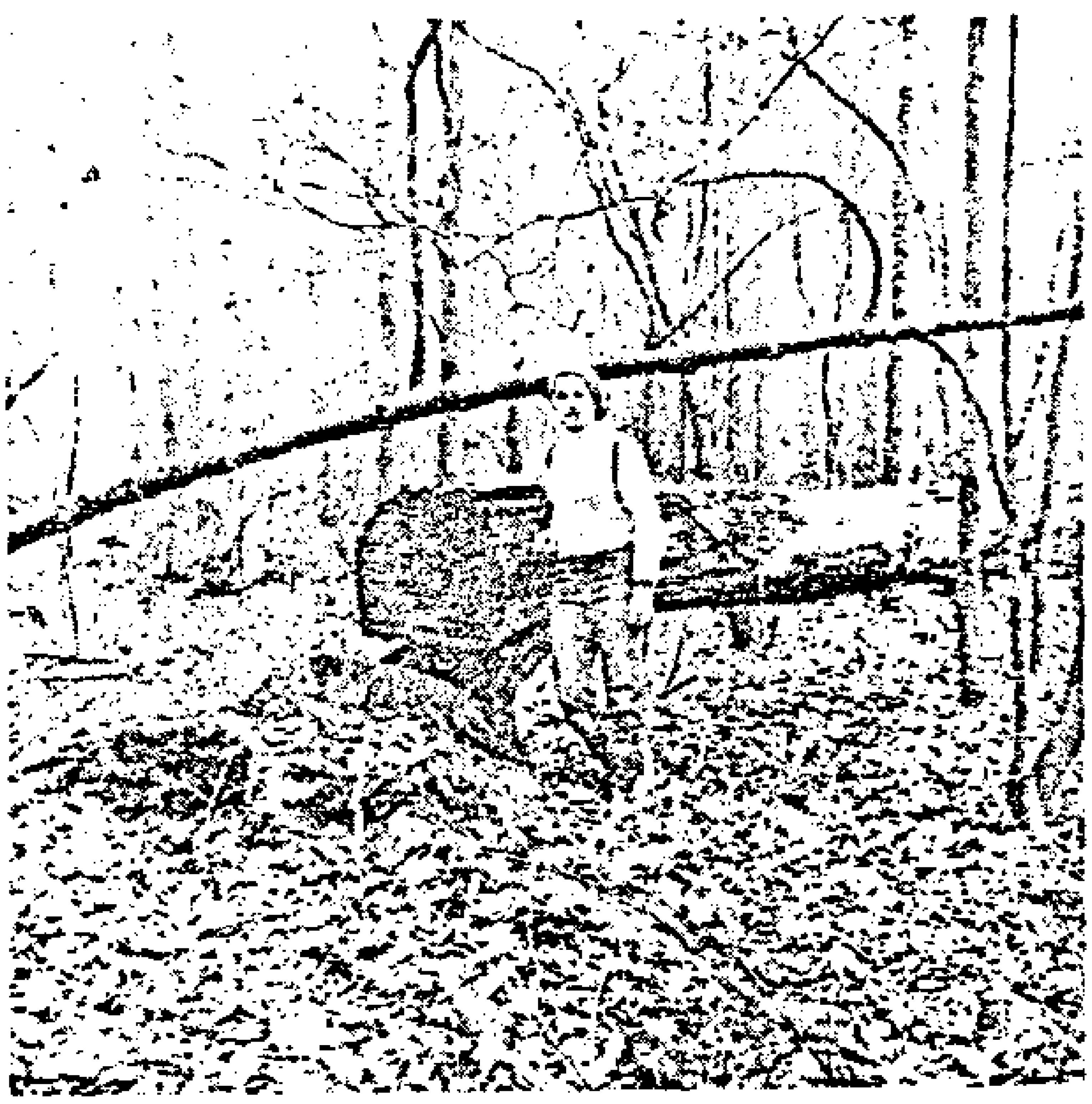

Fig. 5. This tree with loosened roots was wind-thrown in the storms of 1954-55. It was cut in a tilted position.

dition of the mound were the three most important factors considered. Each tree was placed in one of the following storm periods according to the factors described:

1. Before 1950 — sapwood and bark absent, heartwood badly decayed, abundant leaf litter and very little moss on the mound (Fig. 6).
2. 1950 — sapwood decayed, bark absent or rarely present, heartwood badly to slightly decayed, abundant to light leaf litter with fair amount of moss on mound, usually a stump because of salvaging operations in 1951 (Fig. 4).
3. 1954-55 — sapwood moderately decayed, bark present, light leaf litter and abundant moss on mound (Fig. 7).
4. Since 1955 — slight amount of decay, small twigs still present, leaves and buds present on very recent wind-throws.

A stump designated "cut" had no mound, nor did it exhibit any sign of wind damage (Fig. 8). This does not confirm that the tree portion already removed was not wind-damaged, wind-damage being a criterion used in 1951 when certain trees were marked for salvage.

A tree which died of disease was recorded as standing dead or died-and-fell (Fig. 9). A tree which died-and-fell could be distingushed from a wind-throw by the absence of a mound. It was often difficult to separate live-tree wind-snaps from those trees which died before being windsnapped. Hollow stems break neatly; a sound stem shows a much longer break with jagged splinters (Edlin and Nemmo 1956). However, some living trees have hollow stems.

The direction of a wind-throw was determined by a compass bearing taken from the tree base looking along the bole toward the top.

Fallen trees with live branches were not counted in the survey (Fig. 10).

A map was constructed illustrating the approximate location of every visible, harvested tree in the eastern portion of Hutcheson Memorial Forest. By superimposing Monk's map (1957) on this map, upland and lowland sites were delimited. This map is on file in the library at Rutgers — The State University (Reiners, 1964).

RESULTS

A total of 544 trees were recorded in the 7.89 ha area surveyed. Five and thirteen hundredths hectares of the area occupy well-drained or upland soil sites and the remaining 2.76 ha are on poorly-drained or lowland sites.

Eight different taxa are represented as shown in Table 1. Oak, the most important canopy species, represents 74.6% of the total number of harvested trees. Oak and hickory total 80.5%. The values for *Acer* spp. probably would have been greater were it not for the fact that branches of many fallen trees of this species continued to grow (Fig. 10). On the basis of the standing population, presumably most of the maples recorded were *A. rubrum* and most of the cherries were *Prunus avium.*

TABLE 1. *Total number of harvested trees of each taxon surveyed, number per hectare, total basal area and basal area per hectare on well-drained and poorly-drained soil sites.*

Taxa	Well-drained				Poorly-drained			
	Tot. no.	no. /ha	BA ft^2	BA /ha	Tot. no.	no. /ha	BA ft^2	BA /ha
Acer spp.	12	2.3	7.3	1.4	14	5.1	16.6	6.0
Carya spp.	20	3.9	22.4	4.4	12	4.4	15.2	5.5
Fagus grandifolia					1	.4	.5	.2
Fraxinus americana	8	1.6	5.0	1.0	15	5.4	20.6	7.4
Prunus spp.	20	3.9	7.5	1.5	5	1.8	2.4	.9
Red oak group	91	17.7	176.6	34.4	46	16.7	83.5	30.2
Ulmus americana	6	1.2	2.8	.5	3	1.1	1.9	.7
White oak group	187	36.4	296.7	58.0	82	29.7	165.2	59.8
Unidentified	13	2.5	17.6	3.4	9	3.3	8.5	3.1
Totals	357	69.5	535.9	104.6	187	67.9	314.4	113.8

TABLE 2. *Number of trees, according to taxa and soil type, harvested by wind, cutting and disease in the 7.89 ha area. Years indicate estimated date of harvest. W=well-drained area P=poorly-drained area.*

	Harvest type																	
	Uprooted by Wind								Wind-		Cut				Disease			
	Before 1950		1950		1954-5		Since 1955		snap		Before 1950		1950		Standing		Died & Fell	
	W	P	W	P	W	P	W	P	W	P	W	P	W	P	W	P	W	P
Acer spp.			3	4		3			5	3					2		2	4
Carya spp.	1	3	8		3	1		1	5	5	1	1				1	2	
Fagus grandifolia										1								
Fraxinus americana			2	5		3			5	3				1	1	1		2
Prunus spp.			1		4	3	1		7	1			1		1		5	1
Red oak group	6	7	25	19	4	2		1	10	1	8	3	4	1	7		26	12
Ulmus americana			1		1				3	3					1			
White oak group	2	4	60	33	13	11			18	3	12	6	14	5	11	5	57	15
Unidentified	2	2	7	1					2		1			2			1	4
Totals	11	16	107	62	25	23	1	2	55	20	22	10	19	9	23	7	93	38

The total basal area of all harvested species is 849.28 sq ft. While the total number of harvested trees per hectare is greater on well-drained soil than on poorly-drained soil, the basal area per hectare is greater on poorly-drained soil.

All species were classified according to specific harvest type on well-drained and poorly-drained areas as represented in Table 2. Fifty-nine and three tenths per cent of all harvested trees were wind-killed, 11.2% were cut and 29.6% died of disease. A single storm (November 25, 1950) claimed 31.1% of all surveyed trees, a value only 1.5% greater than the per cent of all trees harvested by disease for at least 15 years.

The number of wind-killed trees per hectare is greater on poorly-drained sites than on well-drained sites (Table 3). On the other hand, disease killed more trees per hectare on the well-drained sites.

Forty per cent of all harvested trees fell into the smallest size class including all trees with a d. b. h. of 6 in. to 12.9 in. (Table 4). The trees in size classes 2. 3. 4 and 5 equaled 32%, 22%, 5% and 1%, respectively.

Fig. 6. The base and mound of a tree wind-thrown before 1950.

Fig. 7. Two white oaks wind-thrown in the storms of 1954-55.

TABLE 3. *Number of trees of each harvest type per hectare on well-drained and poorly-drained soil sites.*

	Wind-throw	Wind-snap	Cut	Disease	Totals
Well — drained	28.0	10.7	8.2	22.6	69.5
Poorly — drained	37.3	7.2	6.9	16.3	67.7

The directions of the wind-throws for the two storm periods 1950 and 1954-55 are shown in Table 5.

DISCUSSION

The data are subject to several kinds of errors. Differences in disintegration rates may have caused inaccuracy in dating the wind-throws. Spaulding (1928) listed the following factors which influence the rate of decay of hardwood slash in northern New England: tree species, rate of tree growth, season of cutting, soil type, slope aspect, elevation, moisture in surrounding air and soil, heat of sun and cover quality and quanity. These same factors undoubtedly apply to Hutcheson Memorial Forest.

According to the wood durability list of tree species given by Hunt and Garratt (1953), of all species found in Hutcheson Memorial Forest white oak is the most durable and all other species range from slightly less to much less durable.

Difficulties in determining direct method of harvest, as well as possible mapping errors have already been discussed. Mapping errors could conceivably affect ratios of well-drained and poorly-drained site data.

Table 6 is a comparison between the data of Monk (1961a), resulting from a complete survey of the living trees in Hutcheson Memorial Forest, and the results of this study. It must be noted, however, that this is not a true comparison. Monk counted all trees over 1 in. d. b.h. and our survey included those trees over 6 in. d. b. h.

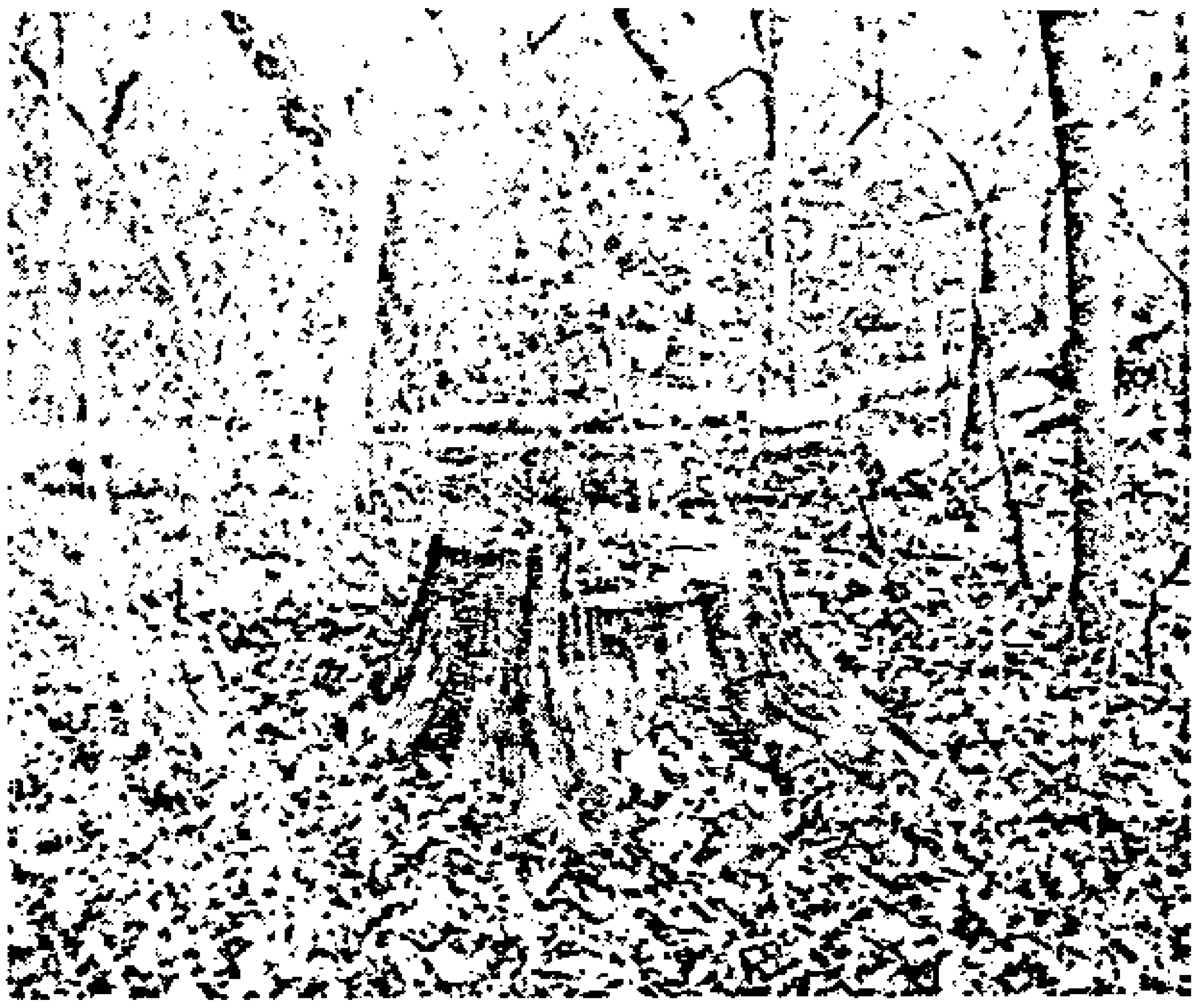

Fig. 8. A "cut" tree showing no sign of wind damage.

The total basal area harvested per hectare as determined from still measurable remnants on well-drained sites was 47% of the total basal area living per hectare, while on poorly-drained sites the comparable total basal area harvested per hectare was 62% of the total basal area living per hectare. In Table 3, we find that 69.6 trees were harvested per hectare on well-drained sites and only 67.8 trees harvested per hectare on poorly-drained sites. Thus,

TABLE 4. *Number of each harvest type in arbitrary d.b.h. size classes on well-drained (W) and poorly-drained (P) sites. Classification follows: 1=6–12.9 in.; 2=13–19.9 in.; 3=20–26.9 in.; 4=27–33.9 in.; 5=>33.9 in.*

Harvest type		Wind-throw				Wind-snap					Cut					Disease				
Size class		1	2	3	4	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Acer spp.	W	2	1			4	1									3		1		
	P	4	3			1	2									1	1	2		
Carya spp.	W	5	5	2		1	2	2			1					1	1			
	P	2	3			4	1				1								1	
Fagus grandifolia	W																			
	P					1														
Fraxinus americana	W	1	1			5										1				
	P	6	2			2		1			1				1	2				
Prunus spp.	W	6				7					1					6				
	P	3				1										1				
Red oak group	W	7	11	13	4	3	2	3	1	1	5	4	4			12	9	9	3	
	P	5	14	9	1				1		2	1	1			4	4	4		
Ulmus americana	W	2				3										1				
	P					2			1											
White oak group	W	13	34	25	3	7	5	4	2		14	8	3		1	32	27	8		1
	P	6	21	16	5		1	2			3	3	2	2		10	4	3	2	1
Unidentified	W	6	1	2		1		1			1							1		
	P	1										1	1			4				

For one cut white oak and two wind-thrown unidentified trees no d.b.h. readings were obtained.

TABLE 5. *Number of wind-throws facing each compass quadrant in the two storm periods 1950 and 1954-55.*

Direction	Number of wind-throws per storm period	
	1950	1954-55
0° – 90°	10	10
90° – 180°	29	3
180° – 270°	49	4
270° – 0°	76	31

Fig. 9. The base of a tree which died-and-fell. Note the absence of a mound.

those trees which were harvested on poorly-drained sites were generally larger. Wind-throw, the only harvest type with a greater number of representatives on poorly-drained sites than on well-drained sites, accounted for 55% of the harvested trees on the poorly-drained sites. Further, referring to Table 4, we find that wind-throw was the only harvest type involving principally trees in the size class between 13 in. and 19.9 in. d. b. h. as well as a large number of trees in the size class between 20 in. and 26.9 in. d.b.h. Wind-snapped, cut and disease-killed trees were preponderantly in the smaller size class between 6 in. and 12.9 in. d. b. h. This perhaps explains why there was a greaer harvest of the standing basal area on poorly-drained areas than on well-drained areas.

Because Monk included trees as small as 1 in. d. b. h., taxa heavily represented by small size classes, such as *Fraxinus* and *Acer*, show higher per cents for standing trees than for harvested trees. The addition of these smaller size classes cause the oak representation to appear lower in Monk's data than in ours. (Oaks represent 88%, 87% and 78%, respectively in the first three columns on Table 6, but drop to only 53% in the fourth column.) Nevertheless. on poorly-drained sites the difference between living and harvested white oaks is greater than the difference between living and harvested red oaks. It would seem that on poorly-drained sites a greater amount of available basal area per hectare of white oaks was harvested than that of red oaks. Perhaps white oak trees were larger so that more basal area was lost per harvested tree. Monk's data (1961b) indicated that on poorly-drained sites more living members of the white oak group than of the red oak group were in the size classes over 15 in. d. b. h. Further. our data show 44% of the wind-thrown white oak group, as opposed to only 34% of the red oak group, in the size classes between 20 in. and 33.9 in. d. b. h.

TABLE 6. *Per cent basal area (% BA) for living trees over 1 in d.b.h. (Monk 1961a) and % BA for harvested trees 6 in d.b.h. and over on well-drained and poorly-drained sites in Hutcheson Memorial Forest. Where there is more than one figure values of less than one (<1) represent separate species within the indicated taxon.*

Taxa	% BA on well-drained sites		% BA on poorly-drained sites	
	Harvested	Living	Harvested	Living
Acer spp.	1	3+<1+<1	5	15+<1+<1
Carya spp.	4	6+<1	5	3
Fagus grandifolia	0	<1	2	1
Fraxinus americana	<1	3	6	15
Prunus spp.	1	2	<1	<1
Red oak group	33	34+<1	26	21
Ulmus americana	<1	<1	<1	5
White oak group	55	52	52	32
Unidentified	3	—	2	—
Total BA/hectare	104.6 ft^2	221.2 ft^2	113.8 ft^2	183.3 ft^2

Fig. 10. A fallen maple tree with many living branches.

The high basal area of harvested trees compared with live trees probably reflects a temporary low status of the standing tree crop. If this forest does "approximate climax," and if we accept catastrophic harvesting agents as part of its environment, then it appears that the stability of the community, as measured in terms of standing tree crop, deviates around a hypothetical mean with a fairly high amplitude (Fig. 11). It would be interesting to see if measurements repeated in 50 and 100 years might produce higher standing tree crop to harvested tree ratios as points on the amplitude around the mean. It would also be interesting to see if the amplitude in net produtivity would be dampened by the compensating growth of vigorous gap-replacement vegetation. Monk (1961b) states:

> When a gap is formed the old field species make their initial appearance and there is a burst of growth of the species present in shrub and herb layers. The omnipresent seedlings and saplings of flowering dogwood and white ash along with red maple which rapidly seeds into wind-throw areas overtop the shrub layer in 5 to 6 years.

Such a compensation might be an example of homeostasis in a diverse ecosystem.

Monk (1957) estimated that in the storms of 1950, 1954 and 1955, 80% of the "wind-throw damage" occurred in the specific lowland area surveyed in this study. In our study, however, only 39% of the wind-throws in those storms occurred on this lowland region. Certainly, because of the predominant amount of upland area, the per cent would dip even lower with a complete survey of the Forest. Monk's figure was only an estimate since he collected no harvest data, but the greatest source of the per cent difference may be unlike interpretations of a wind-throw.

Wind is the most apparent catastrophic factor in Hutcheson Memorial Forest. Reasons for differences in its effects on well-drained sites and poorly-drained sites were discussed in the introduction. Any species discrimination exhibited by the agency of wind-throw was probably exercised only through such secondary factors as d. b. h., height, rootmass size or depth, disease and site location. Small trees such as *Prunus avium*, suppressed trees, trees with very large or deep roots and trees normally found on more xeric sites would be less prone to wnd-throw.

Certain species also may be more susceptible to wind-snap than others. A flexible bole, deep roots and resistance to decay would render a tree more resistant to wind-snap. Based on a total count of 75 wind-snaps, 10.7 per hectare occurred on well-drained soil as compared to only 7.2 per hectare on poorly-drained soil. Many factors could contribute to this per cent difference, the most important perhaps being deeper roots or dryer soil or both.

Well-drained and poorly-drained sites also exhibited differences in the number of disease-killed trees per hectare. About one and one-third times as

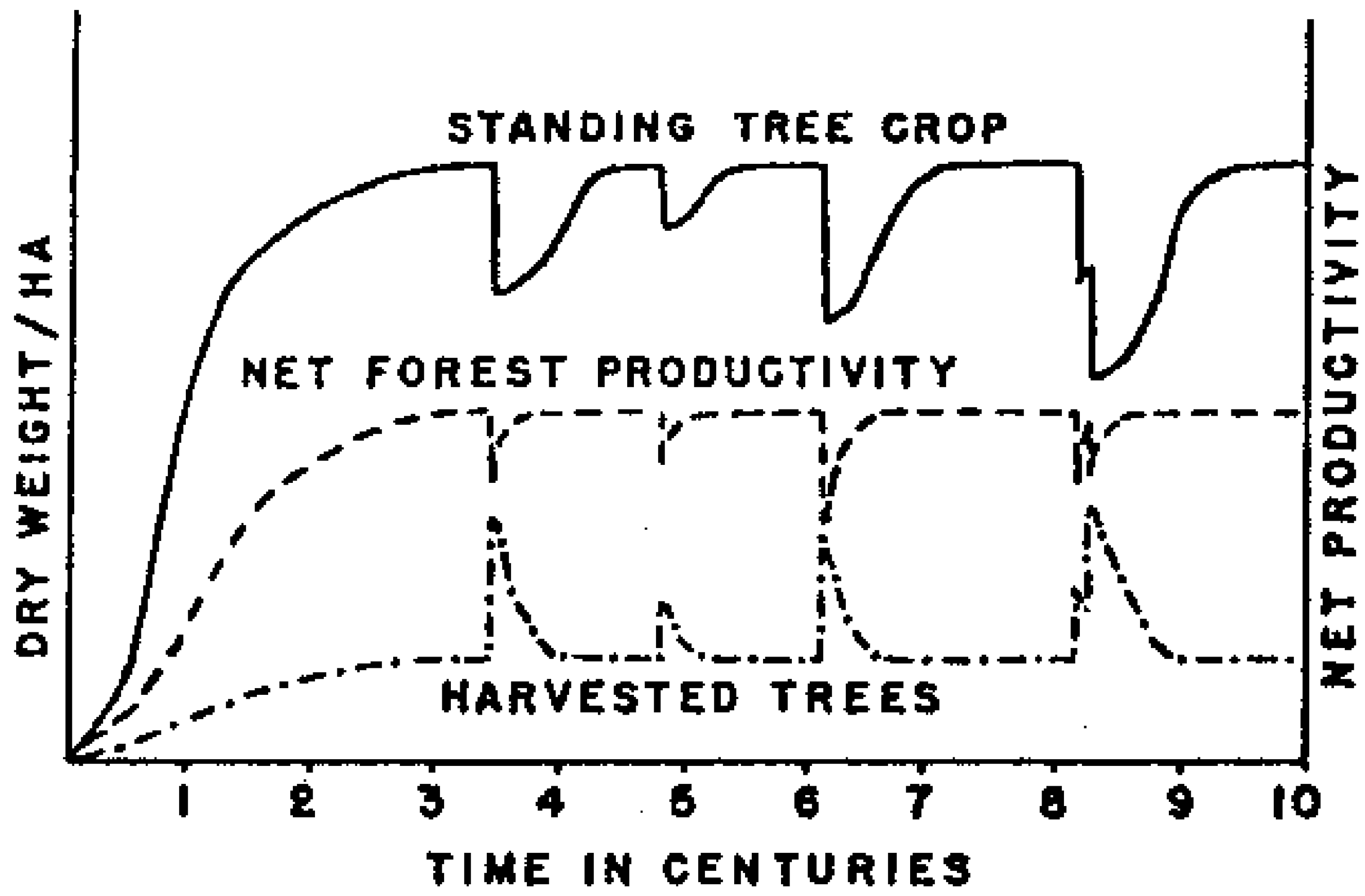

Fig. 11. Postulated effect of catastrophic harvest of canopy species on the distribution of biomass and net productivity in Hutcheson Memorial Forest.

many trees were disease-killed on well-drained sites as on poorly-drained sites. It is diffcult to determine which factors had the greatest influence. It would seem that if *Armillaria mellea* were the main cause of death in this harvest type, the effects would be greater on poorly-drained soil. Drought may have been the cause of a large number of deaths in this category. However, Small (1961) reports that drought effect was more apparent on lowland sites. The number of drought-injured trees which died or which became infected and died as a result of drought remains a Forest secret.

"Cut" trees were found almost as fequently on poorly-drained areas as on well-drained areas. The 1951 agreement authorizing salvaging of wind-thrown trees from the Forest also allowed for the removal of certain wind-damaged standing trees (Buell personal communication).

The unidentified group of harvested trees is presumed to be mostly oaks, merely because most of the trees surveyed were oaks. It is interesting to note that data for unidentified trees are similar to those for oaks whenever they appear together in tables.

As already mentioned most of the trees harvested were in the 6 in. to 12 in. d. b. h. size class. Monk's (1961b) tree census data for the entire Forest indicate that this may be because more trees of this size class were available.

Whether or not random selection alone rendered wind-thrown oaks more frequent among the size class 13 in. to 26.9 in. d.b.h. is unknown. Disease-killed oaks, however, were most prevalent in the 6 in. to 12.9 in. d. b. h. size class, and because more oak trees in the next larger size class were available, it would seem that a selective force was applied. Perhaps the smaller trees were suppressed trees growing under less than optimum conditions. Perhaps they were more susceptible to root or bole decay. Site does not appear to be a relevant factor in this case.

The direction of a wind-throw may have a small amount of value in dating the death of a tree in the future when other identifying characteristics have been lost. In all three storms, 1950, 1954 and 1955, a majority of the wind-throws face a north-easterly direction. However, a large number of 1950 wind-throws face a south-westerly and south-easterly direction.

SUMMARY

1. The natural harvesting of trees was studied in a mature oak-hickory forest located on the New Jersey Piedmont. Wind-throws and wind-snaps due to severe storms were the most important harvest agencies. Death through disease or removal by cutting were of lesser significance.

2. The total basal area of trees harvested and still measurable per hectare was 47% on well-drained sites and 62% on poorly-drained sites relative to the basal area of living trees.

3. Wind-thrown trees were more frequent on poorly-drained sites and were predominantly in the larger size classes. Wind-snaps were more frequent on well-drained soil, possibly because of greater resistance to wind-throw and consequent breakage of the boles.

4. Thirty per cent of the dead trees were disease-killed. These trees were chiefly among the smaller size classes and the majority were on well-drained sites. Possible effects of drought and the fungus *Armillaria mellea* are discussed.

5. Only 11% of the harvested trees had been killed by cutting and these were evenly distributed between well-drained and poorly-drained sites.

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