Shorten to 1 page or less

Methods

M Clearcutting the research plot for stem analyses

In the forests of this latitude, the development of trees is faithfully recorded by annual increments, the cumulated evidence of their ontogeny. The analysis of cross sections removed at regular intervals from the boles of these trees permits their height and radial growth rate reconstruction; their dimensions can be computed for various periods of their life spans. (Fig. M-M-1) Hence the developmental morphology of the main aerial portions of the tree components of these forests can be revealed.

The final phase of field work of the current study involved the sectioning of the live and dead trees that remained on the research plot. Whenever feasible, cross-sections were collected from each of the boles at the following intervals:

Fig. M-M-1. Photo of x-sections of a tree demonstrating radial and ht. growth reconstruction intervals: at the butt as close to the ground as possible, at 4½ feet above the butt, and at every 4 feet thereafter to the top of the tree. The length of the tip that remained above the last section was measured to the nearest 0.5 foot so that the total height of the tree could be computed. Only the main bole or stem of the tree was sectioned.

The main boles of hemlock and white pine were easily determined. However, as sectioning proceeded from the butts of hardwood trees into their crowns, what constituted the main stems was often difficult to decide. Therefore, the branch that contributed most to the height of the tree was considered as that portion to be sectioned. Occasionally it was apparent that the main bole had been broken off in the regions of the crowns years before, and one or several lateral branches had assumed vertical positions to take over the role of terminal height growth. (Figs. M-M-2, and 3) In such a case, the tallest of these was considered as the extension of the main bole. No minimum diameter limit was placed on the sections to be removed. Specimens were collected which included the current year's height growth and which were only 1/16 of an inch in diameter. An attempt was made, nevertheless, to limit the thickness of the cross-sections to between 1 and 2 inches. This maximum thickness facilitates later processing in the laboratory.

Not all of the trees were sectioned at 4½ feet and every 4 feet thereafter up the stems. Eight and twelve-foot logs were sawed from a few of the larger hemlocks and an occasional hardwood. However, cross-sections

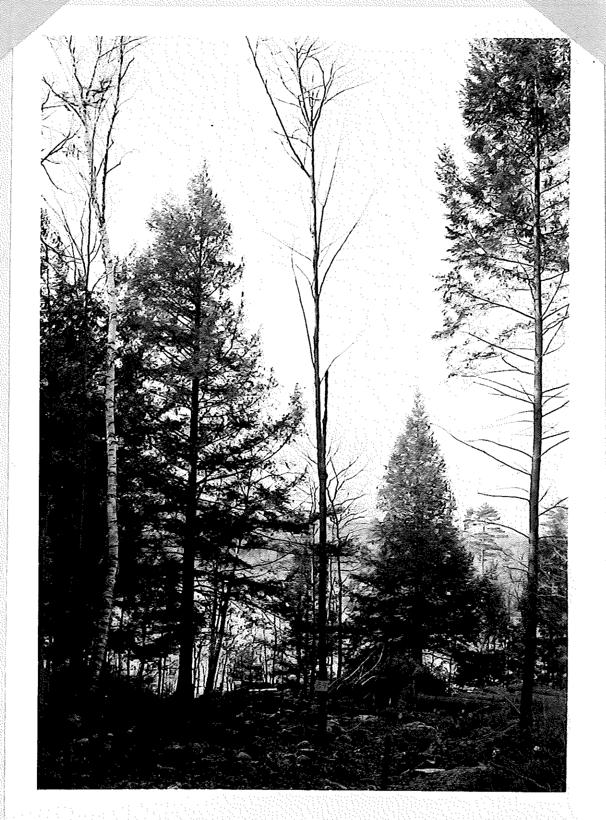


Fig. M-M-2.
Red maple No. 179 (Field No. 84). Main bole is forked about 14 feet above the groun[d]. The present live memb[er] of the fork was considered as the main bole and sectioned. Refer to Fig M-M[-3]. Rod against tree is 6½ feet long.

Fig. M-M-3.
Cross-sections removed from red maple No. 179 above.

were collected from the ends of the logs, and average diameters inside and outside bark were recorded to the nearest 0.1 inch at the regular 4½-foot intervals and inside bark measurements at every 4-foot mark above.

All of the small trees were not sectioned either at all of the regular intervals, but a cross-section was always removed from their butts, if rot did not prevent it, and average diameters inside and outside bark were measured at the 4½-foot interval, and total heights to the nearest 0.5 foot were recorded.

A crew of Harvard Forest woods personnel did the actual felling and sectioning of the trees. As each tree was felled, the bole was measured for sectioning to the nearest inch. Then saw cuts were made approximately one inch on each side of the interval marks to remove the cross-sections. Gasoline

Sentence!

chain saws were employed until the boles diminished to 2 or 3 inches in diameter, and then the sections were removed with axes. These latter sections, though small in diameter, were usually 6 to 8 inches long, since they were apt to split if cut any shorter with an axe. Even though these specimens were several inches long, they still bore the original interval marks which enabled the sawing-out of the cross-sections in the laboratory at precisely the right point.

The sections from each bole were assigned the number of the tree from which they came, and also a number according to their relative position in the bole. The section sawed from the butt of tree No. 1 was labeled 1-1, the section at 4½ feet as 1-2, at 8½ feet as 1-3, etc. Black lumber crayon was used for marking. The specimens from each

bole were kept together by placing
them in a paper bag, burlap sack,
or bushel basket, depending upon the
size, number, and weight of the
cross-sections. The specimens re-
moved from a single, large tree
often required two men to carry
when placed in a large burlap
sack. Paper bags were satisfactory
only for small trees. The containers
of sections were transported by truck
to the laboratory. There they were
removed from the cloth bags and
bushel baskets and placed in in-
dividual stacks on the floor. The
baskets and burlap sacks then were
used again.

Say all this in about 1 sentence.

In the laboratory, the average
diameters were cut from the cross-
sections on a table saw with a
12-inch circular blade. After the
sections were air dried their surfaces
were polished in preparation for analyses.

(seems?

The ages of both radii of the 4½-foot sections were determined, and the annual rings of each delineated with a sharp 6-H lead pencil, every tenth ring being differentiated. The diameters of the trees at breast height, as a result, could be reconstructed over the life span of the tree. The age of only one radius was determined for each of the 4-foot sections. The radius selected was usually the longer of the two involved, or the one that lent itself to the more accurate age determination. The annual rings of these radii also were delineated with a lead pencil, and every tenth ring was designated. The 4-foot sections, therefore, provide the ages of the trees at specific heights above their butts. The inside bark diameters were recorded for every cross-section, while both inside and outside bark diameters were measured for the 4½-foot sections.

A total of 544 boles were sectioned involving the collection of approximately 4400 specimens. The age and diameter of each cross-section was ascertained. (Table — Appendix)

444
22
9
122
34

631

(Chapter Heading)

ALL CAPS, CENTERED (all of Section H)

(Section Heading)

Initial Caps, Centered

(Headings under Section)

<u>Initial Caps, Brought Out to Margin, Underlined</u>

(numbers) <u>1. Sub-heading</u> - indented and underlined

(cap. letters) <u>A. Sub-sub</u>

MOUNDS AND PITS OF UPROOTED TREES

Uprooting may be defined as the toppling over of a tree with the result that some or all of its roots are wrenched from their anchorage in the soil. The mound and pit microrelief created by the uprooting of trees is a common constituent of the forest. Such mounds and pits are another form of the concrete evidence that is utilized by the historical-developmental method of ascertaining and evaluating vegetational trends. The mounds and pits afford several kinds of concrete evidence:

1. Mounds and pits proper.
2. Buried remains of the trees that were uprooted.
3. Pollen content of the buried organic layer of the relatively undisturbed forest floor.
4. Buried charcoal.
5. The stage of developmental morphology and anatomy of the mounds and pits.

The information provided by mounds and pits is essential to the reconstruction of vegetational trends. Each mound and pit pair represents at least one tree. The buried remains of trees that may be incorporated in the mounds provide a means of identifying the kinds of trees that were uprooted. Likewise, the pollen content of the organic layers of the relatively undisturbed forest floor, which also may be incorporated in the mounds, can be analyzed to provide information concerning the species composition of the forest at the times the uprootings occurred. The buried charcoal not only provides concrete evidence of forest composition, it also denotes the occurrence of fire. And the stages of developmental morphology and anatomy of the mounds and pits provide criteria which can be employed to determine their relative ages when the uprootings occurred. All of this information is pertinent to vegetational trends and justifies extreme effort on the part of the investigator.

The mounds and pits of uprooted trees may retain their identity for at least 500 years under the environmental conditions which prevail in central New England. Therefore, the evidence which they can provide fulfills a time interval that ordinarily precedes the advent of the oldest tree or stump in the present forest. The interpretation of this evidence permits the extenuation of the developmental trends of the forest further into the past than the ages of the present trees or stumps would justify.

The investigator is confronted immediately with several problems when he attempts to interpret the mound and pit microrelief of the forest floor. The six-inch contour map of the research area (Fig.) delineated over 60 local areas of elevations and depressions, the origins of which were possibly related to the uprooting of trees. The first major problem, therefore, was to document the origins of these elevations and depressions. The next stage of the investigation involved the determination of the species of trees that were uprooted to create the mounds and pits. And finally, the dates of the uprootings had to be ascertained. How old were the mounds and pits?

Preliminary Survey of the Mounds and Pits of Uprooted Trees:

Determination of the Origins of the Elevations and Depressions on the Forest Floor from their Gross Characteristics.

All of the microrelief on the present forest floor is not due necessarily to the uprooting of trees. Therefore, the first step in this phase of the investigation was to conduct a preliminary survey of the microrelief. During this time, an effort was made to ascertain the origins of the elevations and depressions. Only the criteria of physiognomy and rather surficial features were employed, those characteristics which could be observed with or without slight exploratory excavation. Once the mounds and pits of uprooted trees were isolated, they could be studied intensively and the evidence thus exposed could be fully exploited.

On the basis of origin, the microrelief of the present forest floor of the current research area could be divided into five categories.

1. Mounds and pits of uprooted trees.
2. Elevations due to boulders immediately below the surface of the forest floor.
3. Elevations around the bases of large trees due to root growth.
4. Elevations and depressions due to tree stumps in various stages of decomposition.
5. Elevations due to prostrate tree boles or parts thereof.

Gross Characteristics of Mounds and Pits of Uprooted Trees: No Excavation Required Except that Which Can Be Done With the Hands Alone.

There is no mistaking the origin of a young mound and pit resulting from the uprooting of a tree, especially when the toppled tree is still present on the forest floor (Fig. M-H-1). A live tree when uprooted characteristically wrenches a mass of mineral and organic material from the upper horizons of the soil. A pit results immediately in the forest floor, while a complementary product of the process is a potential mound represented by the mass of material held in suspension above the general level of the forest floor by the root system of the toppled tree.

Over time, however, the uprooted tree of the most durable species will ~~disintegrate~~ deteriorate and finally disappear. The only evidence of its existence will be the mound and pit thus formed, and given enough time lapse, these in turn will vanish. As a result, the longer the time span since the uprooting, the more difficult it is to document the process responsible for the mound and pit.

Fig. M-H-1. Young mound and pit. Hemlock tree, 22 inches d.b.h., uprooted in June, 1953 by a tornado. Photo taken within 24 hours after the uprooting occurred. Note shape of root mass and incorporated material. It is rather flat, being much broader in one plane than the other. This hemlock tree was quite shallow rooted.

naturally!

The mounds and pits of uprooted trees possess general characteristics that are related to their origin, and which can be observed without intensive excavation.

1. Form:

The typical mounds and pits created by the uprooting of trees possess forms which are peculiar to their origin. Many variables influence the forms assumed by the mounds and pits of uprooted trees, degree of slope of the forest floor, form of the root system of the toppled tree, the soil, species and size of the uprooted tree, physical condition of the tree when it went over, and the age of the mound and pit, to cite only a few of the major variables. Since only the gross aspects of form are to be considered at this time, the discussion will be confined to two of the major variables: the degree of slope, and the soils, which are extremely bouldery in texture. These two variables are apt to exert extreme influences upon the external forms of the mounds and pits.

Mound and pit No. 35 resulted from the uprooting of a white pine tree in 1815 (Fig. M-H-2). The mound and pit were 137 years old when sectioned. The uprooting occurred parallel to the contours, the slope being rather moderate, amounting to ~~about 3 feet vertical rise in 10 feet horizontal distance~~, or 30 percent.

When viewed from above, the mound has an oval or egg shape. It is about 12 feet long and 10 feet wide. Even on this percent of slope the mounds are usually broader on the downhill end. The pit is ordinarily situated next to the mound on the side opposite to the direction of tree-fall. The pit tends to be hemispherical or crescentic in shape, and its long axis is usually closely aligned with that of the mound. It is about 9 feet long and 4 feet wide.

Fig. M-H-2

When viewed from the downhill end, the relative relief and forms of the mound and pit can be observed. The profile was constructed through the lower third of the mound at a right angle to its long axis. The vertical difference in relief between the mound and pit is approximately 15 inches. The profile of the mound is that of a smooth curve, and is practically symmetrical, the sides extending from its crest being almost identical in length and slope. The pit is relatively shallow with a slightly concave surface where this particular profile was constructed. It would tend to be more bowl-shaped as the section approached the central portion of the long axis of the pit.

A bench-like form is created in the slope by the mound when it is viewed from the side opposite the pit and parallel to the long axes. The break in slope thus formed is about 11 feet long. The manner in which this mound and pit contribute to the microrelief of the forest floor is demonstrated by Fig. M-H-3, and mound and pit No. 35 delineated by the 6-inch contour map of 1952 (Fig.).

Another 137-year-old mound and pit are shown in Fig. M-H-4. A white pine tree was uprooted in 1815, falling downhill or at a right angle to the contours. The slope is somewhat steeper than the previous one, being about 5 feet vertical difference in 10 feet horizontal distance.

The same relationship exists between the mound and pit in regard to position as with the previous mound and pit. The pit is on the side of the mound opposite to the direction of tree fall. The same shapes persist in general, oval and hemispherical for the mound and pit respectively. However, due to the force of gravity, the long axis of the mound tends to be at a right angle to that of the pit, instead of being oriented in nearly the same direction, as was the case of the mound and pit on the lesser degree slope.

Fig. M-H-3. Mound and pit No. 35, 137 years old. Profile constructed through lower one third of mound at a right angle to its long axis. Pit is to the left of the mound.

This feature tends to be a characteristic of mounds and pits of this age class and older, which occur on rather steep slopes. As can be expected, the mineral material moves down hill. A trail of debris is formed, which also creates an elongated form of mound. The mound, therefore, is apt to be narrower on its downhill end.

A decided difference may be observed between the general shape of the profile of this mound and pit pair and that of the other. The rounded surface of the mound resembles an askew curve. Its form is definitely asymmetrical, the downhill side extending from the crest being much longer and having a different degree of slope than the opposite side. The sides of the pit are also at more acute angles.

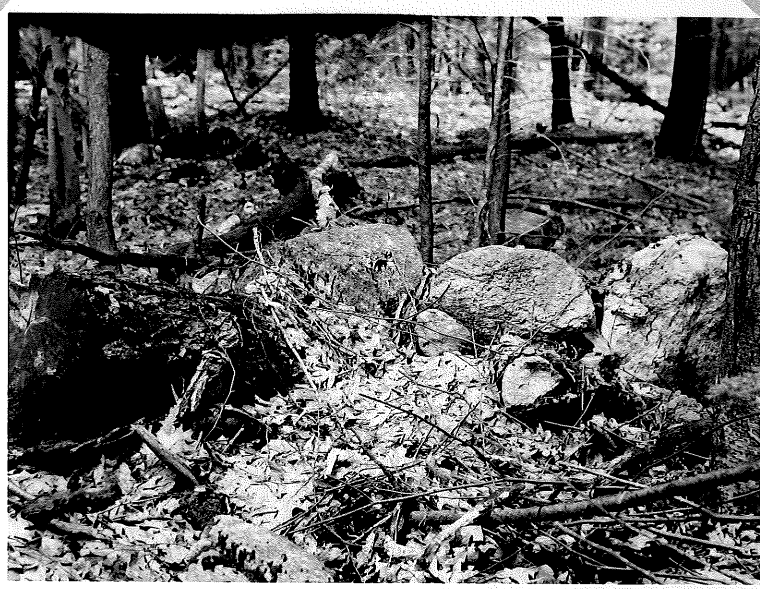
Even a more decided break in the slope is created by this uprooting. In addition to a bench being formed, there is a marked depression. A convex-concave surface has resulted. Fig. M-H-5 depicts the relationship that this microrelief assumes with that of the surrounding surface.

The general forms of what might be considered typical mounds and pits are exemplified by these two examples of uprooting. Both originated with the toppling over of live white pine trees which were comparable in size. Both uprootings occurred in 1815. The soils of each local area are very similar. The major differences concern the degree of slope on which the trees were located, and the direction in which they fell related to the contours. Many variables contribute to the forms of the microrelief created by the uprooting of trees. Nevertheless, the forms of most mounds and pits resemble the basic ones presented by these two uprootings.

One extreme of mound and pit form results when trees are uprooted on very coarse soils, especially when boulders are abundant. The extremely

Fig. (A-H-4) Diagram of mound and pit "A"

Fig. M-H-5. Mound and Pit "A", 137 years old. Profile constructed through southern one-third of mound parallel to direction of tree-fall.



not convincing

Fig. M-H-6. A linear arrangement of boulders resulting from the uprooting of a red oak sprout clump in 1938. The pit is not apparent from this position, but is shallow and barely perceptible from the other side.

bouldery surface delineated on the current research area by Fig.   is an example. Mounds created by the toppling over of trees on such surfaces are very apt to be nothing more than an elongated pile of boulders and stones (Fig. M-H-6). A complementary feature resembling a pit is often lacking in these cases. The arrangement of the boulders and stones constituting the mound, however, is often indicative of the process responsible. The boulders are frequently on edge and arranged in an arc. On steep slopes of talus or coarse soils developed in situ, neither a mound or pit may be formed by up-rooting. The boulders and stones on and in which the uprooted trees were growing, are displaced considerable distances down slope at the time of the disturbance. Such instances of recent uprootings have been observed in the Smoky Mountains and repeated in the Appalachians of West Virginia and the mountains of Cape Breton, Nova Scotia.

2. The Occurrence of Mound and Pit Pairs:

The fact that mounds and pits of uprooted trees commonly occur in pairs, an elevation and a depression arranged in juxtaposition, assists in the documentation of their origin. The 6-inch contour map, Fig.   , verifies this fact. Most of the mounds and pits occur as pairs. It is difficult at this time to conceive of any other natural process which results in the formation of paired elevations and depressions on the forest floor. Burrowing animals might present a major exception.

3. Orientation of the Mounds and Pits:

The orientation of the long axes of the mounds and pits may also provide a clue to their origin. If, for example, a preponderance of the elevations and depressions on a local area tend to have their long axes aligned within a few degrees of the same direction (Fig. M-H-), the possibility is immediately suspected that they are the result of uprootings. In extreme instances, further reasoning based upon additional observations might suggest that the elevations and depressions originated at the same time as the result of severe winds, possibly those of a tornado. Such reasoning cannot be extended too far, however. On limited areas, the blowdowns of strong winds tend to be oriented in the same direction, or nearly so. The blowdowns of the same storm when observed over a larger area may be oriented in radically different directions.

A knowledge of the prevailing winds, especially those of the strong seasonal variety, and the paths of past hurricanes assists in accounting for the particular orientation of elevations and depressions on the forest floor. The same is true of the recognition of the fact that trees growing on rather steep slopes commonly fall downhill when uprooted. Also, a large tree when toppling over may uproot a smaller tree in a direction which deviates as much as 90 degrees from the bearing that it fell. All of these possibilities and more must be taken into consideration when an attempt is made to use the orientation of the long axes of elevations and depressions on the forest floor as a criterion of origin.

Orientation is at best only suggestive evidence. The range of magnetic bearings of the long axes of the 1938 uprooting mounds and pits on the current research area was approximately 220 degrees. Nevertheless, orientation as a criterion, evaluated with the other recognized characteristics of mounds and pits of uprootings, lends credence to the conclusions derived.

4. Trees Growing on Mounds:

Trees growing on uprooting mounds often afford characteristics which may be employed to determine the origin of the elevations upon which they are situated.

The relative position of the root collar region of the tree in respect to the general level of the forest floor is one of these criteria. This relationship is demonstrated by Fig. M-H-7. Here a large black birch tree, approximately 135 years old, is growing on top of a mound that originated in 1815. The root collar region of the tree is about 4 feet vertical distance above the general level of the forest floor. The tree is perched several feet above the ground by a mass of roots.

Trees of this size, 1 to 2 feet in diameter, are not commonly found growing in this extreme position on uprooting mounds. They are definitely the exception. Not a tree of this peculiar growth, form, and size, was present on the current research area where over 60 pairs of mounds and pits were involved. On four or five acres immediately surrounding the area, however, 5 such trees were found. Trees, 10 to 15 years old, perched on the crests of 1938-blowdown mounds are an extremely common observation, though.

The form of the root systems developed by trees which are perched on mounds, seemingly quite precariously, is also indicative of the origin of the microrelief on which they are positioned. The root systems of mound-perched-trees are apt to develop a form which approaches that of the elevation on which they germinated and became established years ago. The forms approximates those of the original masses of mineral and organic material held in suspension by the root systems of the toppled trees. As a result, a unilateral root system is developed by the perched trees (Figs. M-H-7 and M-H-8). These photographs were taken at a right angle to one another, one from the north, the other from the east. That part of the exposed root system is quite narrow when viewed from the east, while from the north, it is very broad. The upper part of the root system has developed more in one plane than the other. This is consistent with expectations

Fig. M-H-7. Mound and pit "B". A 135-year-old black birch growing on a mound which originated from the uprooting of a white pine tree in 1815. The root collar region of the tree is perched approximately 4 feet above the general level of the forest floor. Note also the mineral material in the root system immediately above the snowline, especially the rock fragment suspended by a root above and slightly to the left of the camera case. Photo taken from the north.

Fig. M-H-8. Mound and pit "B" when viewed from the east or at a right angle to that of Fig. M-H-7. Note how thin the exposed root system is in this plane in contrast to the proportions presented in the other plane.

since the shape of the original mineral and organic mass provided by the white pine tree that was uprooted in 1815 was undoubtedly flat or broader in one plane than the other. The presence of coarse mineral materials suspended in the large roots above the forest floor verifies the fact that at one time the younger surfaces of the mound were much higher than its present ones. Over time, the mound has diminished in height. The presence of the coarse mineral materials incorporated in the exposed upper portions of the root systems also eliminates the possibility that similarly perched trees originally became established on old stumps and prostrate tree boles.

Trees are much more commonly observed growing on the lower portions of mounds than in perched positions on the crests. The form of the lower boles of trees growing on the sides of mounds is often of diagnostic value in regard to the origin of the elevations on which they are positioned. The lower boles frequently are curved.

The series of photographs represented by Figs. M-H-9, -10, and -11 presents examples of the manner in which the curves develop in the lower boles of some trees which are growing on the sides of mounds. Fig. M-H-9 depicts several young black birch trees which had become established on the sides of a 1938 blowdown mound. The largest of these black birches was excavated and is shown in Fig. M-H-10. Its age is 12 years, which places the date of its origin as 1939, or the first growing season after the hurricane of September, 1938. A 95-year-old black birch tree growing on the side of a mound is shown in Fig. M-H-11. The mound dates back to about 1850, so the black birch became established approximately 6 years after the uprooting occurred. The characteristic sweep in the lower bole is very apparent.

The curves or sweeps in the lower boles of these trees might be accounted for in several ways. The instability of the surfaces of young mounds is one

Fig. M-H-9. Several young black birch trees growing on the side of a 1938 blowdown mound.

Fig. M-H-10. The largest of the black birches pictured in Fig. M-H-9 after it was excavated. Note curvature of lower bole.

means of explaining the curved boles which frequently characterize such trees. The surfaces on which the young seedlings had germinated and become partially established either slumped or eroded, causing the trees to lean. The ensuing surfaces were stable enough to permit the trees to re-establish themselves securely, during which time the trees righted themselves again assuming a vertical position. The resulting curvature created by the differential in growth rates between the upper and lower sides of the bole (Went and Thimann,) persisted, however.

Another manner in which the sweep in the lower boles might be acquired is based upon the same principle. Only in these instances, small trees are actually picked up in the root mass of the toppled tree and are rotated through several degrees and then left in a horizontal or leaning condition. Here again, the differential in growth rates created by a greater concentration of hormones in the undersurfaces of the boles causes the trees to straighten up. A sweep in the boles is thus formed. Observations indicate that the curvature persists throughout the life of the tree.

There are other means by which sweeps may be formed in the lower boles of trees. Snow and ice accumulations, sheet erosion, the weight of fallen trees, to mention a few. Therefore, all trees possessing a curvature in their boles did not necessarily originally become established on the side of an uprooting mound. However, this criterion in support of other characteristics of origin contributes authenticity to interpretations.

5. <u>The Depth of Organic Accumulations on the Surfaces of Uprooting Mounds and Pits, and its Degree of Incorporation with the Mineral Soil Components:</u>

The mounds and pits of uprooted trees represent local areas of soil disturbance. Radical derangement of the soil profile to depths of 3 feet is

Fig. M-H-11. A 95-year-old black birch tree growing on the side of a mound that originated around 1850. The tree has the characteristic sweep in its lower bole.

common in this part of New England. Uprooting mounds and pits in this region have profiles which are peculiar to their origin, and which may maintain their identity for at least 500 years. The observation of soil profiles to depths of several feet requires extensive excavation. The uppermost strata of these profiles, however, may be observed quite readily, especially the A_{oo}, A_o and A_1 subhorizons. Fortunately, these organic layers provide criteria which may be used to assist in the identification of those mounds and pits created by the uprooting of trees.

The value of the A_{oo}, A_o and A_1 horizons as criteria is based upon the fact that the longer the soil forming processes have been permitted to function without interruption in a given soil medium, the better developed are the horizons within the profile. That the profile of a soil which was disturbed by uprooting 50 years ago is not as well developed as one that was deranged in a comparable manner 100, 200 or 300 years ago is compatible with our knowledge of the soil forming processes.

A cursory survey of the profiles of those mounds and pits less than 350 years old, included in the following pages, reveals a striking difference in the development of the organic layers across the surfaces of the sections. One of the easiest differences to observe is in the combined depth or thickness of the A_{oo}, A_o and A_1 subhorizons. The thickness varies between the mounds and pits of individual pairs, between the mounds and pits of different pairs, and between the mounds and pits and the relatively undisturbed surfaces of the sections beyond the peripheries of the uprootings.

As would be expected, the pits are areas of greatest organic accumulation. Almost any depression in the forest floor, regardless of origin, would tend to function as a reservoir for organic debris. Also as expected, the mounds have a lower potential for the collection of litter on their surfaces.

This difference in the thickness of the organic layers which exists between the mound and pit of a single uprooting is related primarily, perhaps, to the shapes of their surfaces. However, the combined depths of the A_{oo}, A_o, and A_1 subhorizons also vary between mounds and pits of different uprootings. These variations would tend to be related primarily to the differences in the ages of the uprootings. The older the mound and pit, the better developed are the organic layers. Even greater differences are observed when the surfaces of the relatively undisturbed areas surrounding the mounds and pits are used as bases of comparison. Again the function of time would appear to contribute in large measure to these variations. The amount of time that has elapsed since the surfaces represented by the mounds and pits were disturbed ranges from zero to approximately 350 years, while the areas adjacent to the mounds and pits may not have been disturbed by uprooting for a thousand years or more.

These differences in the development of the organic layers are readily observed in the field and serve as criteria for recognizing local areas that have been disturbed by uprooting in the recent past. They therefore contribute to the documentation of the origins of the microrelief of the forest floor.

6. Consistency and Texture of the Soil:

The consistency of the soil in the upper surfaces of uprooting mounds may be markedly different from that of comparable horizons in the immediately adjacent relatively undisturbed areas. This is particularly true of mounds less than 350 years old. The difference in soil consistency between the mounds and the surrounding areas was noted particularly during the construction of the 6-inch contour map, and corroborated later by sectioning with deep trenches.

During the course of mapping the contours, thin bamboo stakes about 3/8 of an inch in diameter, the variety used extensively in nurseries, were stuck in the ground to mark the points of equal elevation. The observation was made at this time that the force required to thrust the stakes into the ground varied markedly between the mound surfaces and the adjacent ones. With only slight effort, the stakes could be pushed 6-18 inches deep into the mounds. When the same procedure was attempted on the areas adjacent, the stake usually broke or required much more effort before comparable depths were reached.

Similar observations were recorded during the phases of field-work which dealt with the stumps and trees. In the process of either removing the stumps and trees or conducting exploratory excavations around the base of each, there was ample opportunity to dig in the upper soil surfaces with the bare hands. The soil around and under the bases of those trees positioned on mounds invariably could be removed much easier without the aid of tools than around those specimens which were located on the adjacent, relatively undisturbed surfaces.

The same observation was repeated later when sections 3 to 5 feet deep were dug across the mounds and pits and into the adjacent areas. The sides of the section walls tended to slump in the region of the mounds and pits while the surrounding wall surfaces remained longer intact.

The texture of the soil, especially the presence of boulder and stone-size components, varies considerably between the mounds and pits of individual pairs. There is a general tendency for a sorting-out of soil particles as they fall from the uprooted portions of the root mass, the coarser particles falling first. There is also a tendency for the coarser particles to fall back into the pit region of the disturbance from which they came originally. As a result, the pit region is apt to contain coarser mineral material than that of the mounds. These differences can be ascertained quite readily by thrusting thin sticks vertically into their upper surfaces or by shallow excavation.

Here again, soil consistency and texture cannot be used as absolute criteria of origin, but their observation assists in making decisions while conducting cursory surveys which will not permit extensive digging.

7. The Presence of Prostrate Tree Boles:

Given enough time, the organic mass of an uprooted tree will decompose and eventually disappear. It loses its identity. Also, given enough time lapse, the mineral and organic masses representing the mounds and pits will ~~also~~ lose their identity. A comparison can be made of the relative rates at which these two kinds of evidence of uprooting, the toppled, prostrate trees and the mounds and pits, actually are erased from the forest floor. In general, the identity of the mounds and pits will persist for a longer period than that of the prostrate trees. In this region, the boles of trees 2 to 3 feet in diameter will remain in a recognizable state on the forest floor for 100 to 150 years. The mounds and pits created by the uprooting of comparable trees will persist for at least 500 years.

There is a time span of over a hundred years during which the mounds and pits and the trees which were uprooted are contemporaries. The presence of these prostrate boles, therefore, may serve as criteria to assist in the determination of the origin of elevations and depressions of the forest floor. There is every indication to believe that the trees on the current research area that were uprooted during the last 150 years had been salvaged. However, other areas have been observed where the toppled trees had not been salvaged. It was not uncommon to see ridges of organic material extending along the forest floor. Many such linear-shaped masses of organic matter originated from well-defined mounds of mound-pit-pairs. Immediately, the elevations were suspected of being mounds of uprooted trees. Further observations corroborated this belief.

The mounds and pits of uprooted trees possess gross characteristics which are peculiar to their origin, and which can be observed with or without slight excavation. These features may therefore be used as criteria for determining the origin of elevations and depressions of the forest floor. Uprooting mounds and pits undergo constant changes, especially during the first 350 years of their existence. As a result, very seldom, if ever, are all of the gross, rather superficial features present in any one mound and pit pair at the same time. Consequently, it behooves the researcher to take advantage of all of the evidence that happens to be available at the time the decisions must be made.

Gross Characteristics of Elevations Due to Boulders Immediately Below the Surface of the Forest Floor:

In many regions, especially those which have been glaciated and where very coarse till litters the landscape, the surfaces of localized areas may be dominated by boulders. The hatched portion of Fig. represents an area of boulder concentration on the current research plot. ~~The surface of the entire plot is quite liberally sprinkled with boulders.~~ Fig. M does not show those boulders which were immediately below the surface of the forest floor. Several of these latter boulders formed mound-like elevations.

The origin of such elevations ordinarily can be easily determined by simple excavation along their extremities. Sometimes, jumping vigorously up and down on them is all that is necessary. The presence of a large boulder imparts a degree of firmness to the elevation that an uprooting mound usually would not have.

The presence of trees perched on these mound-like expressions also provides a diagnostic feature. The roots which are quite often exposed on the surfaces have tended to grow around the boulder, developing a form quite unlike those roots of trees which are perched on uprooting mounds.

Gross Characteristics of Elevations Around the Bases of Large Trees Due to Root Growth:

The elevations created around the bases of large trees contribute to the problem of ascertaining the origin of the microrelief of the forest floor. The eccentric radial growth of some tree roots (Büsgen and Münch, 1929), where the radial growth toward the soil surface is greater than in the opposite direction, tends to push the soil upward so as to form an elevation. The general appearance that may be created is of a tree growing on the upper surfaces of a mound. This characteristic is especially applicable to large white pines.

The origin of the elevations due to root growth is extremely difficult to document when confining observations to gross characteristics. It is perhaps the absence of evidence that assists the most in deciding about the origin of this type of elevation. The form of the mound, the absence of a pit, no sweep in the lower bole of the tree, the form of the exposed portions of the root system, the degree of development of the organic layers on and around the elevation, are the major features which provide the bases for comparative analysis.

Gross Characteristics of Elevations and Depressions Due to Tree Stumps in Various Stages of Decomposition:

The microrelief of the forest floor is contributed to by elevations and depressions which are related to tree stumps in various stages of decomposition.

Stumps, the aerial portions of which have almost completely disintegrated but still barely protrude above the level of the ground, create elevations on the forest floor. The relief of such elevations is often increased by the presence of roots and by partially decomposed organic debris. The result is a realistic mound, one which might be confused with that created by uprooting. The recognition of elevations due to stumps is usually quite easy, especially when no large, live trees happen to be growing on their surfaces. Minor excavation will ordinarily expose rotten wood. If the wood is not covered with mineral soil, and if the grain of the wood tends to assume a vertical relationship with the ground, an old stump is strongly indicated.

Depressions are formed in the forest floor where stumps have rotted away to depths below ground level. When stumps 2 to 3 feet or more in diameter reach this stage of decomposition, definite depressions may be created. This phenomenon is especially significant on slopes where step-like forms may result. The surficial features of these concavities in the slope resemble very closely the convex-concave forms resulting from the uprooting of trees. Shallow excavations may expose wood of the stump, the grain of which might either be vertical or curved to conform to the general shape of a root. The possibility exists that mineral material may be deposited in the depressions, particularly on slopes, which tends to conceal even more the true origin of the pit-like expression. Another alternative exists that the wood excavated is part of a root which might have grown in the mineral soil, and is surrounded by a medium of mineral matter. In such instances, a section dug through the depression will often reveal at depths of 2 to 3 feet or more the existence of root channels or actual roots, the presence of which surely indicates the remnants of an old stump.

Gross Characteristics of Elevations Due to Prostrate Tree Boles or Parts Thereof:

Prostrate tree boles or parts thereof also produce mound-like expressions on the forest floor. In this region of New England, after tree boles have lain on the ground for a hundred years or so, they tend to flatten out and create elevations which contribute to the microrelief. Live trees are often observed growing on such accumulations of organic matter. Leaves and other forest litter also camouflage the origin of these elevations.

As with the microrelief related to stumps, shallow excavation will usually expose wood in various stages of decay. In the case of tree boles, however, the grain of the wood is oriented parallel to the surface of the forest floor. In addition, the presence of wood is limited to one plane, that above the surface of the ground, in contrast to stumps, the wood of which has depth extending into the mineral soil.

The roots of trees growing on decomposed prostrate boles also may have diagnostic value. The roots are inclined to follow the organic matter provided by the tree bole. As a result, the form of the root system approaches that of the organic medium in which it is growing. The roots are apt to be concentrated on either side of the root collar extending along the length of the log. This is particularly characteristic of small hemlocks and black birches 2 - 6 inches in diameter.

When the forest floor is investigated to the intensity of 6 inches difference in vertical distance, many problems arise concerning the origins of the microrelief. In many instances, the origins of elevations and depressions are at once apparent. There are at the same time a large number of local areas the microrelief of which is not immediately explainable. The local area on which trees number 330 and 331 were growing may be cited as an example. The field notes which were recorded during an earlier phase of the investigation describe the situation as follows:

> #331 - hemlock tree - about 21 inches d.b.h. Appears to be growing on a mound. This tree has large lateral branches extending down to within 10 feet of the ground. More or less indicates the tree might have grown under open forest conditions during its life. Crown is very broad, 50-60 feet in diameter. Tree is in dominant crown class. Crown is quite free of branches on northern side up to about 40 feet above ground. Hard to imagine the two red maples growing on that side within about 15 feet could have had that much effect upon its crown development(?) Was there another tree nearer at one time and evidence of it has completely disappeared?
>
> Digging around base of this tree exposed the following: largish rocks underneath tree which could account for a part of the mound-like appearance. Around the base of the tree on the south, east and northern sides are heavy accumulations of organic matter. However, immediately under a rather thin layer of organic debris on the westerly and northwesterly sides is very fresh mineral soil. Where organic layer on other sides might be a foot or more in thickness, on this side it is only 2-4 inches thick, and then one immediately exposes fresh mineral soil. Under this mineral soil and also under the roots of this hemlock tree was found quite an accumulation or amount of wood. One piece, quite sound yet, looks like white pine. The question is - how did fresh mineral soil get on top of this old wood? The configuration of grain in old wood indicates it to have been from the base of the tree. About the only way one could account for this phenomena is from an overturned tree. This large hemlock could have grown on an old white pine stump as many do, but this would not account for the occurrence of mineral soil on top of the wood.
>
> There was also, immediately under the roots of the hemlock, an abundance of charcoal present in small pieces. The tops of the boulders upon which this tree

is growing can be exfoliated quite readily in small pieces. Would a fire have made this rock-surface more subject to disintegration?

Tree #330, a 4-inch hemlock situated within 2 feet of #331, has a definite largish root extending up and into where this mound appears, quite like growing on the side of a slight elevation. The tree is situated on a boulder, but this root is not touching it at all - perhaps 2-3 inches clearance. No mineral soil here at all, just organic matter and some charcoal in very small quantities.

Pit of mound is not very noticeable. Rocky sitution could account for this. Area of organic accumulation seems most logical for pit region.

Question - did fire or fires occur before or after upturning of tree or both? Observations:

1. No indication of fire on present tree boles or roots.
2. Charcoal immediately under roots on surfaces of boulders.
3. Present organic accumulations show no evidence of having been burned.
4. Old wood under tree shows no signs of fire.

From present evidence it would appear that fire occurred after uprooting, but before hemlock tree had become established.

Unneeded?

#330 - small hemlock - 4 inches d.b.h. - suppressed, forest grown form. Refer to #331 for details.

The preceding description is an almost verbatim account as recorded in the field.

The information available at the time of the aforementioned description indicated that the two hemlocks were growing either on a mound of an uprooted tree or on an old stump that had deteriorated almost to ground level. The concentration of wood alone, especially since the wood was confined to a local area and had depth below the present surface of the forest floor, suggested that a tree once grew there. The primary question seemed to concern what had happened to the tree.

The presence of fresh mineral soil, the mineral material usually associated with the lower B and upper C horizons, on top of the buried wood suggested uprooting. The possibility existed however, that the wood collected was from a root that had grown in the soil, hence, it would be surrounded by mineral material anyway. The fresh appearance of the soil, though, still indicated disturbance.

The variation observed in the thickness of the organic layers around the base of the large hemlock also suggested a mound and pit. A comparable condition could have developed from an old stump without uprooting, except for the presence of fresh mineral soil so close to the surface.

The charcoal, if anything, contributed to the confusion. What it seemed to indicate was that the present hemlock trees became established after the fire which produced the charcoal. This conclusion was substantiated by the lack of evidence of fire scars on the present trees. The fact that the buried wood showed no evidence of having been burned might only indicate that the outer rind of a stump had been charred, or only its aerial portion. The easily exfoliated surfaces of the boulders on which the larger tree was growing also led to the conclusion that the fire had occurred before the hemlock entered the scene.

The smaller hemlock tree growing within 2 feet of the larger one also had a story to tell. One of its larger roots had grown upward at a very perceptible angle and into the side of the slight elevation on which the larger hemlock was located. The root was now suspended in mid-air with no organic or mineral matter touching it from a few inches of where it originated until it entered the ground almost a foot and a half away. Roots ordinarily do not grow at such an angle unless there is a medium present of organic or mineral material or mixture thereof. Therefore, it would seem a safe assumption that at one time during the earlier life of the small hemlock such a medium was available for its roots to penetrate. The shape of the root strongly indicated that the medium was provided by the mound of an uprooted tree and not by the organic matter of a decomposed stump.

The boulders and rockiness of the local area also contributed information. While digging around the base of the larger hemlock, it was observed that many of the boulders were quite easily moved, as though their present positions had been acquired in the not too distant past; or as if they had settled only recently from a disturbance.

The preponderance of the information available at the time of this preliminary survey indicated a mound and pit of an uprooted tree, even though the microrelief was barely perceptible. Information derived later concerning the ages of the trees, ages of neighboring mounds and pits and their orientation, and other background facts of general information, all corroborated the conclusion that the two hemlocks, #360 and #361 were growing on an area that had been disturbed by the uprooting of a tree. Thus it was in this manner that each feature of the microrelief was studied. An attempt was made to take advantage of all of the information that was available at the time.

Only the gross criteria of origin were employed during the preliminary survey of the microrelief. However, it was necessary to use all of them at some time or another. Actually, the major objective of the preliminary survey was to delineate the microrelief which should be investigated more intensively later. Therefore, decisions regarding origin could be put off until a later phase of the study. Nevertheless, it would be a decided advantage if the number of "problem areas" could be limited to those elevations and depressions the origins of which had been reasonably assured to be related to the uprooting of trees. Effort could be concentrated then on a fewer areas, thus enabling a more intensive exploitation of the information that they could provide.

The preliminary survey exposed 64 local areas that warranted further investigation. Of these, 18 were mounds and pits that had been created by the hurricane of 1938. Their origin was so apparent that it was only a matter of collecting the evidence that they had to offer. The remaining areas, many of which looked most certainly to be mounds and pits of uprooted trees, required further investigation before their origin could be completely documented.

Final Survey of the Mounds and Pits of Uprooted Trees: The Documentation of their origin, the determination of the species of trees that were uprooted, the collection of buried charcoal and pollen, and the description of their soil profiles.

The preliminary survey revealed 64 local areas of microrelief that probably were mounds and pits of uprooted trees. The next phase of the investigation was devoted to a more intensive study of these mounds and pits.

The origins of the majority of the elevations and depressions designated by the preliminary survey still had to be documented. Then, those elevations and depressions which were definitely established as uprooting mounds and pits had to be studied further. The buried wood, pollen, and charcoal that might be incorporated in the mounds had to be collected. Finally, it was necessary to describe the soil profiles of the mounds and pits. The latter was essential to help determine the relative ages of the uprootings.

The Morphology and Gross Anatomy of Mounds and Pits of Uprooted Trees:

Ten mounds and pits, seven on the current plot and three within 100 feet to the south of it, were selected for intensive investigation. They were considered typical of the other mounds and pits in regard to their surficial features. Sections were excavated through the mounds and pits either at a right angle to their long axes or parallel to the direction of tree fall. The sections ranged from 2 to 7 feet in depth and from 10 to 22 feet in length.

The profiles of the cross-sections were described using color, consistence, and texture of the soil as criteria. The Munsell Color Charts were employed for color designations of the freshly exposed soil horizons. Consistence was determined by the degree to which the soil components either resisted excavation by the bare hands, a knife, shovel or pick, or tended to slump from the vertical walls of the profile. Texture was computed by rubbing the freshly exposed soil between the fingers or in the palms of the hands. The sections were profiled to a scale of one foot to the inch.

In spite of the multitude of variables involved, the mounds and pits of uprooted trees have morphological and anatomical features which are not only peculiar to their origin but also to their age.

1. Mound and Pit No. 1: A cross-section of mound and pit No. 1 is illustrated by Figures M-H-12, 13, 14 and 15. The mound and pit resulted from the hurricane of 1938 when red oak No. 25, consisting of two boles 10 and 7 inches d.b.h. and 53 years old, was partially uprooted. The disturbance occurred on relatively level ground, the tree falling in a northwesterly direction. If the assumption is correct that the red oak originally had been in a vertical position, the boles of the tree passed through an arc of approximately 60 degrees when they fell. The soil is a Jaffrey gravelly fine sandy loam of glaciofluvial origin (Simmons, 1939). The upper 2 to 3 feet of the soil on this local area was free of cobble size particles, and only an occasional pebble 2 to 3 inches in diameter was present. The red oak was salvaged in 1939. The cross-section was constructed through the western two-fifths of the mound and pit at right angles to their long axes. The age of the mound and pit was 14 years when the section was dug.

A. Morphological features: The features of form and structure are essentially those of a mound and pit in the early stage of development. The general surface is characterized by a marked difference in relief between

Fig. M-H-12
Mound + Pit No. 1
Cross Section

Fig. M-H-13. Mound and pit No. 1. Northwestern portion of profile.

Fig. M-H-14. Mound and pit No. 1. Central portion of profile.

Fig. M-H-15. Mound and pit No. 1. Southeastern portion of profile.

the lowest level of the pit and the crest of the mound, the difference in elevation being 2.2 feet over a horizontal distance of 2.0 feet. The outline of the surface is definitely angular and quite asymmetrical. The stump of the uprooted tree is still present and almost intact. The smaller roots of the exposed root mass have rotted away, while the larger elements have persisted and still hold in suspension an appreciable amount of mineral and organic material above the ground.

The face or profile of the exposed section can be separated quite readily into two general areas. The horizontally hatched and stippled portions of Figure M-H-12 are regions where relatively little or no disturbance resulted from the uprooting. They occur at the extreme ends of the section and at depths below the influence of root pull. The angular hatching and stippling denote regions of disturbance. The same distinctions can be made in Figures M-H-13, 14 and 15. That portion of the cross-section with the smoother, firmer walls is the relatively undisturbed region, while the loose, slumping walls characterize the disturbed region.

B. Gross anatomical features: When color, consistency and texture of the soil are employed as criteria, the gross anatomical features of mound and pit No. 1 (Fig. M-H-12) become apparent. The profile may be separated into four general regions: region of relatively little or no disturbance, region of deposition, region of pivot, and the region of overburden potential. Each of these general regions, in turn, can be divided into smaller units.

The region of relatively little or no disturbance, ~~as before,~~ occurs at the extreme ends of the section and at a depth generally below the influence of root pull. It has the appearance of a normal soil profile, the horizons of which are quite smooth with rather clear boundaries. The A horizon is represented by units Nos. 1 and 1A; the B horizon by units Nos. 6, 7, 8 and 9; while unit No. 10 constitutes the C horizon. That the profile across the entire length of the section resembled that of this region before the uprooting in 1938, would appear to be a reasonable assumption.

The region of overburden potential is one of soil disturbance. It is that mass of mineral and organic matter incorporated in the roots of the toppled tree. Its existence in its present state is dependent primarily upon the facts that the uprooting is relatively young, having occurred only 14 years ago, and that the red oak tree was only partially uprooted. Eventually, the mineral and organic material which is now being held in suspension by the root mass will become disengaged and slump to the lower surfaces. At the present time, however, this region resembles the region of no disturbance, a major exception being that the horizons have been tilted and left at a perceptible angle. Even so, the upper horizons of the overburden potential are still continuous with similar horizons in that part of the undisturbed region which is contiguous and to the northwest or leeward side. The units comprising the overburden potential are: Nos. 1, 1AP, 6P and 8P.

The region of deposition is represented by that portion of the section which has been most severely disturbed, at least up to the present time, by the uprooting. It comprises the pit side of the mound, the pit proper, and the area directly underneath the pit which extends down and into the region of relatively little or no disturbance. The appearance of this region is that of general disorder, of horizon discontinuity. Root pull, mass dislocation of mineral material, and subsequent deposition are primarily responsible for the present condition of derangement. It is this region of mound and pit No. 1

that offers the least resistance to excavation but at the same time will not support a vertical wall due to its slumping tendencies.

No true genetic horizons are present in the region of deposition. The region is divisible into 5 units: Nos. 3, 5, 1A, 1B, and 1. Units No. 3 and No. 5 may be considered as the basic parts. Unit No. 1A, in the pit, is a remnant of the A_1 and A_2 subhorizons of the pre-disturbed profile which is still evident in the undisturbed region. That portion of Unit No. 1 which overlies the pit proper is late organic accumulation, while No. 1B is a small deposit of leached mineral material that has fallen recently from the suspended A_2 subhorizon in the overburden potential.

Unit No. 3 has resulted primarily from root pull. The disturbance associated with this area occurred immediately before and shortly after the uprooting. Only the upper extremity of this unit, if that much, has been directly influenced by subsequent deposition from above. The dislocation of mineral material by root pull followed by local slumping into the root channels are primarily responsible for the characteristics associated with this unit. Since the disturbance was essentially local with little deposition involved, it would appear that this unit, No. 3, originated primarily from Unit No. 9 with No. 10 also contributing a minor portion. The general color and the texture of No. 3 are very much like those of No. 9 while its consistence is very loose.

Unit No. 5 is the result of both root pull and deposition. The area under the pit was subjected most to root pull, as evidenced by the fact that a thin layer of Unit No. 1A has retained its original position, even if it has slumped slightly. The larger part of Unit No. 5 that forms the pit side of the mound is the result essentially of deposition over the 14 years since the uprooting occurred. Unit No. 5 originated mainly from Unit No. 8, part of which is still engaged in the root mass. The color and texture of the two units are very much alike. The upper portion of the region of deposition, Unit No. 5, is being added to constantly as portions of the overburden potential slump back into the pit. Unit No. 1B is a vivid example. This small area is the result of very recent deposition. It resembles Unit No. 1A very closely.

The region of pivot, No. 4, is the last major portion of the profile. It also is a region of disturbance, but the factors responsible are quite unlike those of the other two. At the instant of the uprooting, this general region provided the fulcrum or the zone of pivot on and in which the leeward side of the lower tree bole, the stump, rotated through approximately 60 degrees. The disturbance of this region, therefore, resulted mainly from compression and thrust. The amount of thrust is evidenced by the manner in which the horizons of the adjacent units to the northwest have been bent. Units Nos. 8 and 9 of this same adjacent area also appear to have been compressed, their thickness having been diminished considerably. The lower reaches of Unit No. 4 were probably derived from the C horizon or Unit No. 10. The upper extremities of the pivot region might have been contributed to by deposition. The region in general, however, was probably derived from Units No. 8, 9 and 10, and is the result essentially of disturbance in place. The general color and texture of the pivot region resemble those of Unit No. 9 the most. Its consistence is very loose, however, in spite of the pressures to which it must have been subjected.

C. Morphological and gross anatomical features that are of diagnostic value for relative age determination: No chemical or physical analyses required for their observation.

The profile of mound and pit No. 1 possesses characteristics which are peculiar to its stage of development or the length of time lapse since the uprooting. These diagnostic features which can be observed without chemical or physical analyses may be divided into two categories: surficial, those which can be observed without sectioning the mound and pit; and internal, those which require sectioning.

The most pronounced surficial features are the remains of the tree that was uprooted and the marked difference in relief between the mound and pit. The angular shape of the mound is another.

The very obvious presence of four general regions across the length of the profile constitutes a major internal characteristic of mounds and pits of this age class. The regions of relatively no disturbance, deposition, overburden, and pivot, can be readily delineated by the pronounced differences that prevail in their color, consistence and texture. They impart a definite "blocky" appearance to the profile, each region having a different angle of repose. Only at the extreme ends and depths is there a semblance of a normal soil profile.

The relative status of the overburden potential region is also an indicator of age. An actual overburden may be formed concommitant with uprooting. In the instance of mound and pit No. 1, however, no overburden resulted then or since. Not enough time has elapsed.

The discontinuity of the A horizon and the differences that exist in its development across the profile also serve as notable features of age. The undisturbed region is characterized by a well-developed A horizon, the A_2 subhorizon of which, Unit No. 1A, is 2-4 inches thick. The pit proper has only a thin accumulation of recently deposited organic debris, no thicker than that of the undisturbed region. In addition, very little, if any, incorporation of this organic matter has occurred with the mineral soil below. The upper reaches of the pit side of the mound have no organic accumulation. These marked differences in the A horizon are easily observed, and are definite properties of mounds and pits in the early stage of development.

2. Mound and Pit No. 35:

Figures M-H-16 and 17 represent the cross-section of mound and pit No. 35. A white pine tree was uprooted during the hurricane of 1815 and later salvaged. Its diameter at breast height is estimated to have been about ~~two~~ 1.5 feet. The tree fell in a southerly direction roughly parallel to about a 30 percent slope. The soil is a Brookfield stony loam (Simmons, 1939). Pebble-size particles were numerous, and an occasional cobble was present. Underlying the area of the cross-section at depths varying from 16 to 43 inches is a firm-in-place-till (Spaeth, 1938) and (Stout, 1952). This till is difficult to excavate, has a noticeable degree of fissility, and affords considerable resistance to root penetration. A small hemlock tree, No. 413, 2 inches d.b.h. and 63 years old, was growing on top of the mound. The cross-section was dug through the western one-third of the mound and pit at right angles to their long axes. The age of the mound and pit was 137 years when the section was excavated.

A. Morphological features: The microrelief of mound and pit No. 35 may well be considered classical. Its smooth but strongly curved surfaces are those which ordinarily are associated with mounds and pits of uprooted trees. The relief is still pronounced, nevertheless, involving a difference of 1.1 feet in elevation between the lowest part of the pit and the crest of the mound, a horizontal distance of 5.5 feet. The outline of the mound and pit is regular, being almost symmetrical. The lower bole of the uprooted tree is no longer perceptible without excavation, having disintegrated to depths below the mound surface.

The smooth, regular contours of mound and pit No. 35 tend to belie the internal characteristics of the profile. The cross-section has the appearance of derangement. The disturbed portions still can be distinguished readily from undisturbed ones. The horizontal hatching and stippling of Fig. M-H-16 denote areas of little or no uprooting disturbance. This general region occupies the ends of the profile and the depths below the penetration of large roots. The hatching and stippling oriented at an angle designate areas of disturbance. They are confined largely to the central part of the cross-section, the major exception being that small area which forms the lower slope of the leeward side of the mound. Due to major color differences between the disturbed and undisturbed regions, the profile has a decided striped appearance, the bands being broad and oriented at acute angles. This effect is expressed by Fig. M-H-17. Even though definite differences occur in soil consistence across the length of the profile, only minor visual evidence is apparent.

Another very noticeable feature of the profile is the presence of the remnants of a buried A horizon, the upper surface of the soil that had developed prior to the uprooting of 1815. This feature is an integral part of the leeward side of the mound.

Closely associated with the buried A horizon is another distinguishing feature of this mound and pit. Had the cross-section been constructed through the central part of the uprooting instead of the western third, buried remnants of the uprooted tree would have been exposed. Figures M-H-16 and 17 do not reveal this feature, however, further excavation did. The buried remnants in various stages of decomposition occupied an area over a foot in diameter. Due to the organic content, it was very dark brown and of fluffy consistence. Mounds and pits of this age class, when sectioned through the center at right angles to their long axes commonly reveal ~~this property of~~ buried wood.

Diagram of mp 35
Fig. M-H-16

B. Gross Anatomical features: With one major exception, the profile of mound and pit No. 35 can be separated on the basis of soil color, consistence, and texture into the same general regions as that of the 14-year-old profile. The regions of relatively little or no disturbance, deposition, and pivot, are still readily discernible. However, the overburden potential of the younger mound appears as the region of actual overburden in the 137-year-old profile.

The relatively undisturbed region comprises the ends and lower half of the cross-section. It is characterized by true genetic horizons. Units Nos. 1 and 1A constitute the A horizon, Unit No. 8 the B horizon, and Unit No. 10 the C horizon. The boundaries of the horizons within the region are smooth. The upper boundary of Unit No. 10, however, is very wavy under the disturbed regions. The largest undulations occur below the region of pivot. Root pull and thrust probably contributed to this irregularity.

The region of deposition consists of Units Nos. 3 and 5 and segments of No. 1. It constitutes the pit side of the mound and the pit proper, a position comparable to that of the 14-year-old uprooting. The flattening of the mound and the filling in of the pit have resulted in a shift of positions between Units No. 3 and 5. Instead of being superimposed upon No. 3, Unit No. 5 tends to be in juxtaposition with it and almost in the same plane. This region of deposition, therefore, has a more elongated form than its counterpart in the younger profile.of mound and pit No. 1. Also, its angle of repose is more nearly approaching the horizontal.

The upper half of Unit No. 3 is characterized by more particles of pebble and cobble-size than the lower half. At the same time, it also has more coarse components than Unit No. 5. The components of an overburden potential react to gravity in somewhat the same manner as the talus of steep slopes; the larger fragments tend to be displaced farther downhill than the finer. As a result of this sorting process, the pit proper, or Unit No. 3, is surfaced with an accumulation of coarser particles in a matrix of organic and finer mineral materials. A comparable textural relationship tends to prevail between the upper and lower portions of Unit No. 5, only the size of the particles involved is not as large.

Unit No. 3 is also characterized by a thick accumulation of organic debris, much of which has become incorporated with the mineral particles below. The pit side of the uprooting, Units Nos. 3 and 5, is truly a region of deposition in mound and pit profiles of this age class. Its general properties are strongly influenced by the major process involved, deposition. There is a definite sorting of components according to size. Its consistence is loose. The color and texture of Unit No. 3 are more nearly like those of Unit No. 8, while the same properties of No. 5 are more similar to those of No. 10.

The region of pivot in the 137-year-old profile is practically in the same relative position as that of the 14-year-old section. It comprises the major bulk of the leeward side of the mound and approximately the upper one-third of that surface. Its long axis is almost vertical. The region of pivot is essentially one of local displacement. The change in status of the overburden potential, however, has altered the region of pivot somewhat. Its upper reaches are now influenced by the slumping and subsequent deposition of the components which had been incorporated in the root mass of the toppled tree. Consequently, the upper part of the pivot region has a slightly more disturbed appearance. In general, Unit No. 4, or the pivot region, resembles Unit No. 8 most in color and texture, but has a looser consistence.

One of the most pronounced differences between the profiles of mounds and pits Nos. 1 and 35 concerns the relative status of the mineral and organic mass which is wrenched from the soil and held in suspension by the roots of the toppled tree. That mass of material which once constituted the overburden potential of uprooting No. 35, has slumped to the lower surfaces. Part of the potential fell to the leeward and buried a small area that now represents the forest floor that existed prior to the hurricane of 1815. Hence, this mineral mass overlies the old forest floor and is an actual overburden.

This is the area of depositing

The region of overburden, Unit No. 2, is situated on the leeward side of the mound and is in juxtaposition and contiguous with the upper part of the pivot region. It creates the lower two-thirds of the leeward side of the mound. Its long axis is approaching the horizontal position. Unit No. 2 is a highly disturbed region, its consistence being quite loose. Its color and texture resemble most the upper portion of the B horizon, Unit No. 8, of the undisturbed region. A partial explanation for this close affinity is that the mineral material of the overburden was derived largely from the upper horizons of the soil that were picked up bodily by the roots of the toppled tree.

Directly under the overburden are the remnants of the 1815 forest floor. At this stage of development, the buried A horizon is very conspicuous. The central portion of this horizon is markedly thicker and represents, perhaps, the actual point of pivot of the toppled tree. Here, the organic layers of the old surface were folded over, more than doubling their original thickness. ~~Unit No. 3~~, A remnant of an A_2 horizon, is still perceptible. In more northerly regions of the Eastern United States, where podzol soils occupy large areas, the buried A_2 horizons provide a definite earmark of mounds created by the uprooting of trees.

C. Morphological and gross anatomical features that are of diagnostic value for relative age determination: No chemical or physical analyses required for their observation.

The profile of mound and pit No. 35 has characteristics which are related to its age or stage of development. The smooth, strongly curved surfaces of the mound and pit constitute a distinct surficial property of this age class. The diminishment of the overburden potential to minor proportions concomitant with the disintegration of the root mass until it is no longer visible from the exterior of the mound are additional surficial features.

The presence of four major regions arranged along the length of the profile provides a basis for several internal features of diagnostic value. One of the most significant of these is the region of overburden. A well developed overburden is symbolic of another stage in the maturation process of the relief created by the uprooting of a tree; especially an overburden that not only contributes to but also blends with the mound as well as the one of mound and pit No. 35. The general tendency for the regions to have more elongated shapes, for their long axes to approach more nearly the horizontal, and for their positions to be aligned across the profile, also are criteria of age.

The relative value of color, consistence and texture of the soil as bases for delineating the regions of no disturbance, deposition, pivot and overburden, changes over time. The variation in color among the four regions of mound and pit No. 35 is as pronounced as it was in the 14-year-old profile. A comparable relationship prevails with texture. However, the range of variation in consistence is decidedly less within the 137-year-old section than in the younger, especially if the undisturbed regions are excluded.

Two more features exist in the profile of uprooting No. 35 that are immediately apparent upon sectioning, and afford criteria of age. Both of these concern A horizons, one that has developed on the disturbed surfaces since uprooting, and the other that was in existence at the time of uprooting but is now buried under the overburden.

The buried A horizon of the pre-1815 forest floor is a conspicuous feature of mounds of this age class. Its color, very dark brown to black, makes it so. The dark color is due primarily to the high percentage of organic content. This organic matter has persisted for at least 100 years in a buried condition. It is quite heavily laden with pollen, the pollen being well preserved.

The heavy accumulation of organic debris in the pit is also another pronounced feature. Even though incorporation of organic with mineral material has progressed with accumulation of debris in the pit, there is only slight evidence of leaching. This provides an apparent contrast with the A_2 horizon of the undisturbed region. Pits of uprootings of this age category express the optimum of organic accumulation. Never again during the ensuing stages of development will there occur more unincorporated organic debris in the pit. There is also a marked difference in the degree of development of the A horizon across the surfaces of the disturbed section. Organic accumulation diminishes up the slopes of the mound until it is only skin deep on the crest. Practically no incorporation of organic with mineral material has taken place on the higher elevations, the soil immediately underneath the organic veneer being very fresh-looking.

The buried A horizon on the leeward side of the mound and the heavy accumulation of organic debris in the pit are integral components of mound and pit No. 35. As such, their rank of importance as criteria of relative age determination is equal to, if not greater, than that of any other feature of uprootings of this age class.

The buried wood of the lower extremities of the tree that was uprooted is also of significance as a clue to the amount of elapsed time since uprooting. A major variable must be taken into consideration, however, when this feature is employed. That concerns the differential which exists between the woods of various species to resist decay. The lower bole of slow growth white pine will persist longer in mounds than any other tree native to central New England. The presence of buried wood, nevertheless, tends to place a restriction on the amount of time that has transpired since uprooting. Observations dictate that under the conditions which prevail on the current research area, wood of uprooted white pines will persist in mounds for at least 137 years. Judging by the state of preservation of the wood fragments after this length of time under the soil, 175 years is not too long to expect some remnants to persist in an identifiable state.

3. Mound and Pit No. 17:

Figures M-H-18 and 19 depict the cross-section of mound and pit No. 17. The uprooting occurred during the hurricane of 1635. The species and size of the toppled tree is not known. Judging from the size of the mound and pit though, the tree must have been of considerable proportions. Any estimate of size, however, has to be tempered with the possibility that more than one tree was involved. Regardless of the variables involved, 3 feet in diameter

Fig. M-H-18
Cross Section of Mound and Pit No. 17.

Fig. M-H-19. Mound and pit No. 17.

would appear to be a reasonable estimate. The uprooting occurred on relatively level ground, the tree falling to the south~~east~~West. The soil is a Brookfield stony loam (Simmons, 1939), practically the same as encountered in mound and pit No. 35. A very firm-in-place-till also underlies this area. Its depth under the surface varies from 23 to 40 inches.

The remains of two stumps, Nos. 208 and 209, were present on the mound surface. No. 208, a hemlock 24 inches in diameter with a minimum age of 105 years, was situated on the extreme northwestern edge of the mound. No. 209, a white oak stump 15 inches in diameter and at least 127 years old, was located on the very southwestern edge of the mound about midway of its length. The white oak had been felled by the logging operation of 1803, while the hemlock was felled in 1854. Two live trees were growing on the mound and pit surfaces at the time of sectioning. A beech tree, No. 210, 6 inches d.b.h. and 91 years old, was growing on the extreme southeastern edge of the mound. A red oak tree, No. 220, 8 inches d.b.h. and 63 years old was on the edge of the pit.

The mound and pit were sectioned through the western two-fifths of their length at a right angle to the long axes. The age of the uprooting at the time of sectioning was 317 years.

A. Morphological features: The relief involved between the mound and pit of No. 17 is about 1.1 feet over a horizontal span of 7.5 feet. This amounts to almost three-fourths of the total relief involved in the 137-year-old uprooting and one seventh of that of the 14-year-old mound and pit. Even though the contours of mound and pit No. 17 are smooth and gradual, the relief created imparts a definite characteristic to the forest floor; a form the qualities of which can be related readily to the uprooting process by the inquisitive observer.

The cross-section has an appearance of uniformity about it that was not expressed in the two younger profiles. The general region of disturbance still stands out in contrast to the undisturbed portions, especially the pit side of the mound and the pit proper. Differences in color, texture and consistence are not nearly so obvious, though, as in the younger profiles.

The pit region is a pronounced feature of the profile since it is beginning to develop a series of quite distinct horizons of its own, most of which are strongly influenced by organic matter.

A buried A horizon is conspicuous by its absence in the profile of mound and pit No. 17. Another horizon, nevertheless, one closely related to the same buried soil profile, imparts a definite characteristic to the leeward side of the mound. This horizon is a strong brown, a much richer color than its counterpart on the other end of the undisturbed region. It represents that part of the profile ordinarily associated with the upper B horizon. The contrast in color between this and the surrounding strata is very marked.

B. Gross anatomical features: The profile of mound and pit No. 17 can still be divided into the same four major or basic regions as that of uprooting No. 35. However, the impression of vertical "blockiness" and derangement is not nearly so pronounced.

The regions can still be delineated by color, consistence and texture, but closer scrutiny is required. Excluding the horizon of firm till, the color variation across the middle of the profile is actually rather small, being as follows from left to right: Unit No. 9, 10 YR 5/8; yellowish-brown; No. 8A, 10 YR 6/8, brownish yellow; No. 7A, 7.5 YR 5/8, strong brown; No. 5 10 YR 5/8 to 10 YR 6/6, brownish yellow to yellowish brown; No. 4, 10 YR 5/8, yellowish brown; No. 4A, 10 YR 5/8, yellowish brown; and No. 12, 7.5 YR 5/8 to 7.5 YR 6/8, strong brown to reddish yellow.

The variation in consistence is also less across the profile. In the younger sections, differences in consistence were either obvious due to slumping or expressed by the degree of resistance to digging with a shovel. Whereas in the profile of the 317-year-old mound and pit, differences among the disturbed regions required testing with a knife blade before they could be observed. Consistence was nevertheless one of the most reliable criteria for delineating the profile into its basic units.

Texture variation is also diminished in the profile, the soils being much more uniform in this respect. The pit region is characterized by an accumulation of pebble-size particles, as expected.

The region of relatively little or no disturbance still occupies the ends of the section and depths below the penetration of large roots. The leeward end of the section could not be extended beyond the extremities of disturbance because of a large boulder. Therefore, the contrast in development usually expressed by the upper horizons of the undisturbed region could not be exposed on this end. That the leeward end of the profile would have closely resembled the windward end before uprooting appears to be a logical assumption. Units Nos. 10, 9, 8, 7, 1B and 1 constitute genetic horizons of a soil profile that might be considered typical of the brown podzolic region. The upper margin of the firm till, Unit No. 10, again tends to dip under the region of pivot.

The region of deposition overlies two-thirds of the length of ~~the~~ mound and pit No. 17. Even though it occupies the same relative position as that of the 137-year-old uprooting, this region of deposition is basically different from its younger counterpart. Its long axis is practically horizontal. The units which comprise it, Nos. 5, 7A, 8A, 16 and segments of 1A and 1B are essentially superimposed upon one another and parallel. They have acquired the visible characteristics of genetic soil horizons.

The region of deposition features two of the most pronounced properties of profiles of this age class. The pit is especially impressive. The thickness of the unincorporated organic material is not one of its salient features as was the case of the pit in uprooting No. 35; as a matter of fact, the thickness of the unincorporated organic layer is only slightly greater in the pit than on the other surfaces of the profile. However, the amount of organic incorporation and the depth to which it has proceeded are very impressive in the 317-year-old pit. Unit No. 7A, a zone of illuviation comparable perhaps to a B_2 horizon, has a maximum thickness of 10 inches and an average of 6 inches in the pit proper. Pits in the age class of uprooting No. 17 exhibit the optimum development of organic incorporation.

Another prominent property of the pit region, one that is closely related to the organic horizons, is the presence of a conspicuous eluviation zone, Unit 1A. Four inches thick at the center of the pit and dark reddish gray in color, this horizon is comparable to an A_2 horizon of a podzol soil. As such, it imparts a prominent characteristic to the pits of this age class.

Units Nos. 5 and 8A comprise the major proportion of the deposition region. Consistence of soil is the primary criterion of their distinction from the surrounding areas. In general, their soil particles are more loosely arranged, can be excavated with the fingers, and separate into individual components or small aggregates upon removal. Whereas the mineral components of Units Nos. 9 and 4, particularly No. 4, require a knife blade for excavation, and when removed fall out in pieces or aggregates, the mineral components of which adhere together but can be easily separated by crushing between the fingers. The textures of Units Nos. 5 and 8A also tend to be finer than of those below.

A feature appears in the pivot region of the 317-year-old section that has not yet been encountered in those of the younger profiles: Namely, its long axis is practically horizontal. Up to this time, the long axes of the pivot regions have been oriented vertically or at an acute angle. In addition, the pivot region of mound and pit No. 17 is completely overlain by the region of deposition. The factor of time, perhaps, is primarily responsible for this latter relationship. It may be recalled, that in the 137-year-old profile the overburden potential had been diminished to minor proportions. As a result, a veneer of mineral material had been deposited on the surfaces of the mound and pit. The situation presented by the 317-year-old uprooting, where the region of pivot is overlain by that of deposition, would appear to be the result of further accretion from an overburden potential. However, since the overburden potential very likely had been diminished to minor proportions almost 200 years earlier, the volume of debris required to bury the present region of pivot is incompatible with the volume that was actually available. Consequently, what appeared at first to be a deposit on top of the pivot region might be more logically explained as a genetic soil-profile that has developed during the last 200 years. In light of the fact that genetic horizons have been developed in the pit of the same profile, the explanation becomes even more feasible.

The overburden of the 137-year-old profile was "set-off" by a buried A horizon, whereas the overburden of the 317-year-old section is accentuated by a buried B horizon. Since the A horizon of the entombed 1635 profile has disappeared, its disintegration has undoubtedly contributed to the present properties of Unit No. 12. Therefore, this most obvious portion of the buried profile, Unit No. 12, probably includes the A horizon and the uppermost portion of the B horizon. However, since it has developed more of the properties usually associated with the B_1 and B_2 horizons than with the A horizon, it is perhaps more appropriately designated as the upper B horizon of the buried soil profile. Certainly, the windward end of the undisturbed region has no comparable feature.

A significant fact remains, that sufficient time has elapsed since the uprooting to have permitted the soil forming processes to create the alterations that are quite apparent in the profile.

C. Morphological and gross anatomical features that are of diagnostic value for relative age determination: No chemical analyses required:

The 317-year-old profile is characterized by features which are the result of soil forming processes, while the properties of the younger sections, Nos. 1 and 35, could be attributed predominantly to processes associated with uprooting: immediate deposition, root pull and thrust, mass dislocation, and accretion due to slumping. To be sure, profile No. 17 still possesses the morphology and gross anatomy that are inherently those of mounds and pits of uprooted trees. However, the fundamental differences between the profiles of the 137 and 317-year-old sections exemplify an important fact: That at some period during the span of 180 years, the differential in age of the two sections, the role of the uprooting processes in the developmental morphology and anatomy of the mounds and pits becomes subordinate to that of the soil forming processes. Hence, the presence of quite distinct genetic soil horizons in the 317-year-old profile. Actually, the soil forming processes probably become predominate even before the stage of development attained by the 137-year-old uprooting, only their expressions are not so obvious.

The parallel and near horizontal arrangement of the four major regions and their components across the profile of mound and pit No. 17 is one of the distinctive features of its age class. The pronounced expression of genetic horizons is another.

The profile demonstrates an incipient A_2 horizon. About four inches thick in the pit, the layer of leaching diminishes on the slopes to practically negligible proportions, nevertheless, it does persist almost the entire length of the disturbed regions, and it is recognizable. Also expressed in the pit of the 317-year-old section is the stage of optimum development in uprooting profiles of a B_2 horizon. This zone of illuviation is ten inches thick in the pit, and in lesser proportions extends several feet up the windward side of the mound.

The absence of a buried A horizon under the overburden is of diagnostic value for relative age determination. Of more significance, however, is the presence of a conspicuous horizon under the overburden region; one that represents, perhaps, the intimately incorporated A horizon and upper B horizon of the 1635 soil profile, with subsequent alteration. At any rate, this horizon is present on the leeward side of the section, and is a characteristic of mound and pit profiles of this and older age groups.

4. Mound and Pit No. 4:

The age of mound and pit No. 4 is estimated to be between 450 and 550 years. The uprooting occurred on a relatively level surface, the tree falling to the north. The species and size of the tree are not known. The soil is a Jaffrey gravelly fine sandy loam (Simmons, 1939), the same as that involved with mound and pit No. 1; the two uprootings being only about 30 feet from one another. A 9-inch aspen stump, No. 83, created by the logging operation of 1935, was located on the western edge of the mound. The cross-section was dug through the center of the mound and pit at right angles to their long axes or parallel to tree fall.

A. Morphological features: The microrelief of mound and pit No. 4 imparts only minor variation to the general forest floor. However, in conjunction with three other uprootings which are near by and of similar form, a distinct "hummocky" effect is given to the local area. The surface of the profile, Fig. M-H-20, is smooth and gently curved. The actual relief between the mound and pit is four inches over a horizontal distance of 3.3 feet.

The profile has the general appearance of uniformity. Genetic horizons prevail across its length, the regions of disturbance having become obliterated. One major disconformity exists in the profile, and that appears in the pit proper. The remnants of the pit, Units No. 1C and No. 1D, are still apparent.

B. Gross anatomical features: When color, consistence and texture of the soil are applied as criteria, the familiar outlines of the four major regions are not delineated across the profile of mound and pit No. 4, as in the younger sections. Genetic horizons take the place of the regions of deposition, pivot, and overburden.

That portion of the section which excludes the pit and its environs has a profile that is typical in many respects of the brown podzolic soils of southern New England. The differences between horizons are not as marked as in podzols, for example, and the horizon boundaries are gradual, there being

Fig. M-H-20
Diagram of M+P #4

quite a broad transition between them. The A, B and C horizons are represented by Units Nos. 1 and 1A, Nos. 8 and 9, and Unit No. 10, respectively.

Unit No. 1 is a dark reddish brown, predominantly undecomposed organic layer with a slight incorporation of organic and mineral matter. It constitutes the A_{00} and A_0 horizons, and probably includes the A_1 horizon.

Unit No. 1A is a zone of incipient leaching with a relatively high content of organic matter mixed with mineral matter. It is dark yellowish brown and has a loose, fluffy consistence. It represents the A_2 horizon.

Units No. 8 and 9 comprise the B horizon. No. 8 has a strong brown color, and is ~~a very~~ fine loamy sand that feels almost smooth and soft; it constitutes the B_2 horizon. Unit No. 9 represents a transition between Units No. 8 and 10. As such, it is probably the B_3 horizon.

The C horizon is represented by Unit No. 10, an olive-yellow fine sand.

A fine example of transition in color, texture and consistence is presented by the profile of mound and pit No. 4. Proceeding from the top to the bottom of the section, the colors become lighter, the textures coarser, and the consistencies become firmer.

The boundaries between the horizons are quite smooth, tending to form planes. The upper boundary of the C horizon exhibits a pronounced undulation. The dip occurs under the mound part of the section; more specifically, under that portion usually associated with the region of pivot. All of the cross-sections of the mounds and pits on the current research area, the depths of which extended into the undisturbed areas, demonstrated perceptible dips or plunges in the upper boundaries of the C horizons under the regions of pivot. Mound and pit No. 4 is no exception in this respect. In addition, the boundaries of the lower B horizon conform to the same irregularity.

Another disconformity in the profile of the cross-section occurs in the pit region. Units No. 1C and 1D are conspicuous remnants of the organic accumulations of the pit. Markedly influenced by its high organic content, No. 1C is dark yellowish brown and of soft, fluffy consistence; decidedly different in this latter respect from Unit No. 1A which borders it on both sides. Unit No. 1D also exhibits the influence of organic incorporation. The peripheries of Units No. 1C and 1D create a form that is very comparable to those of the organic-influenced pit areas of the younger profiles.

Still another disconformity is present in the profile. Of minor consequence and for which there is no ready explanation, the irregularity appears close to the surface of the profile near its midpoint. Here occurs a doubling in the thickness of the A horizon, Unit No. 1A, comparable to the folding of the upper soil layers that commonly results at the point of pivot when a tree is uprooted. However, judging from the proportions of the profile, the point of pivot should be located more to the leeward. Nevertheless, the possibility exists that due to extremely heavy concentrations of organic matter originating from the unsalvaged lower bole and stump of the uprooted tree, such an expression in the profile could result. At the present time, it is dubious that organic matter would persist so near the surface for 450 to 550 years. Nevertheless, the influences of the decomposed organic debris in the form of leaching or staining might possibly persist.

C. Morphological and gross anatomical features that are of diagnostic value for relative age determination: No chemical analyses required.

You shouldn't leave this without saying something about how you arrived at the age.

The 450-550-year-old profile of mound and pit No. 4 is characterized by the influences of the soil forming processes even more than the 317-year-old profile. Only three gross features of significance remain, and they are the results primarily of the processes associated directly with uprooting.

The characteristic relief of the mound and pit surface, even as slight as it may be, provides a feature of diagnostic value in regard to both origin and relative age determination. The expression of the pit comprises the most distinct internal evidence of past processes, while the dips in the lower horizons below the region of pivot are perceptible with closer scrutiny.

The general uniformity of the profile in conjunction with surficial form, pit expression, and dip of the lower horizons indicate: that the elevation and depression represented by mound and pit No. 4 resulted from the uprooting of a tree; and that the profile is older than those of uprootings Nos. 1, 35 and 17.

5. Mound and Pit No. 25:

Mound and pit No. 25, Figs. M-H-21 and 22, is another example of the 450-550-year-old age class of uprootings. It occurred on a relatively level area, the tree falling to the ~~north~~ south. The species and size of the tree are not known. There is no evidence of any trees larger than 1½ inches d.i.b. at breast height having grown on the mound or in the pit since they originated. The soil is a Brookfield stony loam, comparable to the soils in which uprootings Nos. 35 and 17 occurred. A firm till also underlies No. 25, the vertical distance to its surface ranging from 16 to 41 inches. The cross-section was excavated through the eastern two fifths of the uprooting at right angles to the long axes of the mound and pit.

?

Fig. M-H-22, mound and pit No. 25. At the end of the section, the surface of the underlying firm till intersects shovel about one-fourth down the length of the handle. Under the mound proper, the till surface dips approximately one and a half feet.

M.

The microrelief of mound and pit No. 25 is not a readily apparent constituent of the general forest floor. Nevertheless, when observed critically in relation to the local surfaces, a definite mound and pit expression immediately becomes obvious. Like mound and pit No. 4, only larger in aerial extent, the surfaces of uprooting No. 25 could be walked over casually without realizing what they represented. The surfaces are long, smooth and gently curved. The maximum relief between the mound and pit is about 9 inches over a horizontal distance of 6.5 feet.

The morphology and anatomy of mound and pit No. 25 are in a similar stage of development as those of uprooting No. 4. Several features, direct results of the uprooting process, are still apparent across the length of its section. The pit proper is a very prominent property of the profile. Unit No. 1 comprises the A horizon, a layer of organic accumulation and organic and mineral incorporation with only a trace of leaching evident. The depth of the organic incorporation with the mineral material in the pit proper is comparable to that of profile No. 4. And also as expected, there is a concentration of pebble and cobble size particles loosely arranged in the bottom of the pit.

The dip or irregularity in the surface of the substratum under the mound is even more apparent than in uprooting No. 4 (Fig. M-H-23). This is due essentially to the characteristics of the underlying till. Unit No. 10, the substratum, is a very firm-in-place till. It exhibits a high degree of fissility, its structure appears almost to be laminated. The firmness is due in part to the large proportion of granule size particles present, and to the degree of compactness that the till possesses. There is no evidence of cementation. The contact between the till and the overlying horizons is very abrupt and can be delineated readily (Fig. M-H-24), that is, except under the disturbed

Knife almost invisible

Fig. M-H-23, mound and pit No. 25. Knife at end of excavation marks upper surface of till. Till surface is practically horizontal and uniform on the left wall which is beyond the general regions of disturbance. On the right wall, which is within the disturbed regions, the surface of the till is irregular and has a perceptible dip.

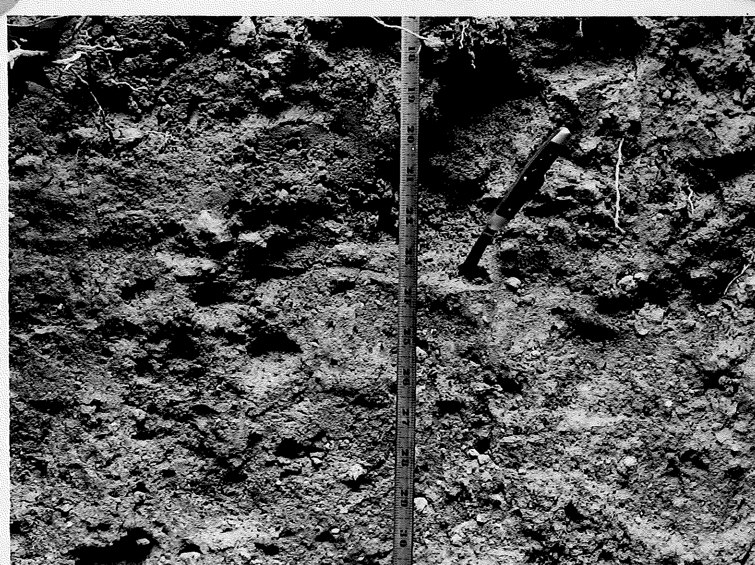


Fig. M-H-24, mound and pit No. 25. Close-up of Fig. M-H-23. Knife marks contact between till and the overlying horizon.

regions of the profile. Beneath the pivot region of mound and pit No. 25, as in all of the other uprooting profiles, the surface of the substratum plunges appreciably, as though a bowl-shaped mass of till had been gauged out by the roots of the toppled tree. On the opposite side of the excavation, which is beyond the general regions of disturbance, the surface of the till is practically horizontal and quite uniform along the entire length of the wall. The surface remains in the same plane across both ends of the excavation. Then as the surface of the till is traced from the leeward to the windward end of the section across the length of the profile of the disturbed regions, it plunges perceptibly under the mound proper and rises under the pit until it engages the plane of the till surface at the end of the excavation.

There are decided differences between the firm-in-place till, Unit No. 10, and the mineral materials, Unit No. 11, which tend to lie in the bowl-shaped concavity in the till. A pronounced color differential exists, the till being a light olive brown in contrast to the strong brown color of Unit No. 11. Iron staining is very apparent in No. 11, while the till has a mottled appearance. No. 11 has a degree of fissility which is less than No. 10, and it also does not have as firm a consistence. Both have numerous granule-sized particles, there being more in the till. There is a greater textural contrast, however, in the amount of fines. The till when wet has a greasy or at least a smooth feel, while the constituents of Unit No. 11 have a rough, harsh feel. The muscovite and biotite, which seems to be present in greater amounts in the till than in Unit No. 11, might account for this difference in feel. Unit No. 11 has the general appearance of having been disturbed in spite of its apparent fissility and firmness.

Unit No. 9 differs from the firm-in-place till even more than No. 11. A yellowish brown, very coarse sandy loam, Unit No. 9 is quite firm in place.

What size? Sure?

It has a suggestion of horizontal structure, there being an occasional individual granule-sized particle oriented horizontally and a tendency for soil aggregates to be platy. At the same time, Unit No. 9 appears to have been disturbed more than Unit No. 11. ?

Unit No. 8 represents the B horizon. Its properties are quite ordinary, except that under the crest of the mound the consistence is rather loose.

The leeward end of the profile has two features, the origins of which are problematical. Unit No. 12 is a fine sandy loam. Strongly mottled, its color ranges from a pale olive to a dark yellowish brown. Overlying Unit No. 12 and a short segment of Unit No. 10, is a layer of pebbles and cobbles 1 to 4 inches in diameter. This pavement-like structure is 2 to 3 pebbles thick. There are at least two plausible explanations for the origins of Unit No. 12 and the layer of coarse mineral fragments. One is based solely upon geological processes, that the features are characteristics of the till and originated at the time the till was deposited or shortly thereafter. The other explanation is based upon the processes associated with uprooting, that Unit No. 12 could be the result of root channels of a tree that had toppled over prior to the formation of mound and pit No. 25. The roots were left intact in the pit region and have since decomposed creating channels in which mineral components were deposited. The layer of pebbles and cobbles represents the bottom of the old pit where coarse fragments usually are found. The latter explanation is preferred at the present time because it is very doubtful if such a formation of geological origin could have persisted in an undisturbed state for several thousands of years so near to the surface of the present floor. It is suggested that Unit No. 12 and the layer of pebbles and cobbles are related to another uprooting, which occurred previously to that which created mound and pit No. 25.

Don't see this geological process - what is it?

Mound and pit No. 25 is in the same age class as uprooting No. 4. A major difference exists, however, between the soils in which they occur. No. 25 involves Brookfield stony loam, while No. 4 is situated on a local area of Jaffrey gravelly fine sandy loam. The Brookfield is derived primarily from till, in contrast to the glaciofluvial origin of the Jaffrey. The differences in texture and consistence are marked between the sola of these two soils, and are very pronounced between their substrata. In spite of these significant differences, both mound and pit pairs have properties in common which are related to uprooting.

6. Mound and Pit "C":

Mound and pit No. C is located a few feet south of the current research plot. The uprooting occurred around 1850, when a white pine tree toppled over. The tree fell to the south, at a right angle to a slight slope. The soil is a Brookfield stony loam. The same firm-in-place till underlies this area also, the distance to its top surface ranging from 23 to 48 inches. Three live trees were growing on the surfaces of the mound. An 18-inch, 95-year-old black birch tree was situated on the crest in a slightly perched position. Two hemlocks, 6 and 2 inches d.b.h. and 70 and 54 years old respectively were growing on lower levels. The cross-section was excavated through the western two-fifths of the mound and pit at right angles to their long axes.

Mound and pit "C" create a prominent feature on the forest floor, the origin of which can be related at once to the toppling of a tree. The uprooting surfaces are distinctly defined by strongly curved but rather regular contours. The maximum relief between the mound and pit is 2.2 feet over a horizontal distance of 5.4 feet.

The black birch on the crest of the mound, Fig. M-H-11, has several properties which are peculiar to the rigorous conditions under which the tree grew during its early years. The lower bole of the tree is curved as though during its seedling stage it had been growing on the leeward side of the overburden potential where either its roots became partially disengaged from the unstable surface by erosion thus permitting the bole to lean, or the tree was tilted by mass slumping. The tree then re-established itself at a lower level and assumed a vertical relationship later through the development of a curvature in its lower bole. The radial growth tends to reflect the unstable conditions under which the birch was growing while young. When the tree was 12 years old, there occurred a decided decrease in radial growth which lasted for two years. The annual rings for a few years thereafter were much thicker on the underside of the bole, thus creating an eccentricity in its cross-section.

Another feature provides vivid evidence pertaining to the former relationship between the tree's position and the mound surface. Resting almost on top of the lower portion of the butt of the birch, in the "saddle" created by the sweep in the bole, is a small mass of loosely arranged pebbles and cobbles, Fig. M-H-25. The coarse particles undoubtedly represent the remains of an overburden potential which at one time must have protruded above the present root collar region of the tree. Shortly after the uprooting occurred, the black birch must have become established on the side of the mound at a level above that which it now occupies.

The black birch and the mound and pit are almost the same age, the birch being approximately five years younger. The presence of the birch on the mound's surfaces, for a length of time almost equal to the age of the uprooting, This is not convincing as to the perched soil

Fig. M-H-25. Mound and pit "C". Note loose pebbles and cobbles resting on top of the root collar region in the "saddle" created by the curvature of the lower bole.

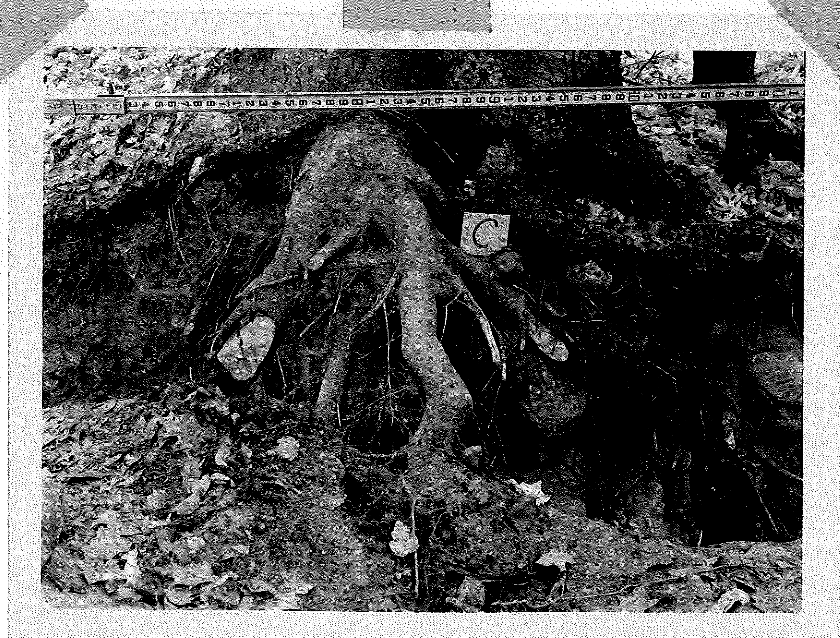


Fig. M-H-26. Mound and pit "C". Note the disturbed appearance of the profile directly under the base of the tree.

has had a definite influence upon the development of mound and pit "C". In general, the profile appears more disturbed than its age would indicate, as though the black birch had had a tendency to stabilize the order of derangement that was created originally when the white pine toppled over in 1850. The surfaces of the uprooting have not eroded as quickly as evidenced by the abruptness of the mound's crest and the depth of the pit. The surfaces are appreciably more angular than those of mound and pit No. 35 which are only 35 years older. The upper surfaces of the mound at and under the base of the birch tree are actually bare of organic debris. The heterogenous mineral mass in the pit is extremely loose and will slump at the slightest provocation. The crest of the mound is capped with a very loose, almost powdery fine sandy loam, while the overburden is heavily influenced with organic debris derived from the white pine that was uprooted (Fig. M-H-26).

Even though the development of the form and structure of mound and pit "C" has been retarded by the influence of the black birch tree, the major morphological and anatomical features exhibited in its profile are decidedly the results of uprooting (Fig. M-H-27). The influences of the uprooting process are even more apparent than had the black birch not been present. The regions of relatively no disturbance, deposition, pivot and overburden are readily discernible, even if the characteristics of the central portion of the profile do tend to be concealed by roots.

7. Mound and Pit "B":

Mound and pit "B" is located approximately 100 feet south of the research area. A white pine tree was uprooted during the hurricane of 1815, falling to the South and at a right angle to a 40 percent slope. The soil is a Brookfield stony loam underlain by a firm-in-place till at depths ranging from 24 to 42 inches. Two large trees were growing on the mound. One, a black birch 18 inches d.b.h. and 136 years old, was perched over the mound on columnar roots so that its root collar region was almost four feet above the crest of the mound. (Figs M-H-7, 8) The other, a hemlock 12 inches d.b.h., and 105 years old, was growing on a lower level of the mound within two feet horizontal distance of the black birch. The section was excavated parallel to the direction of tree fall through the lower one-third of the mound and pit.

Mound and pit "B" is a classical example of an uprooting. Its micro-relief is that which is most commonly associated with mounds and pits of uprooted trees. In addition, the presence of the black birch perched on massive stilt-like roots enhances the expression imparted to the local area, Fig. M-H-7. The relief is strong, the maximum between the mound and pit being one foot vertical difference over four horizontal.

Uprootings "B" and No. 35 are the same age. Both were created by the toppling of white pines which fell to the south at right angles to the slope. The soils on which both are located are practically the same. The major differences between the conditions under which the two uprootings occurred and in which the resulting mounds and pits developed concern primarily the slopes of the local areas and the trees that subsequently grew on the disturbed surfaces. The ~~variation~~ difference in slope is ten percent with No. 35 on the lesser of the two. The fact that the mound of uprooting "B" has had two large trees growing on its surfaces, and one of them almost ever since the mound originated, is the major disparity between the conditions under which the two mound and pit pairs developed.

Regardless of the variation in slope and the trees on the mounds, the profiles of the two uprootings are basically alike. The four major regions are discernible across their length, but their form and arrangement differ slightly. The major discrepancy is related to the shape and size of the overburden regions, (Fig. M-H-28). Due principally to the force of gravity prompted by the slope, the overburden of "B" is about twice as long as that of No. 35. At the same time, as a result of gravity and the influence of the trees on the mound surface, the region of pivot is overlain by a deposit of mineral and organic material, an arrangement quite unlike that of No. 35. Concomitant with the elongated overburden is a buried A horizon of comparable length (Fig. M-H-29). Another significant difference concerns the degree of asymmetry exhibited by the two sides of the mound on the steeper slope. The leeward is noticeably longer than the pit side, while in No. 35 the two sides are almost equal in length. The asymmetry attains higher degrees as the slope is increased and especially when the trees in uprooting topple down the slope.

8. Mound and Pit "A".

Mound and pit "A" is also located off the current research plot, being about 50 feet to the south. It affords another variation in the set of conditions under which mounds and pits originate and subsequently develop.

Uprooting "A" was caused by the hurricane of 1815, the same as mounds and pits Nos. 35 and "B". The soils on which all three of these uprootings occurred are practically the same, Brookfield stony loam. All are underlain by a firm-in-place till. Under "A" the vertical distance to this till varies from 20 to 43 inches; however, it is neither as firm-in-place nor does it have as marked a degree of fissility as some of the other underlying tills.

A white pine tree was uprooted on a 50 percent slope to create mound and pit "A". The tree toppled to the west, parallel to the slope or downhill.

Fig. M-H-29. Mound and pit "B". Leeward side of mound. Buried A horizon evident about one foot below letter "B". Roots tend to follow the plane created by old forest floor, thus concealing it somewhat.

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A black birch tree 14 inches d.b.h. and 130 years old was perched on the mound crest. Two more trees, a hemlock 11 inches d.b.h. and 77 years old, and a black birch 4 inches d.b.h. and 73 years old, were standing on the lower levels of the mound. The section was excavated through the southern one-third of the 137-year-old uprooting parallel to the direction of tree fall.

Herein lies a signigicant variable in the circumstances thus far described. In the previous examples of uprootings, without exception, 90 degrees was the maximum arc of pivot through which the trees passed when toppling over. They either were on relatively level areas or, when uprooted on slopes, fell parallel to the contours. The white pine involved in uprooting "A", on the other hand, toppled through an arc of pivot of about 115 degrees; it fell downhill on a 50 percent slope. The cross-section of "A", Fig. M-H-30, exhibits several variations in its form and structure; properties which are definite deviations from those that characterized the other mounds and pits, and ones which can be attributed primarily to the influences of slope and the downhill direction of tree fall.

The general outline of the mound and pit surfaces of "A" is radically different from those of uprootings of comparable age but which occurred on relatively level ground. The leeward or downhill side of mound "A" is several times longer than the windward side, thus creating an extremely asymmetrical form. The short, sharply pitched sides of the pit fashion a conspicuous concavity in the slope, the deepest part of which is only about two feet horizontal distance from the mound crest. Thus, the actual relief between the mound and pit is pronounced, being about one-half a foot in two and would be twice as much if it were not for the deep accumulation of organic debris in the pit. Since the form is generally askew, the mound proper

Fig. M. H. 30

comprises almost three-fourths of the total length of the disturbed surfaces resulting from the uprooting.

The internal structure and the anatomy of uprooting "A" also exhibit significant variations. The three basic regions of deposition, pivot, and overburden are still identifiable. However, the relative positions which they assume and their consequent forms are quite different from the other 137-year-old mounds and pits thus far described.

The extent of the over-burden is one of the most obvious disparities. It is about 9 feet long in comparison to the overburden lengths of 6 and 3 feet of uprootings "B" and No. 35 respectively. In addition, the buried A horizon also becomes a conspicuous property of mounds ~~and~~ composed of long overburdens.

The region of deposition likewise constitutes a major portion of profile "A". It extends uphill several feet, occupies the pit proper, and dominates the windward side of the mound. Units Nos. 3, 5 and most of 4 comprise the region of deposition.

The pivot region is of almost insignificant proportions. Its aerial limits are so confined that it might better be designated as a point of pivot rather than a region of pivot. The fulcrum or point of pivot is located where the leeward end of unit No. 4 contacts the truncated, relatively undisturbed horizons represented by units Nos. 8 and 9. Practically the whole of unit No. 4 is highly influenced by deposition.

Mounds and pits resulting from trees toppling downhill exhibit even more vividly the results of the physical forces involved than do uprootings which occur on level terrain. The features of fomm and structure that characterize mound and pit "A" are not discordant with the forces spent during and after uprooting simply because they vary from the pattern peculiar to similar dis-

This whole business – p. 78 through 81 – is just pedantry. It can all be said in one simple paragraph. Most of it is of no consequence at all.

turbances on comparatively level forest floors. Rather, the features exemplify the influences of forces which are the same in kind but greater in magnitude. Trees growing on slopes are endowed with a greater potential of physical forces which may be expended through uprooting. Furthermore, since trees on slopes ordinarily topple downhill, the profile of "A" is a typical and rather common phenomenon.

When trees pivot through arcs of more than 90 degrees, overburdens may be formed immediately. Downhill uprootings observed when only a few hours old commonly included overburdens. The overburdens which are contemporaneous with uprooting can be attributed primarily to the sizes of the pivot arcs and the resulting forces with which the trees crash to the ground. The momentum gathered by the toppling tree is directly related to the number of degrees encompassed by the arc of pivot. Trees which are uprooted in a downhill direction and fall unhindered to the forest floor exert their full potentials of physical forces upon the local areas. Energy is released along the entire lengths of the fallen trees upon impact with the ground, and forces are transmitted from the tips of their crowns to the points of pivot at the bases of their boles. The mineral and organic masses wrenched from the soil by the dislocated portions of the root systems are vibrated loose from their moorings, quantities of which tend to fall downhill upon the relatively undisturbed forest floor below.

Comparable mounds and pits which originated on slopes with the hurricane of 1938 also were characterized by overburdens, many of which were from 5 to 7 feet long. Portions of these overburdens were contemporaneous with the actual uprootings, but since their inception have been augmented by the forces of gravity. Invariably, the overburden potentials of these downhill uprootings assume positions whereby their long axes tend to be at right angles to the slopes. Of necessity, therefore, the long axes of the overburden potentials are not vertical; they lean, with their upper extremities farther down slope than their lower. As a result, those individual fragments or masses of aggregates which can drop freely from the overburden potential unimpeded to the surfaces below, fall vertically, and in so doing are laterally displaced downhill to the leeward side. In addition, this same displaced mineral and organic debris is apt to roll downhill, thus increasing the length of the overburdens.

Uprootings resulting from the toppling of trees downhill contain regions of deposition which are also the acme of disturbance. Where deposition was the process primarily responsible for the character of the deposition regions in profiles peculiar to mounds and pits on level areas, root pull and root thrust are the agents most influential in fashioning the features of the deposition regions on slopes. Units Nos. 3 and 5, which comprise over half of the region of deposition region of mound and pit "A", are mainly the manifestation of root pull and root thrust. The overburden potentials which contributed so significantly to the bulk of the deposition regions of uprooting profiles on level terrain, actually have been shunted downhill to become real overburdens in uprootings which occur on slopes. The initial forces of root pull are not necessarily greater on slopes than on the level. However, since the arc of pivot is usually greater on slopes, there is a tendency for more roots to be completely disengaged from their anchorage in the soil. On the other hand, the forces released through root thrust would appear to be considerably larger when trees topple downhill in contrast to when uprooted on relatively level ground. The force and extent of the thrust process is related directly to the size of the pivot arc. Since the point of pivot is usually a foot or more from the extremities of the tree base, depending upon

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the depth of the roots and where they are wrenched from their moorings, the pivot point in reality functions as a fulcrum; the aerial portion of the tree serves as one arm of the lever, while the disengaged underground portions provide the other arm. The difference in the lengths of the two arms of the lever thus provided by the tree is usually very considerable, resulting in the achievement of a tremendous load advantage at its lower extremities, the roots. Therefore, a few degrees variation in the size of the arc through which a toppling tree pivots alters the forces exerted by root thrust immensely but the distance of actual dislocation only slightly. Therefore, immediate and subsequent deposition would not appear to be as influential processes as root pull and thrust in the so-called regions of deposition which are components of the profiles of downhill uprootings.

The pivot regions associated with the uprootings that occurred on level surfaces are even more radically altered by the forces concomitant with the toppling of trees downhill. The region may be more appropriately designated as a point of pivot since its aerial extent has been so diminished. The pivot regions of the other 137-year-old mound and pit profiles ordinarily resulted from the dislocation in mass of soil particles which were thrust down and scooped to the windward by the pivoting roots of the leeward side of the stump. The downward thrust or scooping action of the roots was dependent upon the force provided by the weight of the columnar mass of the tree being exerted upon a small area at its base. The toppling tree tended to grind itself into the forest floor. However, when a tree falls downhill, especially if it topples unimpeded, the downward force of the columnar mass may be transformed by momentum into one predominantly centrifugal in nature. The tree not only falls down, but it tends to fall outwardly as well. That trees which are felled downhill are liable to "jump" from their stumps is common knowledge among logging crews.

The falling down and out of trees down slope, therefore, reduces the scooping function of the large roots which remain intact. The formation of overburden potenetials and actual overburden are enhanced, however, and their subsequent deposition practically obliterate the pivot regions. That the obliteration of the pivot region is due mainly to forces associated with uprooting rather than the process of soil development can be corroborated by observing the same characteristic in young mounds and pits.

In spite of the differences in roles and magnitudes of the various physical forces associated with trees toppling downhill, the resulting mound and pit profiles are comprised of the same basic components as those mounds and pits on level forest floors, namely: the regions of deposition, pivot, and overburden. The influences of the physical forces are expressed in the profiles of downhill uprootings more vividly and for longer periods of time, nevertheless, because the degree of disturbance is greater originally.

9. Mounds and Pits Nos. 58 and 60:

Uprootings Nos. 58 and 60 are illustrated by Figures M-H-31 and M-H-32. Units Nos. 7, 11, 13, and 1A represent Mound and pit No. 58, while uprooting No. 60 is comprised of Units Nos. 2, 3, 4, 1B, and a large part of 1. Mound and pit No. 58 is another example of the 450 to 550-year-old age class, only it resulted from the toppling of a tree downhill. The species of tree involved is not known. Mound and pit No. 60 was created in 1938 when two black birch trees 14 and 11 inches d.i.b. at b.h. were uprooted. The larger of the two trees fell downhill creating most of the disturbance, while the smaller birch fell to the north, or parallel to the slope. Both uprootings occurred on about a forty percent slope. The only evidence of trees larger than one and a half inches d.i.b. at b.h. having grown on the disturbed area are the black birches that were uprooted in 1938 to create Mound and pit No. 60. These two trees had

Fig. M-H-31. Mounds and pits Nos. 58 and 60 (Field Nos. 59 and 61).

been growing on the extreme eastern edge of the pit of uprooting No. 58. The soil is a Brookfield stony loam. At depths varying from 30 to 40 inches is a firm-in-place till comparable to that which underlies most of the current research area. The uprootings were excavated parallel to the direction of tree fall through the southern two-fifths of the mounds and pits.

Figure M-H-32 represents a prime example of a phenomenon that has undoubtedly occurred time and again on the research plot: namely, a local area that has been subjected to repeated disturbance by the uprooting of trees. The overburden of No. 60, Unit No. 2, is superimposed upon the pit and the windward side of the mound of uprooting No. 60. The two areas of disturbance are readily separated by the buried A horizon of the pre-1938 forest floor, that segment of Unit No. 1 under the overburden, Unit No. 2.

The two uprootings are typical of their age classes. The oldest profile still bears the evidence of organic incorporation in the pit, Unit No. 1 A. The concentration of loose angular boulders in the pit is a conspicuous feature, Unit No. 13. Only a slight remnant of a buried A horizon is represented by fragments of a leached layer and charcoal in the extreme leeward side of the mound under the old overburden, Unit No. 7.

Mound and pit No. 60 is a fine example of a young uprooting on a rather steep slope. The black birch responsible toppled through an arc of pivot of approximately 110 degrees. It did not stop until its lower bole came to rest on the forest floor. An overburden was almost surely formed at the time the uprooting occurred. The fingers of organic accumulations projecting into the leeward side of the mound even imply that a period of stability existed for a short time after the uprooting; long enough for organic matter to accumulate, anyhow. Then perhaps, one of the roots holding the mineral mass gave way allowing more material to slump downhill burying the current accumulation of

Fig M-H .37

organic debris. Already the extension of the overburden downhill as the result of slope is apparent. The veneer of mineral material that covers the overburden and which originated from Unit No. 3 exemplifies the influence of gravity. The inverted V-shaped organic mass represented by Unit No. 1, is a good example of a point of pivot, the hinge on which the tree rotated in toppling. Here, Unit 1 is the result of a folding-over of the organic layers of the A horizon that existed ~~prior~~ to the 1938 uprooting. The extremely active state of the mound is expressed by its angular, irregular surfaces, and the highly deteriorated condition of the exposed roots.

Figure M-H- depicts essentially the obliteration of one uprooting profile by the development of another.

Once the morphological and gross anatomical features of the ten uprootings selected for intensive study had been described, their profiles could be compared. The differences in their form and structure and the processes responsible could be determined.

Most of this section is just more pedantry — expanded out of all reason, and so clouded with words that it has very little meaning. I can't mark it intelligently. What seems to be the "meat" is in the last few paragraphs (pp 88-90), but even this

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The Developmental Morphology and Anatomy of Mounds and Pits of Uprooted Trees:

Each tree that stands in the forest is endowed with an uprooting potential, a set of properties that is in many respects comparable to and common with its genotype. The uprooting potential consists of three major groups of factors, all of which are closely interrelated. The first set of factors is comprised of the genetic characteristics of the tree; its crown and root forms, stature, and other properties or tendencies that are usually considered as being inherited. The elements of the environment to which the genotype of the tree is exposed and with which it reacts constitute another set of contributing agents. And the last component of the uprooting potential is actually the manifestation of the genetic and environmental factors. It is represented by the physical forces that are expended if and when the columnar mass of the tree topples over to wrench its roots from the soil and to instigate a mound and pit.

The genetic and environmental factors that influence the possibilities of a tree being uprooted are many and highly diverse. In contrast, the kinds of forces created by uprooting are relatively few and remarkably uniform. Only their magnitude differs significantly. When the aerial mass of a tree topples and wrenches its roots from the ground, tremendous forces can be expended. Root pull, mass dislocation, thrust, consequent slumping, and subsequent deposition, result in the formation of a mound and pit. These are the forces that are peculiar to the process, and each and every one of them is expended almost every time a tree is uprooted. The magnitude of each force can and probably does vary in each instance, however.

The mounds and pits of toppled trees are characterized by basic features which are inherent with and peculiar to the nature of the forces expended by uprooting. These inherited characteristics are subject to changes from their inception; changes which when compared over time constitute stages of development. The factors responsible for the development of mounds and pits are the same as those usually associated with the processes of soil formation. The changes which they effect in the mounds and pits constitute acquired characteristics, properties which are as peculiar to the soil forming processes as those of uprooting are to the physical forces spent when trees topple over. The soils of large regions exhibit attributes which are related to the particular processes responsible for their development: podsols, laterites, chernozems, etc. Within a given region, the influences resulting from a particular process vary considerably. On an area the size of the current research plot, less than an acre, the variation in the processes is perhaps as significant between mounds and pits as it is over the entire plot.

Mounds and pits, therefore, are the product of two contrasting but complementary processes: uprooting, primarily physical in nature, functions with violence, and provokes disturbance; soil formation, physical and chemical processes, a manifestation of time, and allays the agitation wrought by uprooting. The results of these processes can be observed in Figure M-H-31, a series of mound and pit profiles arranged according to age. The basic components of gross anatomy can be delineated in each profile when color, consistence and texture of the soil are applied as criteria. Each of the first three mounds and pits, the ages of which are 14, 137, and 317 years, have profiles characterized by the same three basic regions: deposition, pivot and overburden potential or overburden. The shapes and dispositions of the regions vary in each of the sections, but their general relationships are maintained throughout. These same regions are not apparent in the 450 to 550-year-old profile. They have lost their identity.

The regions of deposition, pivot, overburden potential, and overburden, are inherited anatomical features of the uprooting process. The subsequent changes in form and disposition which they demonstrate with age are characteristics that are acquired through the process of soil formation. Borrowing the approach of the plant and animal morphologists, the regions of deposition, pivot, overburden potential, and overburden, may be considered as homologous parts, and the transformations which they undergo, as evidence of development. The development of each of the basic parts or regions may be traced over time, ~~its~~ their characteristics described, and ~~its~~ their relationship to the unit as a whole ascertained, not unlike the ontogeny of a plant or animal. The four profiles, therefore, may be considered as depicting four stages in the developmental morphology and gross anatomy of mounds and pits of uprooted trees. Stages which include the embryonic through the adult and approaching old age, and which embrace approximately 500 years of development.

There are additional morphological and anatomical features that characterize the different developmental stages of mounds and pits. These properties, as they are related to each of the stages of development represented by the uprootings of Fig. M-H-31, are depicted in Table ______.

Each of the four stages of development has a characteristic surficial form. The diagrammatic sketch accompanying each has been exaggerated slightly to illustrate the maximum relief and the general relationship assumed by the mound and pit. The relief ratios were derived from actual measurements. The relief between the deepest part of the pit and the crest of the mound of uprooting No. 1, for example, is 2.2 feet vertical distance over a horizontal span of 2.0 feet. Within a local area, in spite of the environmental variations, the surface forms developed in mounds and pits appear to be closely related to their age, hence to their stage of development also. The relief diminishes rapidly during the early stages, then ~~tapers off at a considerable rate~~ becomes considerably more stable in the latter.

TABLE No.

Characteristic / Feature	Mound and Pit No. 1 14 yrs. old	Mound and Pit No. 35 137 yrs. old	Mound and Pit No. 17 317 yrs. old	Mound and Pit No. 4 450-550 yrs. old
Form of mound and pit surface - relief ratio - vertical over horizontal (feet)	2.2/2.0 = 1.10	1.1/5.5 = 0.20	1.1/7.5 = 0.15	0.33/3.3 = 0.10
Buried wood of tree that was uprooted				
Buried A horizon of predisturbed soil				
Buried upper B horizon of predisturbed soil				
Unincorporated organic debris in pit				
Incorporated organic and mineral materials in pit				
Degree of genetic soil horizon development - general profile				

Morphological and Gross Anatomical Characteristics that are Most

Peculiar to the Various Stages of Mound and Pit Development.

The inclusion of buried wood of the tree that was uprooted is a pronounced feature of the developmental stage represented by mound and pit No. 35. Overburdens which bury the lower boles and roots can be formed at the time of uprooting, especially when the trees topple down hill. Buried wood as an anatomical characteristic, however, usually pertains to a mass of decomposed wood that is completely entombed by the overburden and cannot be observed without excavation. In this region of central New England, mounds and pits which include buried wood that is still in an identifiable state have a maximum age of about 175 years. Most of the native woods will not persist that long in a buried situation.

A buried A horizon is also a distinguishing characteristic of mound and pit No. 35. Buried A horizons can be markedly influenced by the presence of organic matter, A_{00}, A_0, A_1 horizons, and leached mineral material, A_2 horizons, or both. On the current research plot, the buried A horizons included in the profiles of mounds and pits 137 years old and less were featured by their high organic content. Within the region of podzol soils though, where the processes of base depletion and elluviation are more dominant, buried A_2 horizons become a pronounced property. The buried organic layers or evidence of their remains will persist for at least 137 years. Their observation is much more difficult than that of buried wood. The remnants of buried A_2 horizons have been observed in uprootings that were close to 500 years old.

Buried upper B horizons afford a contrasting property to those uprootings that are old enough to have had their once present organic layers of buried A horizons completely decomposed. Mound and pit No. 17 is in such a stage of development. The upper portion of what was once the B horizon of the pre-disturbed soil provides a diagnostic feature for this age class of uprootings. Younger stages of mound and pit development also possess buried B horizons.

Nevertheless, there would appear to be a period of time during which the remnants of the buried A horizons disintegrate and become incorporated with the mineral materials below, thus influencing the properties of what are probably the upper B horizons. The buried B horizons of profiles older than mound and pit No. 17 evidently have advanced to the stage whereby they are no longer distinguishable; they just contribute thickness to the current or present B horizons which have been formed since the uprootings took place.

The best expression of unincorporated organic debris in the pit proper occurs in the 137-year-old profile of mound and pit No. 35. By expression of unincorporated organic debris is meant, that organic accumulation in the pit the preponderance of which has decomposed to the point where it is no longer identifiable but still has not become incorporated with the mineral material below. Cross-sections excavated through younger uprootings indicate that the stage of optimum development of unincorporated organic debris in pits is reached at about 100 years of age. That this much time is required for maximum accumulations would appear to be the case. Periods of time exceeding 100 years, enhance the possibilities of organic incorporation, thus diminishing the total accretion of unincorporated debris.

The degree of organic incorporation with the mineral material in the pit and the depth to which it has proceeded affords another means of differentiating the stages of mound and pit development. Of the four uprootings listed in Table No. ____, mound and pit No. 17 exhibits the best expression of this attribute. Organic incorporation also is present in younger pits. Its evidence can also be observed in the 450-550-year-old age class. Matter of fact, the incorporation of organic material in the form of pit outlines is one of the criteria which enables the recognition of the processes responsible for elevations and depressions on the forest floor when almost all other features of diagnostic value have disappeared. The evidence of organic incorporation in the pits will persist for at least 500 years on the local area represented by the current research plot. Its maximum expression is attained, however, in the stage of mound and pit development that is approximately 300 years old.

The ages of mounds and pits, or the length of time that they have been exposed to the soil forming processes, afford additional features that can be related to the stages of uprooting development. The older the uprooting, the longer the soil forming processes have been functioning on the local area since it was disturbed. Hence, the various stages of mound and pit development are characterized by different degrees of genetic soil horizon formation.

The profile of mound and pit No. 1 has no semblance of genetic soil horizons, except those which had formed prior to the uprooting. Its general structure is markedly "blocky", the major components of the profile having a vertical arrangement. Its status of profile development is symbolized by two short, vertical lines.

The profile of mound and pit No. 35, even though it is more than 100 years older than No. 1, still demonstrates a blocky structure. To be sure, it possesses details which signify soil development, organic accumulation on its surfaces, some leaching in the pit, more uniform consistence, but still the profile is characterized by inherited properties. Its general development of genetic soil horizons is expressed by two short, parallel lines at a 45 degree angle.

Many of the characteristics inherited from uprooting have disappeared in the profile of mound and pit No. 17. Its major regions of deposition, pivot, and overburden have begun to assume definite horizontal relationships. Horizons influenced by elluviation and illuviation are beginning to affect the general appearance of the profile. The stage of its horizon development is depicted by two short, parallel lines oriented at a 60 degree angle.

Genetic soil horizons are pronounced in the profile of mound and pit No. 4, the 450-550-year-old uprooting. The only inherited properties remaining are the slight relief of its surface, the outline of the pit, and the dip in the substratum underlying the portion of the profile which was once the region of pivot. Characteristics acquired through the soil forming processes dominate the section. Its stage of soil formation is represented by two short, horizontal lines.

The development of mounds and pits can be traced by comparing the morphology and anatomy of different aged uprootings. The deterioration of inherited traits and the formation of acquired characteristics follow a definite, predictable sequence resulting in stages of development, each of which has properties peculiar to it. The developmental morphology and anatomy of mounds and pits is culminated by a mature soil profile.

<u>The Documentation of the Origins and the Determination of the Relative Ages of the Mounds and Pits of Uprooted Trees:</u>

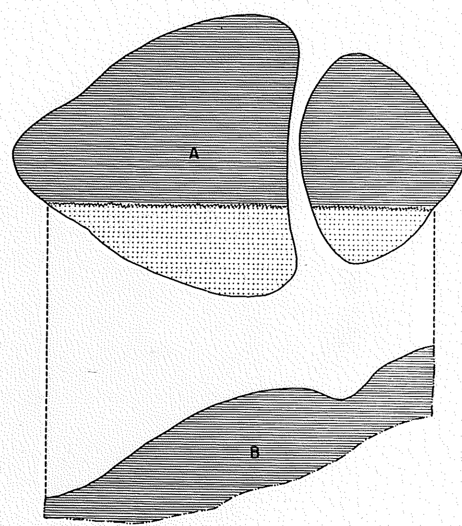
Once the origins and relative ages of the mounds and pits on the current research plot had been ascertained, the number of trees that had been uprooted could be determined and the sequence of their toppling could be arranged in its proper chronological order; two facets of knowledge the acquisition of which would contribute immeasurably to the reconstruction of the forest stands that had occupied the area in the past. The preliminary survey of the microrelief had delineated 64 local areas of mounds and pits that probably originated from the uprooting of trees. That phase of the investigation was based upon the gross characteristics of origin of the elevations and depressions on the forest floor; those features of diagnostic value that could be observed with or without the assistance of slight excavation. Next, the developmental morphology and gross anatomy of uprooting mounds and pits had been established by the excavation and intensive study of ten typical specimens. Seven of these mounds and pits had been delineated by the preliminary survey, while the other three occurred within 100 feet to the south of the research plot. Once the features of form and structure that characterize the various stages of mound and pit development had been ascertained, the next logical step was to apply these criteria of origin and age to the remaining mounds and pits. Therefore, the next phase of the investigation was designed to document the origins of the remaining mounds and pits and to determine their relative ages.

Seven mounds and pits on the research plot had been subjected previously to intensive study. Of the 57 remaining local areas of elevations and depressions of probable uprooting origin, 16 were definitely mounds and pits that had originated from the hurricane of 1938. Their origin and age were obvious. Therefore, sections were excavated through the remaining 41 mounds and pits at right angles to their long axes or parallel to tree fall. Their gross features of form and structure were described, and their profiles were drawn diagrammatically to the scale of one foot to the inch. Color, consistence, and texture of the soil were the primary criteria employed. The same methods were applied here as in the intensive survey of the ten mounds and pits, only the excavations were not as extensive, and appropriate symbols replaced the precise delineation of anatomical features. Coincident with sectioning and describing, buried wood and charcoal, and specimens of buried A horizons were collected. The magnetic bearing of the long axes of each mound was recorded, as was the presence of live trees, dead trees, and stumps on the mound and pit surfaces. Only the surficial forms of the 1938 mounds and pits were profiled.

When the features of form and structure of the probable mounds and pits were compared with those of known uprootings, 39 of the 41 local areas of elevations and depressions were determined definitely to have originated from the toppling of trees. Therefore, 62 of the original 64 mounds and pits that had been delineated on the current research plot by the preliminary survey were the result of uprooting: These latter 39, plus the 16 of 1938 and the 7 subjected to intensive observation. Furthermore, when a more detailed comparison was made of their morphology and gross anatomy, all 62 of the uprootings could be arranged into six different stages of development; stages each of which possessed peculiar characteristics and which almost certainly represented different age groups or classes. The diagrammatic sections of the 55 uprootings which were not intensively profiled are illustrated by Figures M-H- through M-H- The sections are arranged according to stages of developmental morphology and gross anatomy or age classes.

As each mound and pit was sectioned and profiled, it became apparent that several distinct age classes were represented. However, it was not until the diagrammatic profiles of all 55 uprootings could be compared side by side that the affinities and dissimilarities of their morphology and gross anatomy really became significant. The form and structural features of particular diagnostic value for relative age determination are summarized in Table M-H-2, which is merely an expansion of Table M-H-1. All 62 mounds and pits are included.

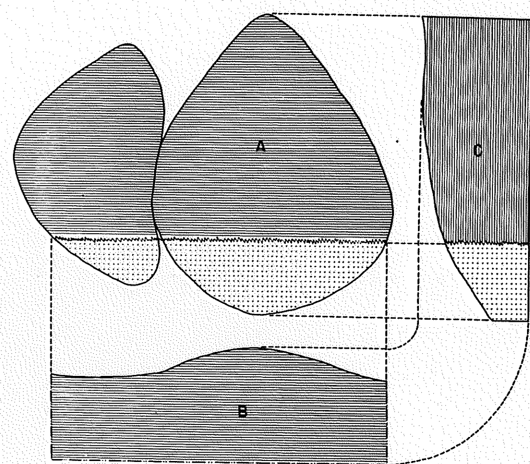
That the mounds and pits can be classified into four major groups according to their stage of developmental morphology and gross anatomy is apparent from even a cursory analysis of the profiles and Table M-H-2. Each relative age class is characterized by a particular set of inherited and acquired characteristics. The salient properties of the youngest mounds and pits, class I, are features resulting directly from the uprooting process. They are raw areas of disturbance. On the other hand, the dominant characteristics of the oldest uprootings, class VI, are mainly the result of soil forming processes. The mounds and pits of the relative age classes between these two extremes possess combinations of characteristics which is mound & which is pit in A?



MOUND AND PIT "A"

A – TOP VIEW
B – END VIEW

0 2 4
FEET



MOUND AND PIT NUMBER 35

A – TOP VIEW
B – END VIEW
C – SIDE VIEW

0 2 4
FEET

not clear

created by both of these influential processes. The stages of development represented by these four relative age classes are the same as those represented by mounds and pits Nos. 1, 35, 17, and 4 of Figure M-H-

The general surficial forms of the mounds and pits demonstrate a remarkable affinity to age. For example, the mere silhouettes of the mounds and pits, regardless of anatomical features or pre-conceived conclusions, can be readily classified according to form into four major groups. When the uprooting members are assigned to the mound and pit members of each group and then arranged in their numerical order, practically the same classification results as when features of developmental morphology and gross anatomy were applied. All the mound and pit outlines can be rationally classified in this manner. When relief ratio, the vertical distance between the depth of the pit and the crest of the mound divided by the horizontal distance involved, is substituted for silhouettes as a means of arranging the uprootings into age classes, basically the same four groups are derived again. As depicted in Table M-H-2, the arithmetic means and standard deviations of the relief ratios of the four age classes are as follows:

Age Class	M (feet)	σ
I	0.83	0.48
III	0.36	0.09
V	0.15	0.06
VI	0.11	0.03

The arithmetic means diminish perceptibly between age classes I and III, less between III and V, and only slightly between age classes V and VI. This rate of relief degradation is as expected, since young mounds and pits are subject to more severe erosion and disintegration than older ones. The dispersions of the relief ratios about their means also becomes less with age. This, too, is as expected. That four major age classes of mounds and pits exist is demonstrated to a remarkably precise degree by an analysis of their relief ratios. If known variations were taken into consideration such as the sizes of the trees uprooted, the manner in which the uprootings occurred, the degree of slope involved, and whether the trees were dead or alive when uprooted, the relationship between age class and relief ratio would be even more distinct.

The comparison of relief ratios also suggests that two other age classes of mounds and pits exist: II and IV. Age class II consists of only two uprootings, Nos. 21 and 22, the relief ratios of which are 0.51 and 0.60 respectively. These relief ratios are between 0.83 and 0.36, the means of the relief ratios of age classes I and III. The relief ratios of 21 and 22, nevertheless, are included well within the degree of dispersal about the mean of the relief ratios of age class I. They do, however, generally exceed the relief ratios of age class III and are not included by their standard deviation. This discord of relief ratios only suggests that mounds and pits 21 and 22 are of an age class which is different from those of the uprootings included in age classes I and III. Further comparisons of anatomical features and the age of the trees on and near their surfaces, however, corroborated this suspicion.

The same approach can be made to mound and pit No. 47, the sole member of age class IV. Its relief ratio is 0.20, between the means of age classes III and IV which are 0.36 and 0.15 respectively. It falls outside of the range of dispersal of the class III relief ratios, but is barely included in the upper end of class V. Here again, relief ratios only suggest that mound and pit No. 47 is older than age class III, but younger than age class V. Further evidence, however, establishes this as fact. The application of relief ratios alone would have enabled quite an accurate appraisal of the relative ages of the mounds and pits on the current research plot. Furthermore, excavation would not have been necessary.

More preliminary

Direction of tree fall is another factor the analysis of which tends to corroborate the previous conclusions derived: that the 62 mounds and pits which occur on the current research plot can be logically separated into four major age classes. The directions of tree fall arranged according to the previous age classes are illustrated by Figure M-H- . The mounds and pits of class I are known to have originated from the hurricane of 1938. Fifteen of the eighteen trees which were uprooted at that time fell in a northwesterly direction. The tree that fell in the southwestern quadrant was knocked over by a dead chestnut tree, while the uprooting in the southeastern quadrant resulted from a dead chestnut tree falling uphill. Since fifteen of the eighteen trees fell in northwesterly directions within 65 degrees of one another, the hurricane winds of 1938 must have approached the local research area from the southeast. Comparable uprooting situations are suggested by the directions of tree fall of the other major age classes of mounds and pits. In each, the directions in which the trees fell are concentrated in one or parts of two 90 degree quadrants. Five of the eight trees involved in class III fell to the south and southwest covering a span of approximately 80 degrees. Fourteen of the fifteen trees of class V fell to the southwest and northwest involving an arc of 115 degrees, while the toppling directions of fifteen of the eighteen trees of class VI are concentrated in the southwestern and northwestern quadrants with a maximum dispersion of 110 degrees. These group-wise concentrations of tree fall directions displayed by age classes III, V, and VI more than suggest that the uprootings resulted from three distinct storms. The storms were probably hurricanes comparable in many respects to the one of 1938, and in general, the winds came from the east.

Which hypoth.

Through the application of principles based upon developmental morphology and anatomy, the origins of the mounds and pits on the current research plot were documented and their relative ages were determined. Sixty-two mounds and pits of uprooted trees were ascertained on the plot, an area slightly less than one acre in extent. Fifty-nine of the uprootings comprised four major relative age classes, while three probably belonged to two others. The distribution of the mounds and pits known to be of uprooting origin is illustrated by Figure M-H- .

Whole section much too wordy— obscured by words!

The Determination of Some of the Characteristics of the Trees that were Uprooted and of those that Grew on the Local Areas Before and After the Mounds and Pits were Formed.

The mounds and pits of uprooted trees may yield additional evidence which is pertinent to the reconstruction of the forest stands that had grown on a specific area. The concrete evidence which uprootings might afford is in the form of wood, charcoal, and pollen that were buried by the mineral masses wrenched from the forest floor by the toppled trees, and from the stumps and roots of trees that grew on, in, and near the uprooting surfaces since they were created. From this concrete evidence can be directly derived the species and partial growth rates of the trees that were uprooted and of those that grew on the area before and after the mounds and pits were formed. The inferred evidence which might be yielded is related primarily to the sizes of the trees uprooted and the conditions under which they grew. The sizes of the trees can be directly approximated from the proportions of the mounds and pits which they created. And perhaps, some notions can be garnered pertaining to the growing conditions of the trees prior to uprooting from the annual rings exhibited by the remnants of wood and charcoal. It was essential, therefore, that this evidence be collected as the mounds and pits were sectioned.

Condense to one or two sentences

The wood incorporated in uprootings may be of various origins. The wood might actually be remnants of the trees that were uprooted originally to create the mounds and pits. It might be of post-uprooting origin, from roots of trees that had grown on the mound and pit surfaces. Or the wood might be from roots, boles, or branches of trees that were near the immediate area before or after the uprooting occurred. The origin of the wood must be ascertained before its presence can be interpreted correctly.

The best expressions of buried wood of the trees that were uprooted on the current research plot occur in mounds that are from 100 to 150 years old. This length of time is required for the aerial portions of the toppled trees to have lost their identity and for the overburdens to have developed to the stage where they completely cover the remnants of the stumps of the uprooted trees. Under these circumstances, the buried wood is concentrated in the leeward side of the mound in the region of overburden above the buried A horizon of the predisturbed forest floor. As such, these organic masses constitute several cubic feet of volume and contribute prominently to the uprooting profiles of which they are definitely an integral component. Smaller masses of wood may occur in the regions of pivot and deposition where roots have been thrust. These outlying remnants are often encountered first as the mounds and pits are sectioned, but as the excavations approach the central portions of the mounds, the largest concentrations of wood are revealed. The main masses are usually composed of individual pieces one-half to four inches in diameter and up to one and a half feet long. These more rot-resistant-remnants are usually surrounded by a matrix of highly decomposed wood. Also, the long axes of the trachieds and vessels of the wood tend to be oriented toward the horizontal. The specifications that must be met before the wood incorporated in mounds can be considered as having originated from the specific tree or trees that were uprooted are quite rigorous, and necessarily so, because wood in the forest is common both on and beneath the forest floor.

Only 10 of the 62 profiles contained wood that was considered as valid buried remnants of the trees that were uprooted: the 2 mounds of relative age class II and the 8 of class III (Table M-H-3). The species of wood indicated that 9 of the 10 mounds and pits resulted from the uprooting of white pine trees, while one was due to the toppling of a white oak. Since the extremely resinous lower portions of white pine trees are perhaps the most decay-resistant of all of the native species, its remnants in the mounds afforded the best expressions of buried wood that could be expected. Each of the 9 mounds created by the uprooting of white pines contained enough wood to fill a bushel basket.

Wood ~~that~~ was removed from three other mound and pit profiles (Table M-H-3). These specimens originated from sources other than the trees which were uprooted to create the specific disturbances. The wood occurred within the general regions of disturbance as pieces 1 to 4 inches wide and 3 to 10 inches long. Only one specimen was found in each mound. Since the wood occurred in the disturbed regions of profiles 300 to 500 years old, it almost had to be of post-uprooting origin.

The wood in mound and pit No. 29 was definitely the remnant of a white pine branch spike. It was about one inch in diameter, 5 inches long, and round in cross-section. The manner in which the spike became buried in the mound is highly conjectural. It might have been driven into the mound when the white pines were uprooted to form mounds and pits Nos. 31 and 32. This hypothesis is based upon the facts that uprooting No. 29 is much older than Nos. 31 and 32, and is practically in line with the directions in which the white pines toppled to create the two younger mounds and pits. Another theory would be that a large branch or a bole of white pine was lying on the ground and was buried when the tree which formed No. 29 was uprooted. The branch spike, being more resistant to decay, persisted longer than the surrounding wood and was the only remnant present at the time of excavation. This latter hypothesis would be the more probable of the two if uprooting No. 29 was not so old, but it is difficult to believe that even a white pine branch spike would maintain its identity after having been buried over 300 years in mineral soil.

Mounds and pits Nos. 9 and 47 also contained wood. The specimens probably came from the roots of trees that had grown on the area since the mounds and pits were formed. Both remnants occurred as isolated individual pieces in the region of overburden. The wood in No. 9 was definitely white pine and probably originated from one of the pines that had grown nearby. The specimen removed from No. 47 was so highly deteriorated that its species could not be ascertained. The presence of wood in uprootings Nos. 29, 9 and 47 indicates only that white pine trees grew in the immediate vicinity probably after the mounds and pits were formed.

Charcoal may also be incorporated in the profiles of mounds and pits. It has several possible origins. The trees that toppled over subsequently burned, leaving remnants of charcoal instead of wood in the regions of overburden. Burned forest floors often become buried by uprootings, and charcoal can originate under the forest floor when roots and the lower extremities of boles are burned in place. Any one of these sources or combinations thereof can be responsible for the presence of charcoal in uprooting profiles. The origin of the charcoal also has to be determined before its presence can be correctly interpreted.

Charcoal was found in 18 of the 62 mounds and pits of the current research plot (Table M-H-3). Its occurrence included all but one of the six relative age classes, No. II; quite unlike the occurrence of wood which for all practical purposes was confined to age classes II and III. The more general occurrence of charcoal can be accounted for largely by the fact that charcoal will persist in the soil for a much longer time than unburned wood. Charcoal will persist in forest soils for at least 500 years in this part of New England. (How much longer it can remain in an identifiable state is an enigma.)

Only 2 of the 18 uprootings contained charcoal that was derived from the trees that had been uprooted, Nos. 16 and 43. An abundance of charcoal occurred in both, which was located where one would expect to find wood of the toppled trees, if it were to be present, as though the trees had burned shortly after uprooting. In fact, No. 43 contained both wood and charcoal, white pine in each instance. The charcoal of No. 16 was hemlock.

Buried forest floors which had been burned prior to uprooting were observed in five profiles. All five are of the same relative age class, No. V, and are grouped quite closely together, Nos. 45, 50, 52, 53 and 55. The burned forest floors have an expression similar to that of buried A horizons. However, charcoal replaces the organic matter, and the upper parts of the burned B horizon are brick red in color. The charcoal was concentrated on the surfaces of the buried, pre-disturbed forest floors. It occurred abundantly, but in pieces most of which were less than 1/2" in diameter. Most of the pieces were too small for identification; nevertheless, charcoal of birch, hemlock, and red oak was recognized. On one occasion, all three species were found in a single profile. (The origin of the burned forest floors is difficult to relate to natural factors, causes other than man.) The burned profiles are confined to five uprootings, all of which are grouped at the eastern end of the plot around a bench-like feature in the slope. Furthermore, the burned layers and charcoal are limited to these five specific local areas. The surrounding uprooting profiles do not have comparable (anatomical inclusions.)

The fire or fires responsible for the burned horizons, therefore, were not general even over the local area. About the only feasible means at hand to account for the phenomenon is Indian camp fires. The western exposure, sheltered mid-slope flat, and the accessible water supply down the hill would provide a likely site for human occupancy. Subsequent uprootings both destroyed and preserved the burned horizons thus created. Another alternative would be to subject the whole area to fires, then inject enough time lapse to permit sufficient uprooting to have destroyed all of the burned profiles with the exception of those in the five local areas. The first hypothesis seems the more formidable, but the latter cannot be discounted completely.

Charcoal present as individual isolated fragments occurring sporadically and at depths of several inches to 2 feet was observed in 7 other mound and pit profiles, Nos. 36, 37, 47, 17, 5, 7 and 58. Its observation required careful scrutiny since the pieces were scarce and quite small. The charcoal's presence definitely did not lend obvious earmarks to the profiles in which it occurred. The charcoal of this category, since it was buried in the disturbed portions of the uprootings, must surely have been of pre-disturbance origin. Its scarcity, sporadic distribution, and lack of particular form practically dictate the origin to be other than burned-in-place roots or stumps. The charcoal was probably derived from trees that had burned on the local area prior to the uprootings. The species of charcoal identified were hemlock, white pine, and chestnut.

Charcoal was also observed lying in the pits of 4 uprootings or in the organic layers of their surfaces, Nos. 1, 42, 8 and 51. This charcoal was also scarce and occurred as small pieces, only one of which could be identified. It was oak of unknown species. The source of the charcoal was probably from trees or parts thereof that had grown on the area since the uprootings occurred.

The charcoal collected from the 18 mound and pit profiles indicates certainly that the current research plot had been subjected to fire. The species of the charcoal specimens contribute to the knowledge pertinent to the composition of the forest before, at the time of, and after the uprootings occurred, while the origins of the charcoal assist in determining the chronological sequence of the fires and the uprootings.

The buried A horizons of the pre-disturbed forest floors that are often incorporated in mounds and pits are apt to be local concentrations of pollen and spores. The forest floor functions as a reservoir for that proportion of the "pollen rain" that falls. Subsequently, the pollen and spores are trapped by the mineral masses that are deposited on the forest ~~floor by~~ the toppling of trees, especially when overburdens are formed concomitantly with uprooting. The pollen and spores are a product, therefore, of the vegetation that existed prior to the occurrence of the uprootings. The interpretation of the pollen and spores is of course subject to the well-known deficiencies of pollen analysis: species identification, differential rates of deterioration, and areal source. Nevertheless, the species of pollen and spores represented in the samples ~~would~~ can contribute a facet of information pertaining to the floristics of the forest that existed on the general area prior to the uprootings.

Specimens of well-defined buried A horizons were collected from nine uprootings: Nos. 46, 56, 61, 62, 21, 35, 36, 37, and 43. The first three relative age classes were represented. Specimens were also collected from the regions of the upper B horizons of four other uprootings: No. 53 of age class V, and Nos. 4, 57, and 59 of class VI.

The specimens of pollen and spores were not fully exploited at this time. Only one sample was analyzed. ~~However,~~ some time in the future the remaining specimens will be subjected to analysis. Their species composition can then be compared with the composition of the forest stands that were known to have existed at the time of the uprootings. In this manner, the degree that pollen samples represent the forest that produced them might be ascertained. If the analyses are proved to be valid, another technique will have been derived that will enable the investigator to accumulate evidence from the forest that will lead to a better understanding of its development.

The conditions under which the forest stands grew before and after being subjected to uprooting can be inferred from the radial growth rates expressed by the specimens of wood and charcoal collected from the mounds and pits. Such inferences, however, are almost rank speculations. The specimens collected were fragmentary remains of bole, root, and branch cross-sections. The portions of the cross-sections represented can only be approximated from the curvature of the arcs of the annual rings. Sampling of the specimens was practically impossible, even when the opportunity presented itself. Whenever possible, fragments were collected from each profile which sampled the range of growth rates.

In general, the growth rates expressed by the wood and charcoal fragments were quite slow, ranging from 8 to 40 rings per inch (Table M-H-3). The growth rates of the wood collected from the uprootings of relative age class III are interesting. The wood in all cases represented the trees that were uprooted to form the mounds and pits. All eight of the trees were white pines. Growth rates of 8 rings per inch were found in two of the profiles, while the rest were either 12, 13, 15, 23, or 33. These rates of growth would not be considered fast for white pine. In general, they might be regarded as slow, what might be expected of white pine growing in forest stand conditions when competition is quite keen. That this was actually the case was substantiated later on when the forest stands were reconstructed. However, great care must be exercised in the interpretation of such meager evidence. It can seldom stand alone, but can contribute a glimmer or shadow when regarded in the light of more conclusive data.

One of the basic questions related to the mounds and pits on the research plot concerned the dimensions of the trees that had been uprooted to create them. The ages of the toppled trees were even of more importance to the reconstruction of the forest stands than their sizes. The diameters at breast height of 24 trees that had beeh uprooted to form 18 of the 62 discernible mounds and pits on the area were known. These were the trees of the youngest uprootings, relative age class I. The trees or their lower boles were still available for measurement. It was paramount, therefore, that these data be exploited in an attempt to ascertain the relationship, if any, which existed between the sizes of the toppled trees and the mounds and pits which they created. No other rational approach was available.

It is axiomatic that trees grow larger as they get older. It would also seem axiomatic that little trees when uprooted create small mounds and pits, while big trees create large ones. The fallacies of relating mound and pit size directly to tree size, however, are apparent when the proportions of the uprootings of relative age class I, Figures M-H-33, 33 and 34, are compared with the known diameters of the trees that formed them.

Uprootings Nos. 38 and 41 resulted when two live hemlock trees, 2 and 3 inches d.i.b. at b.h.. were knocked over by a large chestnut tree. Their mounds and pits are of approximately the same dimensions. The outlines of uprootings Nos. 13 and 15 when compared with those created by the two small hemlocks would indicate that they were the result of similar sized trees having been uprooted. The trees that produced Nos. 13 and 15, however, were 13 inches in diameter, one a hemlock, the other a red oak, both live trees. The significant variable involved is the concentration of boulders and cobbles in which uprootings Nos. 13 and 15 are located. Only minor disturbance resulted when the larger red oak and hemlock toppled over. Boulders were displaced, but only a relatively small quantity of soil was picked up.

Uprootings No. 44, 46 and 62 present examples of other variables. All occur on rather steep slopes. Dead chestnut trees are involved in all three; a 15-inch tree in No. 44, a 16-inch in No. 46, while No. 62 resulted from the uprooting of a 12-inch chestnut and the leaning of a 5-inch black birch. The dimensions of profiles Nos. 46 and 62 are similar, but No. 44 is considerably larger than the other two. What are some of the known variables involved that might account for these expressions? The tree that toppled to create the largest of the three uprootings fell downhill. Being of sprout origin from a parental stump of 24 inches in diameter, it split at the base allowing a small part of the clone to remain in the ground intact. The chestnut of No. 46 fell uphill, creating only a minor disturbance. The chestnut of No. 62 was a third generation sprout from a 36-inch parental stump. It fell downhill, but in doing so its base rotated on the organic mass of the parental element, broke loose and created only a minor disturbance. So, even though dead trees of the same species and comparable size are uprooted, the mound and pit expressions which result can be quite variable.

The mineral masses moved in uprootings Nos. 27 and 49 are quite comparable, in spite of the fact that the tree of 49 fell downhill while that of 27 occurred

These genetic terms - all through the ms - are confusing and unnecessary on a relatively flat area. Red maples were involved in both, one of 13 inches in diameter and the other 15 inches. However, the larger of the two which fell downhill to form No. 49, actually passed through an arc of pivot of less than 90 degrees. Its crown became lodged in the trees below, so that its bole was suspended several feet above the ground. The 13-inch tree responsible for No. 27 rotated 90 degrees, in fact, it fell over a dead chestnut tree which provided another fulcrum, thus enhancing the degree of disturbance.

When profiles Nos. 56 and 61 are compared with No. 60 of Figure M-H- , a remarkable resemblance appears. All three occur on rather steep slopes, and all resulted from the toppling of trees downhill. If the fact were not known, all three trees would have been expected to be of similar size. The trees which created Nos. 56 and 60 were of almost the same dimensions, black birches of 10 and 14 inches in diameter respectively. However, uprooting No. 61 resulted from the toppling of a 24-inch hemlock tree. The masses of the mineral materials wrenched from the forest floor are practically the same for all three, as are the surficial forms.

The comparisons of the mound and pit dimensions with the known variables related to the uprooted trees reveal several pertinent coincidences. Within limits, the sizes of the trees do not appear to be as influential in the degree of disturbance resulting from uprooting as the factors of soil, condition of the trees, and the direction of fall in relationship to slope. With age of the mounds and pits held constant, the dimensions of the uprootings vary tremendously with the conditions which existed at the time of toppling. Comparatively large dead trees were apt to create less disturbances around their immediate bases when uprooted than much smaller live trees. Trees growing on and in bouldery soils produced small mounds of mineral soil and scarcely pits at all when they toppled over, regardless of their size, physiological conditions, or direction of fall. Nevertheless, when age of uprooting was held constant, along with slope, direction of fall, and general physiological condition, the mounds and pits which resulted from trees quite variable in diameter were essentially of the same proportions. If for example, the sizes of the trees that had formed profiles Nos. 49, 56, 60, and 61 had all been estimated from the dimensions of the mounds and pits to have been 18 inches d.i.b. at b.h., the prediction would not have been far from reality. The actual diameters are 15, 10, 14, and 24 inches, the greatest discrepancy between the real and the estimated values being 8 inches.

The basic question now involves the degree of precision that should be expected in the estimation of toppled-tree-diameters from the sizes of the uprootings. The conditions under which uprootings occur are highly variable. Estimates of tree size, even when the known factors of influence are considered, are at best general predictions. Nevertheless, if the diameters of the white pines, that were uprooted to create the mounds and pits of relative age class III, were estimated to have been between 12 and 18 inches, the error involved is probably within the error of estimate that would be expected when tree age is predicted from d.i.b. at b.h. or stump, especially when the conditions under which the trees grew before toppling are so enigmatic.

With the known data at hand and the possible range of variables under consideration, the diameters of the trees that created the mounds and pits were estimated from the dimensions of the uprootings. The estimates are incorporated in Table M-H-3. With the exception of age class I, one of the most striking features of the uprootings is the uniformity of their sizes; a uniformity that tends to exist within and between age classes. There are a few exceptions. In class III, No. 35 is noticeably larger than its associates. No. 17 stands out in class V in this respect, as does No. 25 of class VI. Another pronounced characteristic of these uprootings is their size. With the exception of Nos. 17 and 25, the trees that toppled over to produce the mounds and pits were not of extraordinary proportions. They could have been trees from 12 to 30 inches in diameter at breast height. Regardless of the ages of the uprootings and the variety of conditions under which they were created, their sizes do not demand the toppling of excessively large trees. The trees which were uprooted were probably alive also. The depths to which disturbance occurred would indicate this.

Much redundancy

Discrepancies in mound and pit dimensions do exist within the relative age classes, even when the notable exceptions are taken into consideration. The uprootings of classes II and III demonstrate the most uniformity. The trees that created these uprootings were estimated to have been between 12 and 18 inches in diameter, in general probably closer to 12 inches, while No. 35 more likely resulted from a tree closer to 18 inches in diameter. All 10 of these uprootings occur within about 100 feet of one another. The soil and slope do not vary significantly.

The slight differences in the sizes of the mounds and pits of class V permit their separation into groups; subclasses which are likely related to the diameters of the trees uprooted. By coincidence, the mounds and pits of most comparable dimensions also tend to be arranged in groups on the forest floor. Nos. 16, 17, 18 and 19 constitute one such group, Nos. 26, 28, 29, 34, and 42 another, while Nos. 45, 48, 50, 52, 53, and 55 comprise the remaining group.of class V (Figure M-H-). In general, Nos. 16, 17, 18, and 19 are slightly larger uprootings than those of the other subgroups. No. 17 has considerably greater proportions. It would appear that larger trees were involved on this local area, especially when the influences of slope and the direction of tree fall upon the degree of disturbance are taken into consideration. Nos. 16, 17, 18, and 19 occurred on comparatively level surfaces, while over two-thirds of the remaining uprootings of this class occurred on slopes as the result of trees toppling down hill. Ordinarily, the uprootings of larger trees are required on level areas to produce disturbances comparable to those that occur on slopes. The trees that were uprooted to form Nos. 16, 17, 18, and 19 were assigned diameters of 18, 40, 24, and 24 inches respectively.

Uprootings Nos. 26, 28, 29, 34, and 42 comprise another group of class V mounds and pits. Nos. 26 and 28 are the largest of these, and they in turn are comparable to Nos. 18 and 19 of the previous group. Therefore, Nos. 26 and 28 were probably created by trees about 24 inches in diameter, No. 42 by an 18-inch tree, and Nos. 29 and 34 by trees around 12 inches in diameter.

In general, the same approach was made to the remaining uprootings on the current research plot. The dimensions of uprootings that were created by trees of known diameters were compared with those formed by the toppling of trees, the diameters of which were not known. All of the recognized variables were rationalized, and approximate diameters were assigned to the trees that created the mounds and pits. When all of the imponderables involved are realized, the results of such an approach cannot be considered dogmatic, nor can the conclusions which might be extrapolated. Nevertheless, the estimated diameters are based upon what is considered a logical rationalization of the evidence that was available. Actually, the estimated diameters are probably close to reality.