1968 No. 29

# BLACK ROCK FOREST PAPERS

## OAK MORTALITY AND DROUGHT IN THE HUDSON HIGHLANDS

*By*

JACK J. KARNIG AND WALTER H. LYFORD

HARVARD BLACK ROCK FOREST
CORNWALL, NEW YORK 12518

# OAK MORTALITY AND DROUGHT
# IN THE HUDSON HIGHLANDS

BY

Jack J. Karnig and Walter H. Lyford[1]

## ABSTRACT

Unusually high mortality of scarlet oak (Quercus coccinea) in scattered locations on the highlands along the lower Hudson River in New York resulted from summer droughts during the period 1962-1966. Aspect, depth of soil to bedrock and location of trees in relation to topography are important factors contributing to the heavy mortality.

## INTRODUCTION

A five year period of drought (1962-1966) caused many trees to die in areas of shallow soils at the Harvard Black Rock Forest. Mortality became most evident in 1966 and 1967 due probably to an accumulative effect of unusually dry growing seasons. Trees in the dominant and co-dominant crown classes died as frequently as intermediate and supressed individuals.

Death of trees from drought is an important factor in the management of forests. Present trends in using mountainous areas and non-commercial forests for recreation makes study of such sites useful and necessary. It is valuable to know what species are involved, the soil characteristics and effect of management upon recurrence of such large scale mortality.

## LITERATURE

Drought effects on forest trees in the eastern part of the United States have been studied by several investigators.

Effects of a one-year drought on species composition of oak and conifer forests in Pennsylvania reported by McIntyre and Schnur (1936) are much the same as the findings reached in our study. They found that crown class or degree of competition to which a tree is subjected is unimportant as a factor affecting loss due to drought and that scarlet oak suffered very heavily from drought. In stands classified by them as black oak - scarlet oak type (Quercus velutina - Q. coccinea) the before-drought scarlet oak basal area was 46%. After the drought it was only three percent.

Effects of a severe one-year (1925) summer drought on southern Appalachian Hardwoods is described by Hursh and Haasis (1931). They noted distinct browning of leaves and early leaf

1. Forest Manager, Harvard Black Rock Forest, Cornwall, N. Y. 12518 and Harvard Forest, Petersham, Mass. 01366 and Soil Scientist, Harvard Forest.

fall. Four years after the drought those trees which showed no evidence of drought damage in 1925 continued to thrive. About one half of the trees showing definite drought injury in September 1925 completely recovered. The remainder sustained injury in the form of dead branches in the crown, or were killed by drought or by secondary causes. Individual species behavior according to these investigators followed a pattern somewhat similar to those reported by McIntyre and Schnur, (1936). Black oak, scarlet oak and red oak (Q. rubra) mortality registered very high on the scale. Chestnut oak (Q. Prinus) and several species of hickory in most cases recovered after displaying slight or moderate browning of their leaves in September 1925.

Staley (1965) studied the effects of drought during 1956-61 and found damaged oak trees exhibiting progressive root deterioration. Death was most common during mid-summer moisture stress following defoliation by Argyrotoxa semipurpurana.

## PROCEDURE

Dead crowns were readily evident within and outside the Harvard Black Rock Forest in the early summer of 1967. Heavy concentrations of dead and dying trees seemed to be most abundant at or near the ridgetops especially where bedrock exposures are common. High mortality areas within a representative portion of the Harvard Black Rock Forest were mapped and species composition, vigor, tree and crown sizes, outcroppings of bedrock and soil depth were obtained on a single representative area 50 x 200 feet.

Related information on mortality of oaks from Bear Mountain Park (some 15 miles to the south) also was obtained.

## RESULTS

The region-wide well publicized drought, locally severe during late spring and summer months, persisted from 1962-1966 in much of the northeastern United States. Many municipal reservoirs approached depletion toward the end of this period since recharge rates of winter and early spring did not offset summer usage. The water reserves for New York City, for example, dropped to nearly one-third of capacity, whereas under normal conditions greatest draw-down leaves reservoirs three-quarters or at worst two-thirds full.

Figure 1 presents rainfall data collected at a rain gauge immediately adjacent to the north boundary of the Forest. Subnormal rainfall is clearly indicated for each of the years 1962-66, for the months of April through September. Departures from normal precipitation of 21 inches for the six month period for each year are as follows:

| | |
|---|---|
| 1961 | Normal |
| 1962 | -18% |
| 1963 | -15% |
| 1964 | -27% |
| 1965 | -22% |
| 1966 | -28% |
| 1967 | +26% |

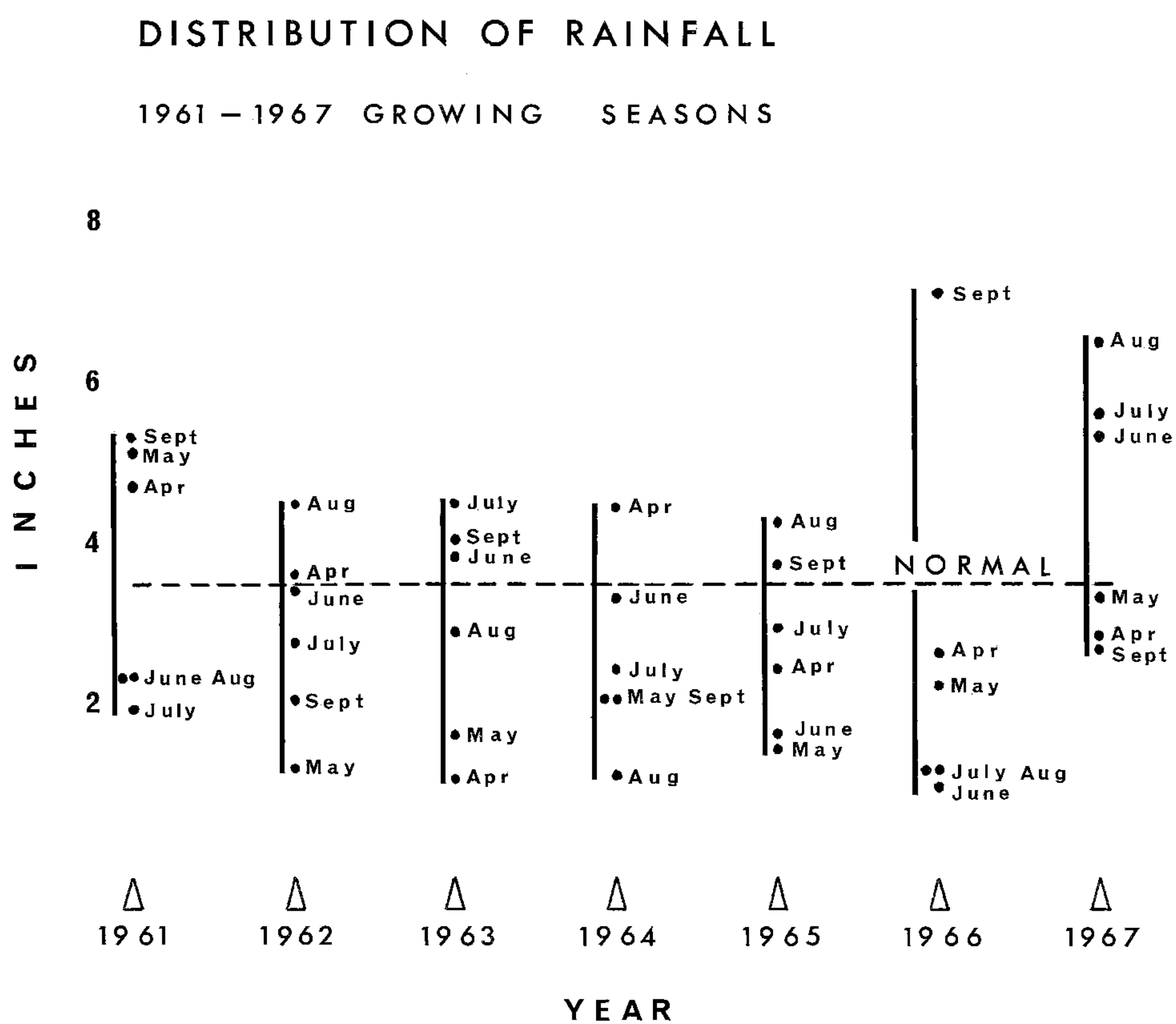


Figure 1. Monthly rainfall data during the 1961-1967 growing seasons in relation to the normal monthly rainfall.

On several occasions understory vegetation on or near hilltops actually wilted. Concurrent with, or soon after wilting, ground cover plants and low shrubs began to brown prematurely. Leaf fall from shrubs occurred sooner than normal following these signs of distress.

Drought was never severe enough at any one time to cause discolorations of leaves or leaf fall from any of the deciduous trees such as that noted by Hursh and Haasis. Dieback in most cases was evidenced by gradual decline in crown vigor or sudden mortality in mid-summer. Many trees showing symptoms of decline during one summer died during the dormant season and did not leaf out the following spring.

About thirteen percent of the 1966 acre portion of the Harvard Black Rock Forest studied in detail suffered heavy mortality (Fig. 2). Criterion for inclusion into the heavy mortality condition was the loss of twenty percent or more of the basal area. Generally speaking, trees on westward facing steep slopes near ridgetops were hardest hit. These areas also have shallow soils and bedrock outcrops are common (Fig. 3).

Figures 4 and 6 illustrate conditions on the study area at the end of the 1967 growing season.

Figure 4 shows the location of all living tree crowns on the plot and also those trees that have died in the last five years. All of the dead trees with but one exception were scarlet oaks and they are rather evenly distributed throughout the plot. Live crowns in 1967 covered 57 percent of the plot area. Dead crowns cover another 24% and natural openings in the canopy account for the remaining 19% of the area. Tree condition classes as observed in 1967 are shown in Table 1.

TABLE 1

Tree condition classes on the study plot.

| Species | 1967 Tree Condition Class * | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | Total |
| | Number of Trees | | | | | | | |
| Scarlet oak (Q. coccinea) | 3 | | 1 | | | | 13 | 17 |
| Red oak (Q. rubra) | 7 | 4 | | | 2 | | | 13 |
| Chestnut oak (Q. Prinus) | 7 | 1 | | 1 | | | 1 | 10 |
| White oak (Q. alba) | 2 | 3 | | 3 | 1 | | | 9 |
| Miscellaneous ** | 3 | | | | | | | 3 |
| Total | 22 | 8 | 1 | 4 | 3 | 0 | 14 | 52 |

*Condition classes: 0, - Healthy; 1, - Slight distress; 2, - Crown 1/3 dead; 3, - Crown 1/2 dead; 4, - Crown 2/3 dead; 5, - Barely alive; 6, - Dead.

**Miscellaneous includes: Black oak (Q. velutina), Hickory (Carya glabra), and Hemlock (Tsuga canadensis). Plant names are from Gray's Manual of Botany, 8th edition.

Scarlet oak registered the greatest loss of basal area within the plot. (Fig. 5). Expressed in relative terms its standing slipped from first place to fourth behind red, chestnut and white oaks. As a result of this mortality, a natural thinning of close to one third of the original stocking has resulted.

Exposed bedrock accounts for only 8% of total plot area (Fig. 6). Soil less than 24 inches to bedrock occupies 33% and soil deeper than 24 inches covers 59% of the sample plot. The shallow soils are members of the Chatfield series and the deep soils are Rockaway (Ross, 1958). In the study area the underlying bedrock is granite and many of the coarse fragments within the soil are granite but the lithology of the fine earth portion is mostly slate. Origin of the soil parent materials has been discussed by Denny (1938).

## DISCUSSION

Forests on thin soil at high elevations usually are classified as non-commercial. In these forests tree form is poor, stocking is meager and species mix is always limited. Very little research has been carried out in these non-commercial forests but with increasing emphasis on water supply, recreation and amenities there is also increasing need for an understanding of some of the factors limiting growth of these trees and the proper management for objectives other than lumber and fuel wood.

Drought certainly is one of the factors causing poor growth of trees on thin soils and the effects are probably felt by the trees during most years, especially the trees growing on soils only a foot or two thick over massive bedrock such as the granite of the Harvard Black Rock Forest where cracks for deep penetration of roots are infrequent.

The inadequate moisture effect is rather insidious and it is only occasionally that the effect is dramatic enough or conspicuous enough to attract special attention. Browning of leaves during the growing season or early leaf-fall such as that observed by Haasis and Hough is uncommon and even wilting of tree leaves is seldom observed.

Droughts severe enough to kill trees outright are periodic and perhaps occur only every 50 to 100 years. This probably accounts for the few reports in the literature relating to the effects of extended severe drought on tree mortality. Death or injury by fire, disease, insects, or storms by comparison is rather frequent.

The rather unusual nature of extended severe drought in the Harvard Black Rock Forest is perhaps best illustrated by the fact that death of trees by drought is not mentioned in any of the bulletins and papers of the Black Rock Forest since experimental work was initiated in 1929. Especially striking is the lack of any mention of this by Ross (1958) who was particularly interested in climatic effects on growth.

Drought alone may not be the sole cause for the mortality observed. It could result from a combination of events. In the present instance an important contributing influence may have been an unusually severe incidence of canker worms and loopers (Paleacrita vernata and Erannis tiliarica) during the summers of 1962 and 1963. Oak forests were subjected to nearly complete defoliation

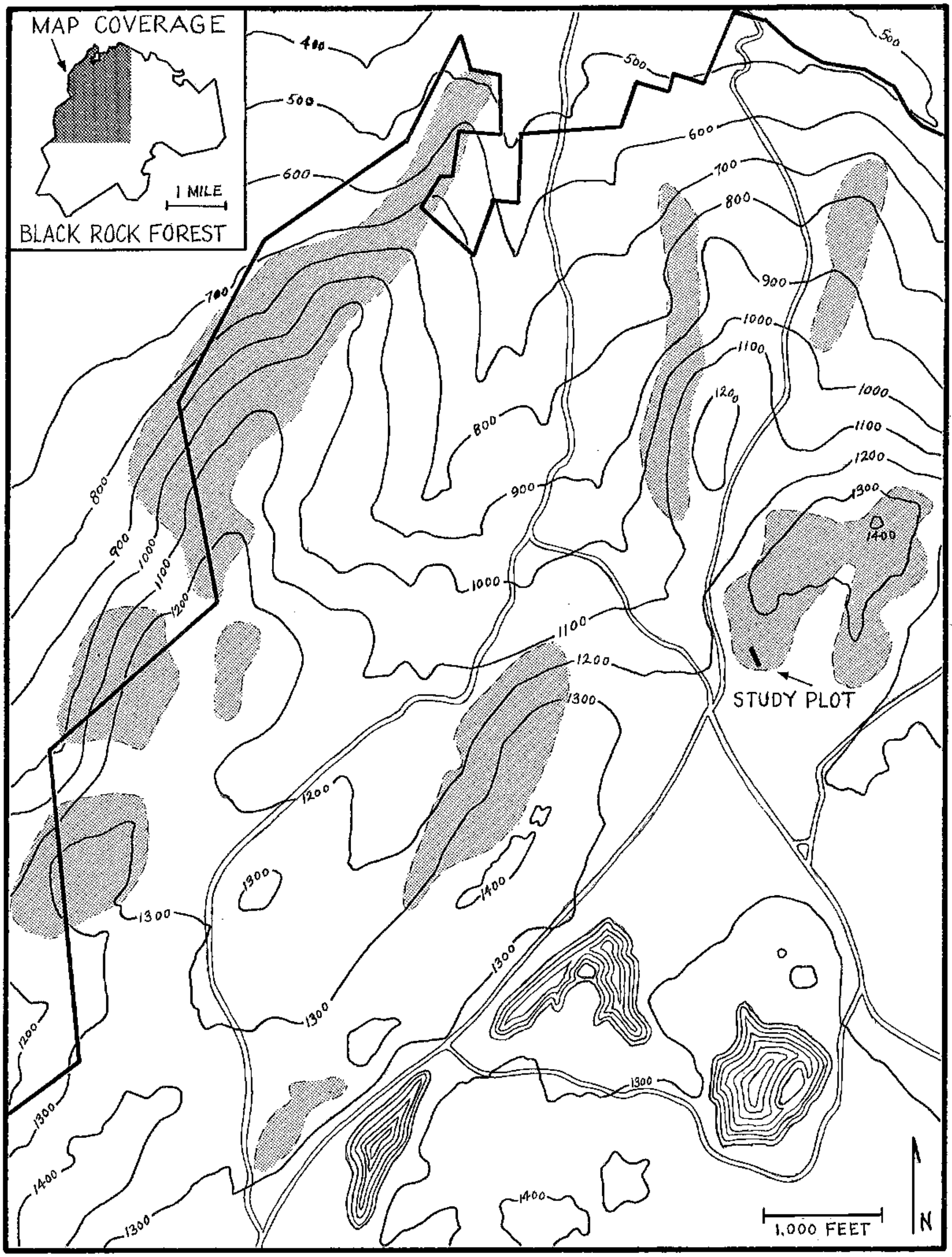



Figure 2. Areas of high mortality of oaks on a 1966 acre portion of the Harvard Black Rock Forest are shown by shading.

Figure 3. Bedrock outcrops are common in the areas where mortality is greatest. Trees tend to be short and scrubby where the soils are shallow. Many of the trees are of sprout origin.

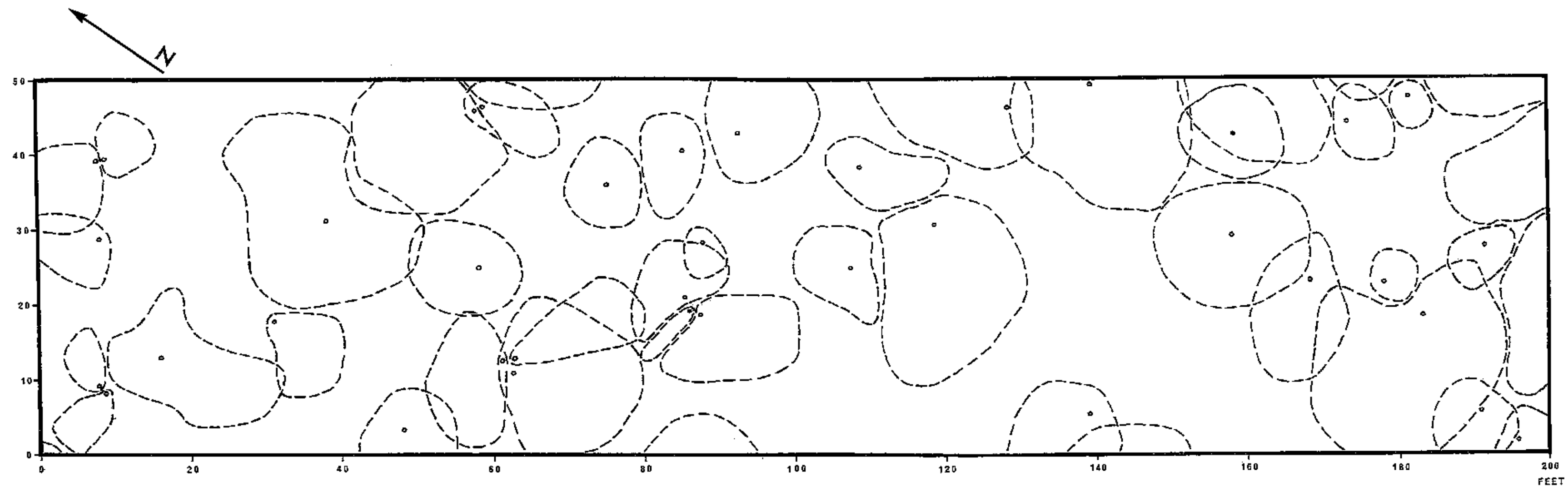
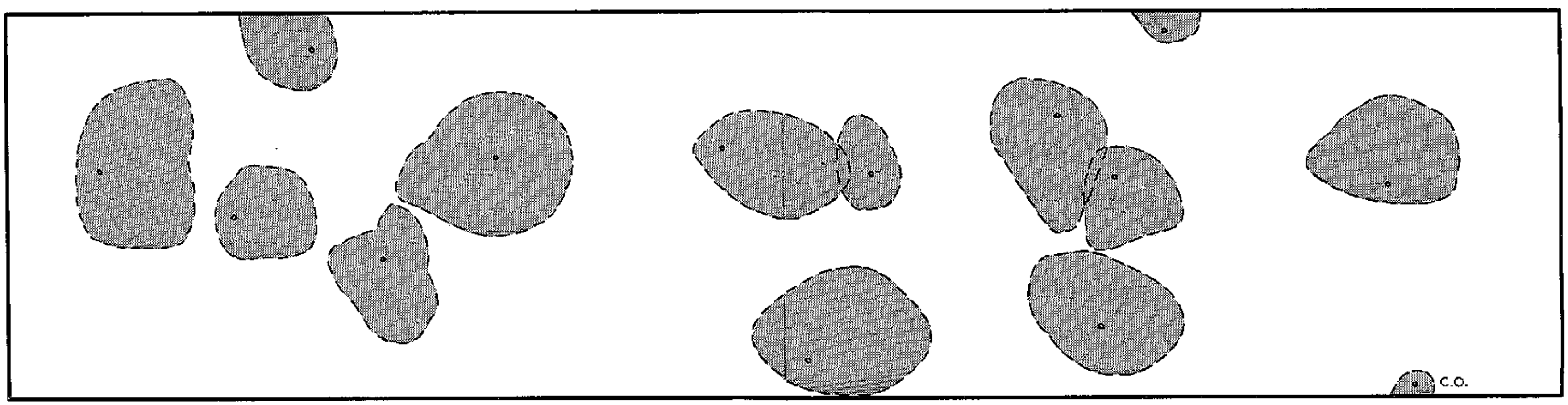



Figure 4. Crown canopy map of the study plot (top) showing location of all living trees over four inches in diameter breast height and (bottom) all trees killed by drought. With but one exception all dead trees are scarlet oak.



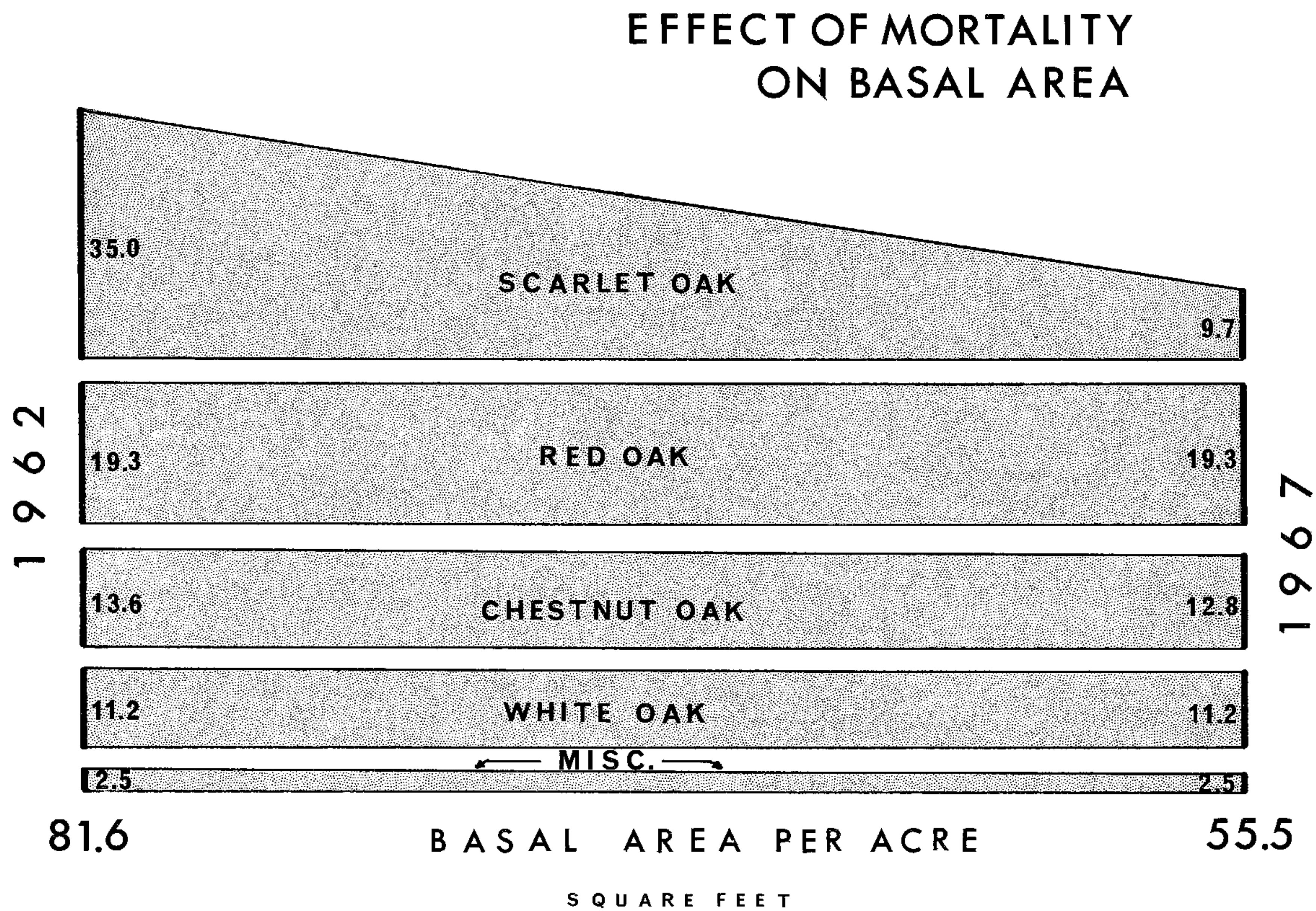



Figure 5. Changes in basal area on the study plot during the period 1962-1967.

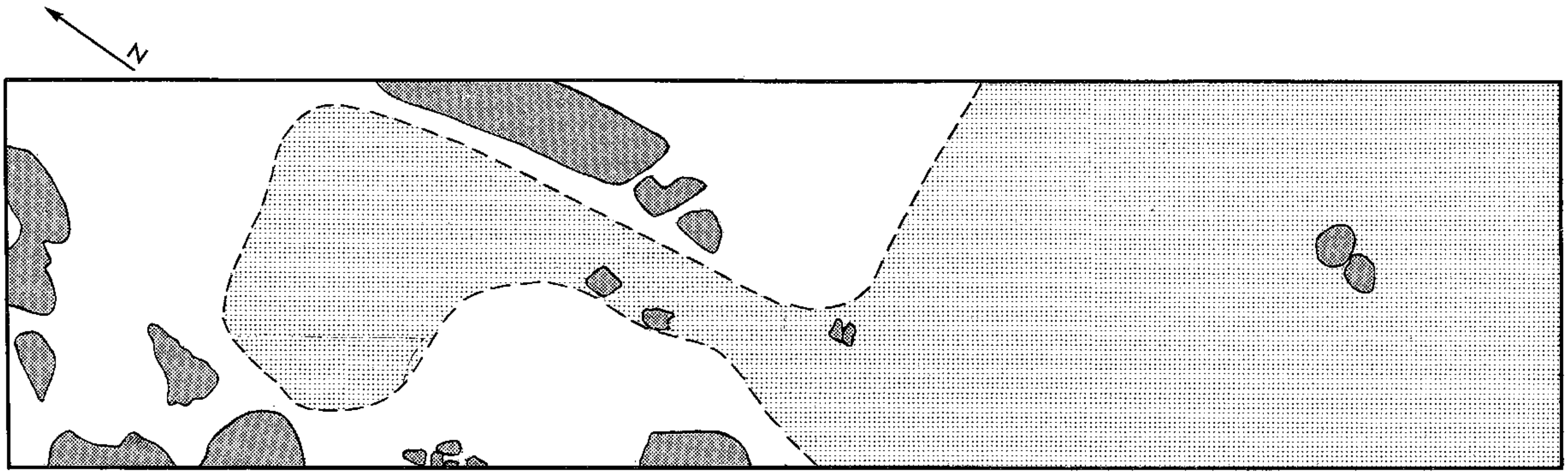
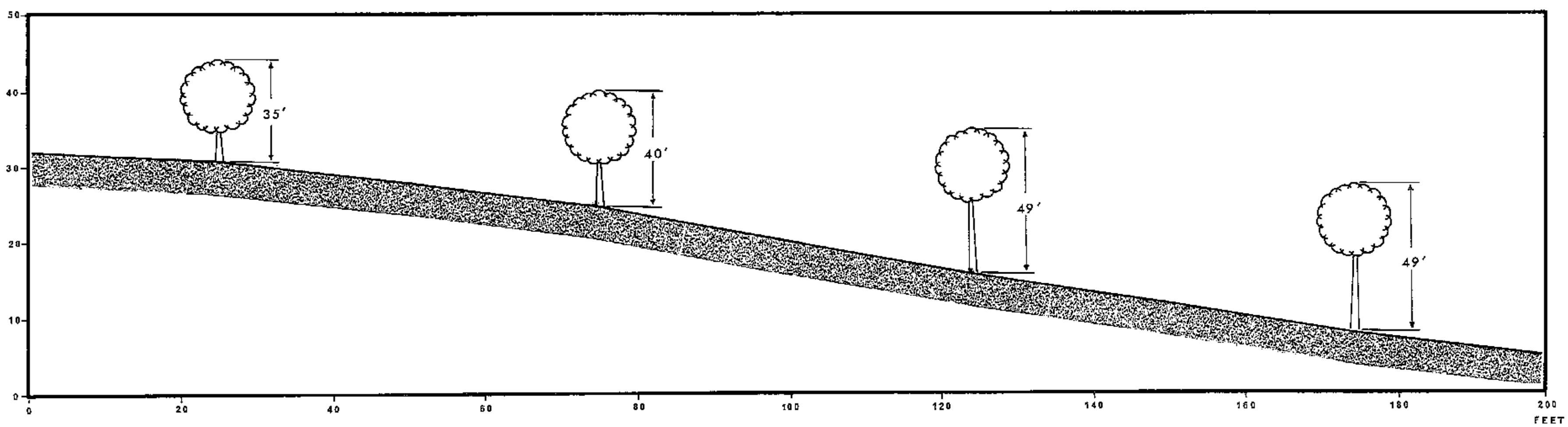
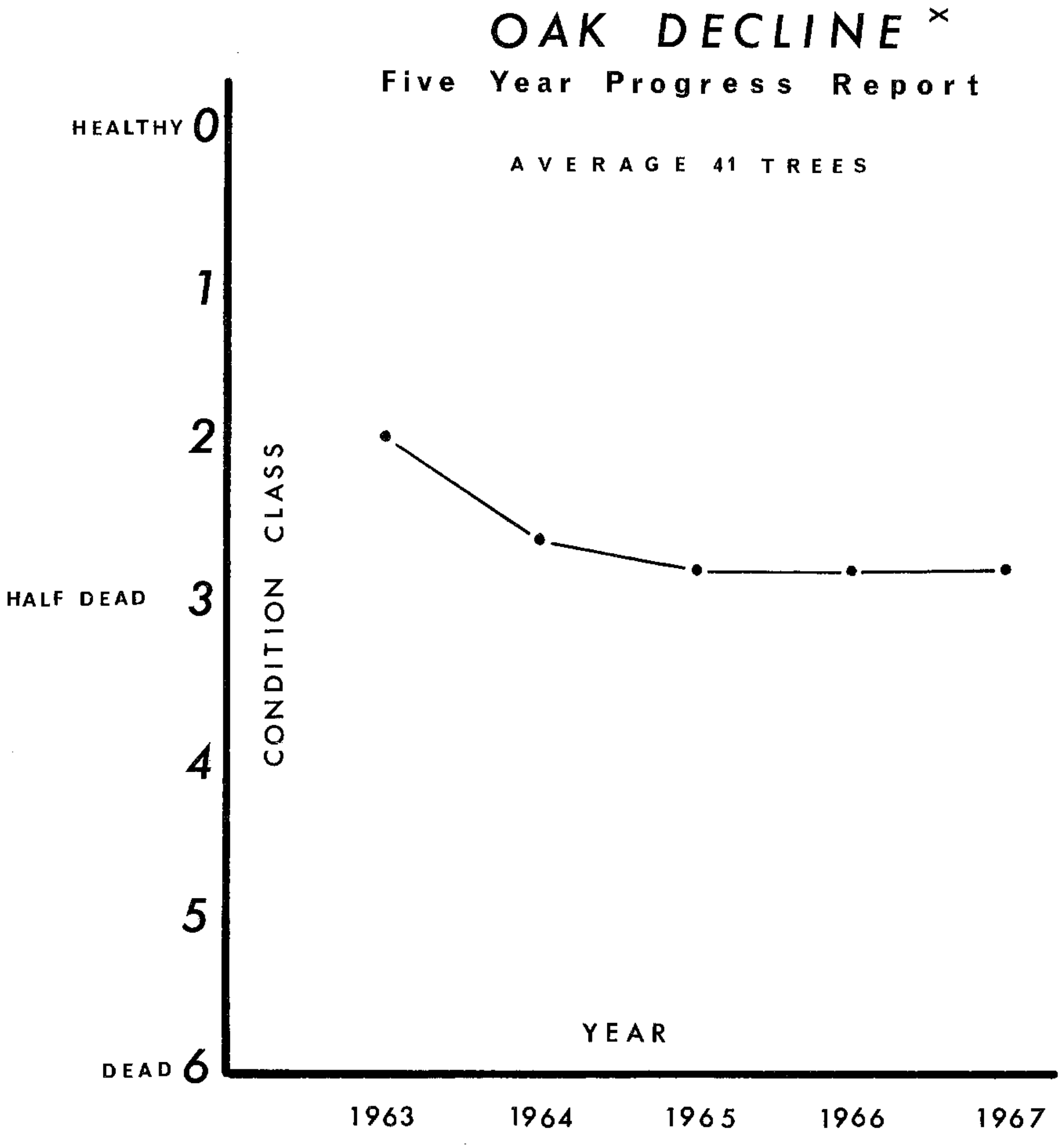



Figure 6. Location of bedrock, large boulders, kinds of soil and relative height growth in relation to position on the slope of the study plot. Bedrock and large boulders are indicated in the top diagram by dark shading. Soil depth is greater than 24 inches in the light shaded areas and varies between 0-24 inches in the unshaded portion. The bottom diagram is a cross section of the study plot showing slope at actual horizontal and vertical scale. Heights of trees are an average of dominant and co-dominant stems within the plot.






× FROM AN UNPUBLISHED STUDY CONDUCTED BY THE SENIOR AUTHOR FOR PALISADES INTERSTATE PARK COMMISSION AT BEAR MTN. PARK, NEW YORK.

Figure 7. Oak decline during a five year period in Bear Mountain Park, New York.

in places. No doubt this weakened many trees and these same trees later may have been the ones killed by lack of moisture.

Mortality of trees was not confined to the Harvard Black Rock Forest during the 1962-66 drought. About fifteen miles south of Black Rock Forest mortality of a similar nature was studied during the same period of time at Bear Mountain Park. When first observed in 1963 by Park officials, the dying had been in progress for a year or two. Several study plots established in affected areas revealed a gradual loss of vigor of the sample trees during the ensuing two years (Fig. 7). Between 1965 and 1967 no further decline was observed: by this time conditions had stabilized. Some trees died while others in various stages of decline maintained a somewhat static crown condition.

Drought effects are not confined to all shallow soils. The major effects seem to have been on westward facing, steep slopes. The areas generally are characterized by considerable amounts of exposed bedrock such as shown in Figure 3, so shallowness, steepness and aspect are probably important factors.

This study suggests that in the management of non-commercial forests, especially those in the hilly areas of the Hudson Highlands, attention can be given to the steep westward-facing shallow soils with the reasonable certainty that during some future drought period there is likely to be considerable mortality of scarlet oak. While this species need not be eliminated from all consideration in the management of these areas it would seem reasonable to favor other species of oak if a cover of long-lived large trees is one of the goals of management. On the other hand it is conceivable that scarlet oak might be favored in some instances, especially when young because death during drought produces a kind of natural thinning that might be more economically feasible than man-made thinning. Then, too, long-lived large trees may not be a management objective everywhere. There can be real beauty in dead or stag-headed trees in some situations. And a mixture of several species of trees may have advantages for amenity as well as for ecological reasons. Also from a practical standpoint it would appear that greater variety of tree species on a given unit of forest should provide many more management options to the landowner.

Although our study shows that scarlet oak has been reduced in numbers they have not been completely eliminated and it is likely that through reseeding new trees will be established in the newly created openings. If a severe drought does not occur for a while, say 50 - 100 years, this species may regain its former prominence. Obviously this whole process of death and regeneration must be considered in any management program of such a dynamic ecological system.

## LITERATURE CITED

DENNY, C. S. 1938. Glacial geology of the Black Rock Forest. The Black Rock Forest Bull. 8.

HURSH, C. R. and F. W. HASSIS, 1931. Effects of 1925 summer drought on southern Appalachian hardwoods. Ecology 12: 380-386.

MCINTYRE, A. C. and G. SCHNUR, 1936. Effects of drought on oak forests. Penn. Agri. Exp. Sta. Bull. 325.

ROSS, P. 1958. Microclimatic and vegetational studies in a cold-wet deciduous forest. Black Rock Forest Papers 24.

STALEY, J. M. 1965. Decline and mortality of red and scarlet oaks. For. Science 11:2-17.