THE BLACK ROCK FOREST

BULLETIN NO. 10

HENRY H. TRYON, *Director*

TEN YEAR PROGRESS REPORT 1928–1938

By

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With an Introduction by
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INTRODUCTION

More and more are foresters becoming thoroughly convinced as to the outstanding utility of well-located and well-developed demonstration and research forests and that their usefulness will increase many-fold with each decade of successful operation. Also it is generally agreed that too few demonstration and research forests are available in the United States. All the more interest, therefore, centers in such of these forests as have been in existence for some time.

The Black Rock Forest, of which this bulletin is the first decennial progress report, is rapidly taking its place as a seasoned demonstration and experimental forest. This Forest, because of its proximity to both the metropolitan areas of New Jersey and lower New York State and to the wooded, rough, hilly land of northern New Jersey and the Highlands of the Hudson, should contribute substantially to the solution of important economic and social problems involving land use peculiar to the region. Because of the representative nature of the Black Rock Forest, and because of its size, location, and the valuable records which are being accumulated it is serving well as a research and demonstration forest. A research program has been in progress long enough to bear fruit in the form of bulletins and papers. A variety of silvicultural treatments are under experimental trial, numerous forestry practices are being demonstrated, and much attention has been devoted to research in the problems of timber growing. These objectives are essentially the same as those of demonstration and research forests in other parts of the country.

Now that the value of many of the demonstration and

experimental forests of New England has been greatly impaired by the hurricane of September 21, 1938, and since considerable time will be required for their rehabilitation, all the more reliance must be placed on similar forests in adjacent regions in seeking answers to the problems of forestry. These forests must and will be used to point the way to technically correct and economically sound forestry practices.

Notable results have been obtained during the last 10 years and more will accrue as the Black Rock Forest continues longer under efficient, intensive management. It is safe to predict that as the Forest becomes better known it will attract foresters, timberland owners, forest managers, and operators who will wish to see on the ground the results of various treatments and to obtain first-hand information as to their success and costs. Although no two foresters would present a progress report in the same way, it is hoped that more such reports on demonstration and research forests will be forthcoming. They will contribute materially toward developing rational forestry practices on sound bases.

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DESCRIPTION

Location

The Black Rock Forest, a tract of some 3,000 acres, lies about one and a half miles west of the Hudson River in the upper limits of the section known as the Hudson Highlands. It is partly in the town of Cornwall and partly in the town of Highlands. Two dirt automobile roads connect the forest with the villages of Cornwall, Cornwall-on-Hudson, and Highland Falls. These, coupled with the network of woods roads and foot trails maintained within the forest, make the area easily accessible.

Inception

The Forest has been held under private ownership for several decades. In 1927 it was decided to utilize the area as a research and demonstration forest, and this work was initiated in the fall of that year.

Objectives

In adapting the property to this use, three objectives have been maintained; a model forest to demonstrate the practice of forestry; an experiment station for research primarily in fundamental and applied silviculture; and, to a lesser extent, as an instructional unit in cooperation with forest schools. In the background, however, and somewhat obscured by the detailed activities which of necessity must accompany the actual physical work, there lies the principal goal—that of improving living conditions on farms through the dissemination of increased

knowledge of practical and profitable forest management with especial reference to the farm wood-lot.

The Forest lies at the back door of the greatest center of population in the country. It is representative of an extremely large area (approximately 1,000 square miles) of rough, stony, wooded land, much of which, following emigration from about 1850 on, has reverted to what is practically a wilderness. For such rocky, steep, and thin-soiled areas, the only foreseeable use is for recreation or the production of forest products.

The technical results thus far obtained seem to justify the venture. The Forest has, we believe, been accorded its place in silviculture in the United States generally and in the sprout hardwood region in particular.

Scope of Program

The first objective of any demonstration forest should be the preparation of examples of forest lands which can be profitably cropped at more or less regular intervals. To this end we began our field work with several cautious applications of various types of improvement cuttings. These have included cleanings, increment, reproduction and clear cuttings. Following the expansion of our program in 1932, a number of projects of intensive research in fundamental silvics have been undertaken. Coupled with our cutting program, there have automatically appeared numerous opportunities to gather useful data on various phases of mensuration and management. In similar fashion our laboratory work on soils and nutrients made necessary the establishment of a small experimental nursery. In 1933 this nursery was expanded as a source for planting stock of species not ordinarily obtainable in the open market. Beginning with the spring of 1928, 16 acres of abandoned farmstead have been reforested, 45 acres of mixed hardwoods have been cut clean and replanted with coniferous species in a definite exper-

imental attempt at type conversion, and 64 acres of mixed hardwoods have been cut clean and partially reset with conifers with the object of establishing both groupwise and stemwise mixed stands.

Publications

From the beginning we planned to publish such of our silvicultural findings as seemed to have merit. But with the inception of research here, there promptly became evident a need for the study of forest problems upon a distinctly broader biological base than has hitherto been customarily employed in this country. Hence we decided on the publication of a series of monographs dealing with our various biotic and edaphic factors.

Our first bulletin appeared in 1930. With the completion of our soils laboratory in 1932 we were enabled to expand our program to include detailed research in intensive silviculture. A fairly wide array of worthwhile data on fundamental silvics has since accumulated, much of which resulted from work in several fields and was none too well adapted for publication as a single bulletin. So, as an outlet for these shorter, less formal articles, the Black Rock Forest Papers were initiated in 1935.

With the aid of Mr. Harold F. Scholz of the U. S. Forest Service, Dr. A. B. Hatch, of the School of Forestry, University of Idaho, Dr. Hugh M. Raup of the staff of the Arnold Arboretum, Mr. Charles S. Denny of the Department of Geology of Harvard University and Dr. R. F. Chandler, Jr., of Cornell University, we have issued five bulletins dealing with soils, forest botany, geology, mycotrophy and tree nutrients. Various other allied lines of investigation—ecological studies, essays on land tenure and use, the effect of colonization upon local timber types, type succession, and entomological and mammalian studies—are being considered.

Certain of these fields will unquestionably be entered,

using a viewpoint and technique differing markedly from those customarily employed to date by the American forester. We believe this will be of mutual benefit, since we are in favor of greatly broadening the biological base of forest research. While these differences of method, of viewpoint, perhaps of actual concept undoubtedly exist, their earnest and sincere application here cannot fail to open lines of stimulating interest.

Through the kindness of the Oberlaender Trust, the Director had several months of study in Germany during 1938. Some time was also spent in the oak and beech forests in Denmark, and we believe that these visits have yielded much valuable silvicultural data, with especial reference to the management of young stands of broad-leaved species.

We are not yet prepared to make definite forecasts, but we expect to make various applications of the knowledge gained abroad, particularly in the technique of thinnings in young hardwood forests.

Equipment

The forest is handled as a complete operating unit. A wide array of appropriate activities, both for experimentation in, and for the demonstration of, applied forestry are carried on. The existing equipment includes a fairly complete soils laboratory, the usual quota of teams, wagons, sleds, woods tools, scoots, trucks and a tractor; a sawmill, wood-saw, wood yard and shed, a portable steel wood chute,[1] a battery of portable charcoal kilns, a carpenter and blacksmith shop, a small stone-crusher, and the necessary engineering, mensuration and photographic equipment.

[1] Jour. of Forestry, 1932, XXX, 8.

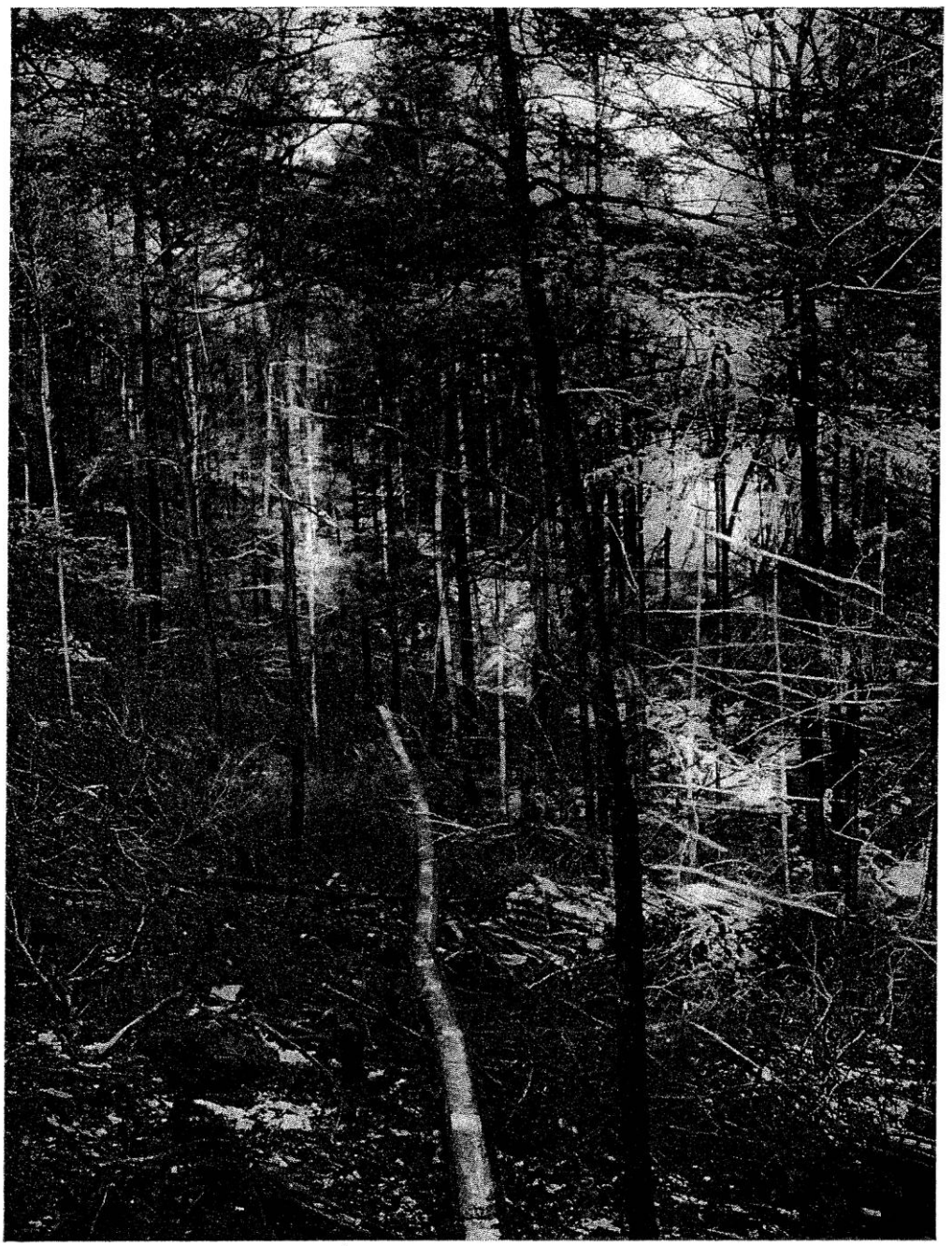


PLATE I. BLACK ROCK FOREST PORTABLE SECTIONAL STEEL WOOD CHUTE. CTG. 5A COMPT. II; WEST BANK OF ALECK MEADOW BROOK. 225′ OF CHUTE LAID IN PLACE READY FOR USE. WATER HAS BEEN SLUICED IN, BUT RESULTING ICE DOES NOT SHOW.

Utilization

The chief commercial timber species are, in order of value: white oak, white ash, red oak, black oak, yellow poplar, hemlock, sugar maple, hickory, red maple, yellow birch, and black gum. Seldom do any of the other species attain a grade which warrants using them for anything but fuel. The Forest operations yield some dead chestnut, blight-killed about 1916, which occasionally makes a few loads of medium-sized posts, but as a rule cuttings of this species are either too small, or too deeply checked to be successfully used for other than fuel.

Our sawmill products are chiefly 8/4 and 12/4 rough stock in hardwoods and rough dimension in hemlock. We occasionally saw a special order for a few feet of hickory. The bulk of the thick, rough stock is used for heavy construction, stalls, truck bodies, wearing strips for stone barges (Hudson River traffic), ferry slips, wagon bodies and axles, poles, reaches and bolsters, bridges, ice runs and railroad cars, or is resawn by the customer for handles, net bows and other uses. Our low-grade plank is used by road contractors for temporary bridges: our sawdust has a fairly regular market for ice-houses and bedding. Slabs are sold for fuel.

For the present, we estimate our annual increment at 1/3 cord per acre per year. Our average yearly cut has been 790 cords to date. For our first three years our wood sales moved slowly and we held the cut to a salable maximum of about 300 cords. In 1930 we designed the Black Rock Forest portable charcoal kiln,[2] which provided a fairly satisfactory outlet. We operated a 12-kiln battery from that date until the autumn of 1932, by which time we were well established in the fuelwood market.

[2] Black Rock Forest Bulletin 1933, IV.

PLATE II. GENERAL VIEW OF 12 KILNS IN OPERATION:—TOOL SHED, WOODRANKS, BRICK FLOORS, KILNS COOLING, BEING LOADED AND BURNING, CHARCOAL READY FOR SCREENING, DUMPING COAL THROUGH WINDOW ONTO SCREEN IN BAGGING SHED.

SILVICULTURE

Previous Exploitation

The economic history of the Forest has been previously set forth.[3, 4] Raup questions the assumption that the combination of clear-cutting, followed in most cases by repeated severe fires, has increased the percentage of inferior species—*i.e.*, species of comparatively lower commercial value such as red maple, gray birch, aspen and cherry. These and other local weed species are prolific producers of light, wind-disseminated seed which are quick to seize upon the hot, open areas left by the foregoing agencies. Foresters have long been in agreement as to the results of such practice; Hawley[5] and Graves[6] concur in accepting this viewpoint.

We personally feel there is no great room for argument. Any forest complex, be it a permanent or a transient type, is by no means static, even though the area be entirely free from disturbance by any of the familiar extraneous factors such as man, fires, storms, insects, and the like. Such a community is constantly losing its members by death, and the resultant openings in the overwood are, of course, effecting changes in the illumination of the soil, the local climate and the factors of locality, which changes in turn set up certain inevitable vegetational successions which are usually transient and whose composition nearly always varies from the main "permanent" type. Such intermediate successions are

[3] Tryon, Henry H., 1930. The Black Rock Forest. Black Rock Forest Bull. 1930, I.

[4] Raup, Hugh M., Botanical Studies on the Black Rock Forest. Black Rock Forest Bull. 1938, VII.

[5] Hawley, R. C. The Practice of Silviculture: Wiley & Sons, 1931.

[6] Graves, H. S. Principles of Handling Woodlands: Wiley & Sons, 1931.

often, in part, at least, short-lived forest weeds of various species. Again, if such a weed community be left undisturbed, it will, in nearly all cases, revert in time to the composition of the main stand. On the other hand, if severe extraneous disturbance occurs, such transient successions will also be initiated, the chief difference being that under such conditions the invasion by temporary associations will be aggravated, and the period necessary for "reversion to type" will probably be lengthened.

It is a complicated and perhaps touchy subject, yet we are willing, for the sake of healthy discussion, to take our stand with the adherents to the belief that over-cutting or other disturbance, does temporarily alter stand composition, usually in the direction of inferior species. We believe that many American foresters are none too well aware either of this phenomenon, or of the fact that such transitory successions must often be temporarily endured as their presence is frequently necessary properly to prepare a given site for the permanent association.

From the beginning our cutting policy has been extremely flexible. Only two definite limitations have been adhered to. One was to open the main canopy no more than seemed absolutely necessary, and the second was to confine these operations to what appeared to be the more potential areas. We assumed that as our detailed knowledge of conditions increased, we could then advance further up the slopes into the poorer sites. In general, these limitations have been well observed except that there has been evident a tendency to lower the altitudinal limit of our operations.

An examination of the records of the cutting operations since the fall of 1927 reveals an interesting change in silvicultural policy. Our first cuttings were based primarily upon the old German system of thinning from below. We sought to raise the annual increment, to improve both tree form and species mixture, and to increase the percentage of seedling reproduction. Our first

cuttings made clear to us the possible inadvisability of further applications of the German method in this region. The aggressive sprouting ability possessed by practically all of the indigenous hardwood species made it plain that cutting the underwood invariably present in the two-storied hardwood forests common to this region would usually produce dense heads of sprouts which not only greatly hindered desirable reproduction, but which could not, save by the application of highly expensive cultural methods, be brought through to commercial size or quality.

The forest records contain recommendations for future treatment of each cutting. Our first impressions here frequently suggested that the initial thinning be followed by two or three subsequent operations. As we grew better acquainted with our conditions, our policy became proportionately simplified. Today we believe that with the majority of the associations now present on the forest, it is possible to bring the site in question into fairly productive condition with a thorough cleaning, followed later, perhaps, when natural reproduction has been sufficiently started, by the mowing and clear-cutting treatment worked out at the Harvard Forest by the late Dr. R. T. Fisher. This plan is put forward only as regards such of our stands which, owing to previous lack of any culture are today fit for nothing but fuel—and cannot now be changed over to a higher grade of product. This suggestion applies only to our more productive soils. We are not as yet sufficiently familiar with the possibilities of our sites lying much above the 1200-foot contour.

One cutting made in the winter of 1927-28 was largely intended to be a rather heavy thinning. In actuality it worked out as the coppice with standards method. Repeated examinations of this area made during the first three years following the cutting caused us considerable mental discomfort. We could find little indication of any future promise as all the large hardwood stumps sprouted

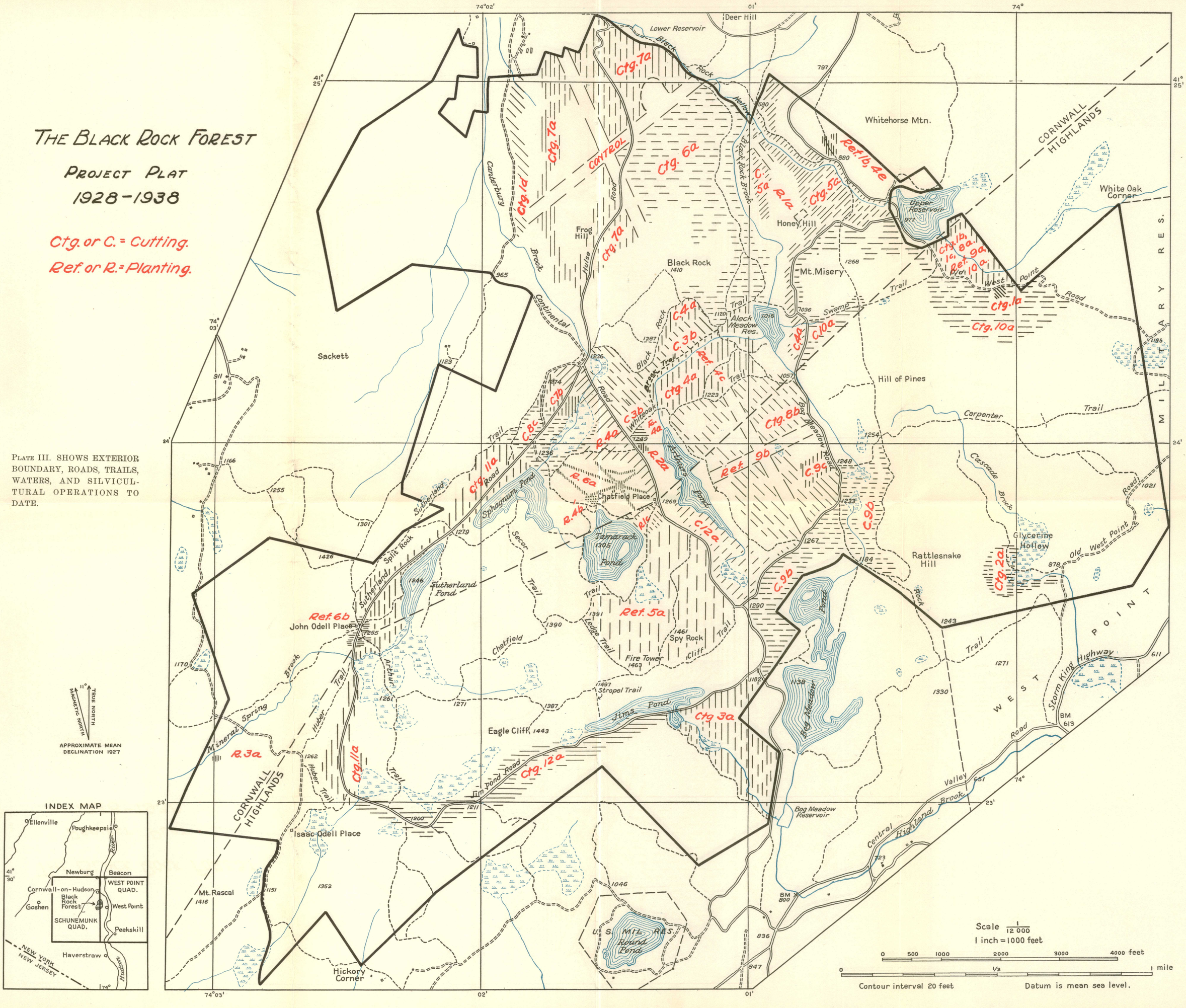
THE BLACK ROCK FOREST

PROJECT PLAT
1928–1938

Ctg. or C. = Cutting.

Ref. or R. = Planting.

PLATE III. SHOWS EXTERIOR BOUNDARY, ROADS, TRAILS, WATERS, AND SILVICULTURAL OPERATIONS TO DATE.



with tremendous vigor. In the third and fourth seasons, however, the natural reproduction began to take hold in very satisfactory fashion. The area has since been given two careful weedings with the machete, and today we regard it as one of the most promising experimental cuttings on the forest.

Another small area was clear-cut in the winter of 1931-32. Here again the sprouting capacity was very evident. With the object of determining the least expensive and most expeditious method of producing the greatest number of cubic feet of low-grade hardwoods per acre, two-thirds has been weeded very lightly, and the remainder has been left to grow as a control without any cultural treatment whatever.

In the winter of 1934-35 we put through our first complete application of the Fisher method mentioned above. Some nineteen acres of mixed hardwoods which had been given a reproduction cutting in 1927-28 and which had since seeded down to a good setting of valuable species were first mowed and then cut clean. Our plan is to give this area the minimum amount of cultural work necessary to produce mixed hardwoods of high quality. At present we estimate that the first weeding should take place five or six years after the clear-cutting.

Generally speaking, our cleaning policy today calls for the removal of all gray birch, aspen, and elm, together with all dead chestnut which is occasionally present in large numbers. Where conditions warrant we remove some of the intermediate and codominant trees with perhaps an occasional dominant member of the community. We do not now interfere with the underwood more than is necessary for the choppers to get at the trees which are to be felled. We believe that the comparatively high shade cast by this understory preserves the factors of local climate better than does the low shade thrown by dense heads of stump sprouts.

Our Existing, Tenative Practice

To be successful—that is, to be a salable article—any form of silviculture must show something resembling a profit. The majority of our operations to date have been carefully planned with the thought of combining reasonably correct practice with a profit, or at least completing the operation without a deficit. The latter outcome may be fairly translated to mean that the improvement work done was obtained at the cost of the interest on the cash outlay involved, plus the depreciation on the equipment employed. As might be expected, we have not always succeeded in this; and in planning certain cutting operations we have deliberately ignored the cost factor for the sake of making a detailed and intensive experimental cutting. Our horizon is by no means limited by cost figures; where the possible results appear to warrant it, we are willing to attack a problem from the angle of pure research.

Our general working policy is a cleaning-up process of the more potential sites. Our plan is to give these areas a quick preliminary treatment as rapidly as funds permit. We expect to complete this part of our program by 1948. At that time we anticipate retracing our steps, although not necessarily in exact order. This second exploitation is expected to yield timber crops containing a higher percentage of saw timber, and a lower percentage of fuelwood than is the case with our current cleaning operations. These second treatments, some of which will be thinnings, some reproduction cuttings, some of which may perhaps be final cuttings, are expected to be carried forward on a more modest acreage scale than is at present the rule, and we are hopeful that these later cuttings will aid materially in meeting some of the various budget items in addition to the operating costs. These future treatments will be carried on in more intensive fashion. It is confidently felt that with the start of the

second cutting cycle we shall reap a deal of accurate, quantitative data on the effect of our first treatments—just as the cuttings we are making today are telling us much about the early local cutting practice and its effects during the interval when the brickyards, charcoal pits and the wood-burning river steamers consumed vast supplies of cordwood from these hills.

With this second series of operations we shall enter the hitherto comparatively unexplored field of our upper slopes and ridge tops. Thus far we have done no improvement work on these sites, as we deemed it imperative to put the most potential areas of our household in order to provide, so far as we are intelligently able, for a steady source of future income. We believe that by 1948 we should be sufficiently familiar with our various types and their response to varying treatments to begin a cautious management of our poorer, "Alpine" areas.

Silvicultural Concept

One of our most fascinating forest problems, and one which may apparently be attacked from a varied assortment of viewpoints is the determination of the composition and the degree and kind of productivity of the pre-colonial forests of this section. Considering our intention to place this tract on a sustained annual yield basis, we have great need of precise knowledge of the early stands and their relationship to the existing timber types.

The various and somewhat conflicting hypotheses on the composition of these pre-colonial stands is outlined below. Investigative work on this problem should be carried forward as rapidly as accuracy will permit, to afford a sound basis for silvicultural practice today. Our knowledge of the highly involved interactions taking place between the forest complexes and their immediate surroundings and even within the associations themselves is distinctly scanty. But accurate determination of the

pre-colonial growth is not easy. We should make clear that reliable written data is practically non-existent in this region. There are available a number of diaries and journals kept by early settlers and travelers, but, save for Cadwallader Colden and André Michaux, no one of these was a botanist, and Colden's interest lay almost wholly in field crops and flowering shrubs. The writings of these early visitors show little more than a general interest in tree growth. Occasional remarks appear anent the extent of the forest, or the size of trees, but there is very little in the way of definite statement on the composition. A typical quotation occurs in Bacon's "The Hudson River from Ocean to Source."—"We anchored between two high shores bespread with spruce, chestnut, oaks and other trees, very like the towering banks of Bergen." Similarly, Lossing (1866) expatiates "The rocky shores of the Hudson . . . rise to almost 1600 feet above the river, and are scantily clothed with stunted trees." Yet Colonel William Fox fires this contrasting broadside in his "History of the Lumber industry in New York."—"New York was essentially a white pine state. . . . There exists ample historical evidence of uniform distribution of this species throughout the state." Again, the 15th annual report of the New York Forest, Fish, and Game Commission remarks of this section, ". . . the original mixed forest, in which pine and hemlock were present in considerable proportion, has become hardwood almost entirely, with inferior species predominating."

Turning to the utilization phase, the early commentators give us at least a vague picture. Perhaps the Marquis de Chastellux[7] sums it up after climbing Storm King Mountain, "There I halted to consider the landscape, which, combined with a number of sawmills and

[7] Travels in North America in the Years 1780-'81-'82; 1827.

furnaces compose a most capricious and romantic prospect.'' A number of similar excerpts might be quoted: and it is clear that sawing timber was a good deal of a business in Orange County. But no early traveler has been specific regarding the location of the plants or the source of the timber. The point has been made that the great chain stretched across the Hudson to halt the British fleet was buoyed up with great white pine logs. These might have been cut locally, or perhaps rafted down from up-river. On the other hand, the county land records pertaining to the Storm King and Cro' Nest area, make mention of ''Tiffany's Pitching Place''—a spot on the northeast shoulder of Cro's Nest whence logs were delivered by a chute to the Hudson. As hardwood logs are not driveable, it seems probable that these were either white pine or hemlock and, unless the early loggers held to ideals of logging efficiency sharply different from those observed today, these species grew at least at the same altitude as the ''Pitching Place,'' for no logger hauls uphill.

A recent personal examination of ''Tiffany's Pitching Place,'' made in June, 1938, reveals that:

1. Oxen were undoubtedly used for hauling.
2. There is today some excellent hardwood timber tributary to the road leading to the ''pitching place.''
3. Judging by the diameter of the sprouts now standing here, the last cutting was made fully eighty-five years ago.
4. Hemlock is strikingly plentiful here.
5. White Pine is scatteringly present.
6. Much of the area has been burned.
7. The amount of labor expended on the road to the ''pitching place'' indicates that much valuable timber must have been rendered accessible thereby.
8. There is no spruce present today.

To close, and perhaps to add further to the confusion, Ruttenber, in his History of Orange County, states ''the great business of the period (1700-1800) however, was lumbering; for which avocation the dense woodlands in the vicinity of the river gave abundant opportunity for

sawmills and sturdy woodsmen, whose pathway is still marked by deserted mill privileges.''

But, with these comments, let us outline these various hypothetical concepts.

A. That the present arrangement and content of the timber types in the Black Rock Forest have persisted from pre-colonial times.

There exists some admittedly scanty evidence to this effect. It does represent, however, various lines of inquiry, and little has been found to point in the opposite direction. For a detailed discussion, see Raup, 1938, *loc. cit.*

If it be granted that the disturbance of any species association by extraneous factors will result in a temporarily upset condition followed by a fresh series of vegetational successions, there exists a sturdy piece of evidence which should make one pause abruptly before completely accepting the ''A'' hypothesis given above.

This evidence lies chiefly in the time element. Exploitation of these hills began but a few generations ago, and in the case of the Forest, ceased only during the past quarter-century. So far as we have been able to ferret out the facts, the long easterly slope of Sackett Mt. (Compt. I) is our oldest stand, having been cut approximately 70-100 years past. All our other stands are younger, and were operated (and frequently burned) within a considerably shorter period. So, if a cutting be admitted as the cause of vegetational changes, can it be claimed with accuracy that 70-100 years is a sufficient time in which to re-establish the pre-colonial associations? From what we have observed of the behaviour of our aggressive weed species we cannot visualize this happening in this short interval. We feel that not enough time has passed and that we are still in the transitory stages.

B. That the pre-colonial stands on the Black Rock Forest contained a larger amount of coniferous species, especially hemlock and white pine.

The available maps and records of land tenure reveal that there were at least fourteen cultivated farmsteads on the Forest between 1793 and about 1880. If the owners of these holdings ran true to the usual colonial type of individual (and thus far we know of no reason why they should have differed), they probably made intensive use of what lay close to hand. The presence of a tannery on the Continental Road just below the south line of the Forest, and the existence of three lime kilns, one close to the northeast shore of the present Spruce Pond, another on what is today called Limekiln Hill overlooking Round Pond, and the third on Canterbury Brook about 200 feet north of the Sands Bridge is regarded by us as reasonable evidence of the presence of stands of commercial hemlock as well as these familiar pioneer traits. Of the several houses which formerly stood on this forest, portions of the one occupied by Isaac Odell have been found and examined.[8] Portions of the sills, the framing, the rafters, and part of a long table were found and identified. The sills were white pine, the framing and rafters hemlock; the table, which had partly rotted, had a top of unknown length, but it was a white pine plank about 42 inches wide and 2½ inches thick. There are several old woodsmen living here who used to peel hemlock bark for their winter living. There is ample evidence that these hillsides have been repeatedly cut clean, and that these cuttings were often followed by fires. The latter agency is admitted to be a most efficient deterrent to white pine and hemlock reproduction.

Hence we feel that there exist a few bits of evidence that conifers, chiefly hemock and white pine, were for-

[8] This dwelling stood near the Cat Hollow Road, and about 0.7 miles from the White Pine stand scattered through the swamp just south of Sutherland Pond.

merly more common here, but that cuttings and frequent fires have conspired greatly to reduce the percentage.

The White Pine-Mixed Hardwood Areas

The Forest includes areas whose present composition have not yet been satisfactorily explained by such ecologists as have seen them. The largest of these is the white pine-mixed hardwood section extending southerly along the south shore of Sutherland Pond. Here occur the usual local hardwoods—red, chestnut, and white oak, with some white ash, yellow birch, red and sugar maple, and hemlock in the more moist hollows. But scattered through the stand are fairly numerous single white pines running up to 14 inches d.b.h., with a maximum age of perhaps 75 to 100 years. Elsewhere in the forest, occasional similar, smaller groups of white pine may be found, with some spotty reproduction of this species ranging from 4 inches to 10 feet in height. Fire-scars are plentiful. In the Sutherland Pond area, except for a chestnut operation which was made some time prior to 1916, signs of previous cuttings are almost entirely lacking. The majority of the hardwoods is of sprout origin, and their size indicates that the last cuttings, if any, must have taken place at least sixty years ago. In this area the ground is rough and ledgy. The rather shallow, somewhat porous, friable soil is scattered between rocky cliffs and large flat surface outcroppings of ledge. In other areas, however, white pine is found on heavy, deep soils and even in rather moist sites such as hummocks and islets in the swamps. The one factor common to the sites where white pine is now present is the lack of accessibility.

Whence came these white pines? Was this species once more common? Were they the trees first to be cut by the early settlers? Were the few remnants spared merely because they were in sites too difficult of logging?

Or are they the result of some other combination of secondary agencies?

It does not appear unreasonable to assume that in pre-colonial days white pine and hemlock was rather more plentiful here than at present. The outcrop of ledge and surface rocks was probably fairly well covered with a layer of organic material much deeper and of a different composition than the present deposit now covering the mineral soil. Such a thick humus layer would retain moisture for a much longer period than the present scanty blanket. With the appearance of the white man, rapid removal of the virgin forest for building material and for heating purposes must have followed. In fact, these hills must have been well denuded by 1830 when agricultural development reached its peak. It is known that at about this date the smelting of iron ore was abandoned, due to lack of charcoal. At the same time forest fires became more common. The combined removal of the overstory, with the consequent death of the stools followed by successive scorchings, converted this organic layer into the familiar gray powder which subsequent rains quickly washed away. The ash left from the consumed humus rapidly leached away into the soil, leaving only bare, rocky ledges and impoverished soils unable to sustain a good stand of timber.

In the areas where fire has not altered nature's processes so severely there exist frequent examples of the effort to reclothe these exposed rocks and ledges with an organic blanket. Various mosses, lichens and leaf deposits are slowly, but persistently, creeping up over these bare spots. Here and there, where the process has formed deposits of sufficient depth about the base and sides of an outcrop, or perhaps where a weathered pocket on the top has served as a catch-all, the small, woody plants are appearing. With these are found scattered white pine seedlings. In addition, white pine of fair size (up to 12 inches d.b.h.) are frequently found standing on such ex-

posed rocky sites, maintaining their hold with the usual octopus-like root development.

These observations lend support to the theory that white pine was formerly more abundant here and that it is able to reproduce and maintain its presence in the stand when occasional breaks in the main canopy occur. Such breaks may easily have been due to lightning, which in these areas is apt to kill several trees in the immediate area where it strikes, or to openings caused by blow-downs.

Our General Scheme of Attack

Let us set forth the questions to be answered. First, are our forest types of today the same as the pre-colonial associations? If this be true, is it unreasonable to seek, through careful, planned experiment, what systems of forest management may be applied to the various associations here represented which will return the growing stock from its present somewhat degenerate condition to a yield of greater volume per acre and higher average quality of product per bole? Or, save that today's trees average smaller in size, and that there are many more sprouts than seedlings, are these types again perhaps essentially as they were in the primeval forest? Or, are these types new and perhaps transient associations which are the result of the repeated clear-cuttings and burnings definitely known to have occurred during the past 200 years? If this be true, can we, by the application of proper treatment, restore these associations to a condition of productivity at least equal to their former state, and probably distinctly more profitable than the present yields?

We admit quickly that we have not yet found the answers to the foregoing. We are carefully modeling our applied silviculture to test all three. Roughly, the keystone of our silvicultural arch is to determine as accurately as human failings will permit, what nature is try-

ing to do, and help her; not to work counter to nature, but rather to harmonize our efforts with natural tendencies.

Point of View

The statement has been made (Raup, 1938, *loc. cit.*) "... There seems no other way to determine the potentialities of the sites in this region than by such study of past productiveness." To this we take exception. This comment perhaps arises from the concept of type succession and interlocking fields held by the ecologic and floristic plant geographer. Inasmuch as we have thus far unearthed practically no reliable or complete written record which might throw any light on the problem of type succession in this region, the foregoing assertion seems to close the door rather abruptly in the face of further experimental work in applied silviculture. It is our feeling that this, to us, seemingly unwarranted limiting of effort may be promptly dismissed from further discussion on the grounds of unfamiliarity with what has thus far been accomplished in the field of determination of increment and the possibility of improving forest soils and of increasing growth and yield by deft, observant, silvicultural treatment.

Our whole field of effort appears to center about one point. What several associations of species will make the most profitable growth on the various soil sites reported here? Our findings during the past ten years indicate strongly that the indigenous mixtures, if given the proper amount of cultural "tending" will probably produce paying crops of hardwood sawtimber on our better sites, with salable yields of fuelwood operated on a rather short rotation on the less productive areas. But this assumption needs, and will receive, a deal of additional long-term testing, both in the field and in the test-tube.

We propose to continue these tests along the same general lines that we have thus far employed. Each year

one or more cuttings of various types is to be set up, with careful records. Except in a few acres of our plantations, we are not yet attempting to create pure stands, nor do we now expect to do so. Mixed stands either stemwise or groupwise, with their numerous known attendant benefits are what we seek, for, excepting a few areas of chestnut oak, there are no natural pure stands in the Forest. It is our admitted intent to produce stands which, as regards percentage of sprout representation, shall not vary from our existing natural facies; to create stands which shall deviate decidedly from these; in short, in our search for full silvicultural data, to produce, for study and observation, as complete an array of combinations of species associations as it is possible between these two limits.

Sprouting Capacity

The sprouting possibilities of the local hardwood species cannot be disregarded. Ring counts made over the past ten years indicate that cordwood cuttings were frequently made here in the old days on about a 35-year rotation. The operators who cut 4-inch wood for the brickyards actually handled their holdings on a straight coppice basis. As small-sized wood was desired, the financial side of such operations probably wore a pleasing aspect. But this practice of repeated clear-cutting over a short rotation was in large measure clearly responsible for the lowered conditions, both as to volume and quality, of many of our stands today.

Our chief commercial species—white ash, white oak, red oak, black oak, and yellow poplar are all sturdy sprouters, though they do not all display the same height growth possibilities. White ash and yellow poplar are usually the leaders, with white oak tailing the field.

It is our increasingly firm belief that studied cultural work applied to stands here, such as cultural work tending chiefly in the direction of careful selective cleaning

and thinning of young stands, will produce profitable results. We believe further, that such work, if thoughtfully done, can be applied with the minimum danger of upsetting the delicate interactions operating between or within the several facies. Our period of experimental work has been too brief to afford us definite, quantitative proof; but the data gathered here thus far show beyond argument that such cultural work does, at least, tend to start these young stands in the direction of yields far higher both in quality and quantity than would accrue if left untreated.

Underlying much of our silvicultural practice here is the consideration of the lack of sturdy seedlings. Well over two-thirds of our stands are of sprout origin, usually from stools six inches or more in diameter. We feel this representation should be gradually lowered in favor of either more seedlings, or more seedling sprouts, produced so far as possible from stools not over one inch stump diameter, although sprouts of high promise can be grown from stumps up to three inches. Numerous counts of such sprouts indicate that they possess a quick height growth, and that the stumps heal with such rapidity that rot seldom enters.

Since such sprouts make much faster height growth than seedlings, it is a problem how to produce crops from both origins on the same area. If adequate natural reproduction can be secured, some form of groupwise stocking would seem feasible.

Lopping Technique

Except where open land is being reforested, any planting made here will encounter sprout competition. Usually this will be so aggressive that the planted stock will require varying amounts of periodic releasing if it is to be pulled through to maturity. This has been true of every

planting we have made, either of coniferous or deciduous stock.

The most effective tool we have tried thus far is the Collins machete. We prefer a rather straight, 18-inch blade, with a horn handle. The crew should carry one or two coarse carborundum stones; it is folly to attempt this work with a dull knife. We are about to test out the suitability of Filipino bolos of several shapes and weights, all having blades about 13 to 14 inches long.

Releasing work in coniferous plantings does not call for much technical skill. We use our regular woodsmen for this and get satisfactory results. There is virtually no need for dendrological knowledge except the ability to recognize promptly the planted species. Our usual practice is to put a man on each row, working abreast, and each planted tree is carefully freed as encountered. The cleared area about the released tree should take the shape of an inverted cone, with the butt of the conifer at the tip.

The objective is to admit all available sunlight to the planted stock for as long as possible. We have tested the system developed by Dr. R. T. Fisher of "nicking and breaking" the undesired stems, but it does not pay with our species, chiefly because it is not sufficiently discouraging to the sprouts, and partly because, unless a man is highly skilled with the machete, he will take too much time in trying to "nick" a stem and will probably end up by cutting it off clean anyway. One area (Honey Hill) where this method was thoroughly tested showed that white oak especially could be nicked and bent down, yet the partially severed stems grew horizontally for three to five years, put forth a vigorous array of vertical branches, and in many cases dropped a generous supply of acorns. In the several instances, however, where we have tried this plan on aspen sprouts, it has produced gratifying results.

To make this releasing work as effective as possible,

we found it worth while to determine during what part of the growing season our several species of conifers made their peak growth. The results appeared in Black Rock Forest Paper I, 9. From this it is evident that in this locality red pine and white spruce make their greatest height growth during the first three weeks in May, while European and Japanese larch reach their maximum during the last week in May or the first week in June.

We do not regard this phase as completely worked out. Parallel studies, showing the "peak growth period" for our hardwood species, appear to be necessary. Such studies are under contemplation, and the results will be correlated in practical fashion with the data already published.

Selective Weeding on Cutover Hardwood Land

There seems to be little doubt that this sort of cultural work pays well. There are various well-known areas, especially on the Harvard Forest, Petersham, Massachusetts, where sufficient time has elapsed to render further machete work unnecessary, and to demonstrate clearly how such attention, when properly applied, usually makes a marked improvement in the stand both as to amount and grade of product.

Our treated areas are still too young to yield wholly definite conclusions; but it is difficult today to contemplate our stands of young hardwoods and to feel that they are headed elsewhere than toward the production of a good yield per acre of high-grade lumber.

So far, all work of this sort has been done by our technical staff. We have entrusted very little of it to the woods crew, partly because we wanted the work done with considerable precision and also since a formidable array of silvical factors must be considered. Soil sites, comparative rates of height growth, sprout forms and origin, the scarcity or frequency of trainers, the relative

feeding power of the species involved and the general alignment as to competitive weed species must be weighed.

"Take the worst and leave the best" is our general fundamental guide. By "best" we mean sprouts of the most promising origin, the best form, and showing a height growth nearest the average for their immediate community. A strict application of these tenets leaves little opportunity for selective weeding with regard to species. Our advance growth is often patchy in distribution, making it sometimes necessary to leave groups of lesser value to serve as trainers or to maintain factors of local climate.

Where the stools are numerous and of good species, lopping practice may change almost completely into a selective operation wherein weed species, or those of low commercial value, may be cut back rather heavily, leaving only such trainers as may be needed to help in pruning the better stems.

In such thick stands, if the first treatment be applied at an average height of 6 to 8 feet, it is then frequently possible to select and release a number of the crop trees. We believe it wise practice in this first operation to lop chiefly for correct stand density, with particular attention to form. Treatment for proper species distribution may be completed in some later operation. Where quality timber is desired, it is of primary importance to provide a plentiful supply of trainers during the formative years. We believe that hemlock, sugar maple and dogwood will serve admirably in this field.

The question arises: when is the best time to weed stands of mixed hardwood sprouts? Our counsel is: be not too hasty. We learned by the costly experience of doing such work in a most promising area when the average height was perhaps 3 to 5 feet. The weeds and other undesirable competitive species were cut back to about 24 to 30 inches in height. In one or two seasons nearly

all these undesirables had closed the gap and were again on a level with and were threatening to overtop the good species, leaving us to realize that we had thrown away several man hours per acre. The moral is: do not, as a rule, attempt such selective work in sprout land until the average height approximates 7 to 10 feet. Under these conditions, lopping work can impose a handicap of 4 to 6 feet on the cut stems, which seems hereabouts to be too big an obstacle for the weeds to overcome in the face of the eminently favorable growing conditions accruing to the remaining stems.

Chestnut Oak Disappearance

About 1929 we noticed that frequent chestnut oak were showing water sprouts on their stems. These in some cases extended from stump height up to, and occasionally into, the living crown. Since this had occurred in unthinned stands, it did not appear to be due to the admission of added light to the boles; rather it seemed to result from some physiological change within the tree caused by some factor or complex of factors as yet unknown.

Trees showing this condition usually die in about two years. From both commercial and silvicultural standpoints it seemed reasonable to widen our general cleaning-up policy so as to include all trees of this species showing either this characteristic "feathering" or the persistence of dead leaves beyond the normal period—another well-defined symptom of approaching death.

A field examination, made in March, 1937, by Dr. H. J. MacAloney and J. R. Hansbrough of the Northeastern Forest Experiment Station brought out the following:

Since 1911 this area has suffered a marked minus departure from the normal precipitation. This deficiency has apparently caused a general loss of vigor in the case of this species. Continued attacks by the golden or pit-

making oak scale, (*Asterolecanium variolosum,* Ratz) and in later years (notably 1935 and 1936) by the canker worm has weakened these decadent trees to a degree where the two-lined chestnut borer (*Agrilus bilineatus* Web.) can attack and kill them. At present our plan of gradual elimination of this species from much of the Forest appears to be sound.

There is another interesting angle to the golden oak scale activity. In that portion of the clean-cut area in Cutting 4a where the sprouts have been either pruned, selectively thinned, or both, the young sprouts show far less scale attack than in the dense, untreated sprout stand. It seems possible that the somewhat greater vigor of the treated stand may have made the chestnut oaks more resistant.

Chestnut Blight

Growth measurements over the past ten years indicate that the greater part of the native chestnut was killed by the blight during 1915, '16, '17. There are few untreated areas in the Forest today which do not still contain either some of the familiar gray, dead, barkless chestnut stems, or numerous clumps of apparently dead stools left from a previous cutting.

It is a part of our cutting policy to salvage as much as possible of the dead stems. Those too small, or too badly checked or decayed for utilization are felled, knocked into a few short lengths and left to rot. Thus far these salvage operations have always been combined with a cleaning or improvement cutting.

We were struck by the large number of chestnut sprouts that appeared following our first cutting. Many of these clearly originated from the old, dry stumps. By far the majority came from old stumps where our choppers had felled chestnut trees which had been standing dead for about ten years. A few came from stumps which had obviously been cut some years before; and in some

cases, judging from the strongly weathered condition of the stump and the presence of heart-rot, it appeared that some of these chestnut cuttings had been made prior to the blighting of the parent tree. An occasional authentic seedling chestnut was found. The most careful uncovering of the root-system revealed no connection whatever with any adjacent stools.

Lacking any detailed study of this persistent sprouting, we feel that perhaps the added sunlight admitted to the root-collar by the improvement cutting may have been a causative factor. We are at a loss to explain the presence of the seedling chestnuts which have appeared during the past ten years. Fertile seed has been produced now and then by an occasional sprout which escaped the blight for several seasons, but the total seed thrown can hardly be held accountable for the number of seedlings present.

In partial support of the hypothesis that the admission of added sunlight is a stimulus to the growth of the chestnut sprouts, we cite the following observations from the clear-cutting in Cutting 4a. This operation was made in the winter of 1930-31. Today, on the upland area forming the south half of the cutting there are a number of uninfected chestnut sprouts 15 to 20 feet high. Several of these bore full, mature fruits in the fall of 1937. One such sprout displayed eleven burrs, nine of which carried fully developed, meaty nuts.

At this writing we can offer no explanation in addition to the light factor. But there are certain other aspects to this chestnut sprout situation which we feel should be mentioned here. We have observed with almost monotonous frequency that chestnut sprouts are very rarely attacked by the blight while their bark remains smooth and glossy. Such attacks rarely appear until after the appearance of the characteristic longitudinal fissures. It may be that the spores of Endothia have difficulty in making a permanent landing on the slippery bark of the young sprouts.

OLD GROWTH: RESERVED AREA

THERE are no virgin stands in the Forest. There are a few scattering veteran hardwood stems which our borings have shown to be at least three hundred years old. Broadly speaking, since we have practically no sound basic data, historic or otherwise, from which to reason, we are as yet unable to state definitely whether we possess any examples of true permanent types for this region. We greatly prefer the word "permanent" in lieu of "climax," and have employed the former herein.

So far as we now can judge, our nearest approach to a permanent association lies in the narrow, north-facing valley of Canterbury Brook near the north exterior of the Forest. Here the hemlock-hardwood association is well defined. Always excepting the possible effect of the usual secondary agencies, we believe this facies is probably permanent for this and similar sites. The somewhat similarly composed stand of old cove timber lying along Caesar's Lane in the town of New Windsor (Raup, 1938) is our chief argument on this point. We are not prepared at this time to offer further definite statements on the composition of the local permanent associations.

This Canterbury Brook area is to be reserved from any cutting whatsoever.

PLATE IV. A BIT OF THE PERMANENT HARDWOOD AND HEMLOCK ASSOCIATION ALONG THE CANTERBURY BROOK. COMPT. I.

CUTTING METHODS AND COSTS

THE major part of our cutting work to date has been for cordwood. Only a few thousand feet of saw timber have been harvested, partly because for the first few seasons we had no mill, but chiefly because sawlogs were only occasionally encountered. The usual local method of hiring cord cutters is to pay by the piece, cut clean, and make no attempt at brush disposal. We have tried out the following variations (all in thinnings):

1. Cutting by the day, 4-foot wood in marked timber
   (Both green and experienced men)
2. Cutting by the cord in marked timber
   (Both green and experienced men)
3. Cutting by the cord in unmarked timber
   (Experienced men only)
4. Cutting by the day, pole wood, in marked timber
   (Well experienced men)

4a. Cutting by the day, pole wood, in unmarked timber
   (Well experienced men)

After ten years operating here, we believe that (4) is best adapted to our immediate objectives of getting the preliminary improvement work done as we wish to have it, and at the most reasonable cost consistent with leaving the area operated in proper condition as regards the overwood, the advance growth, the disposal of the slash, and the manufacture of a marketable product. We add below a brief discussion of these several schemes.

1. This will give fair results if well-trained men are employed; but even so, more trees will likely be cut than was originally contemplated. The average chopper cutting 4-foot wood, will take an unmarked

tree here and there to fill out a rank. He is also prone to cut the advance growth too freely.
We no longer hire green choppers. They require too much training and watching. They are inefficient, expensive, and prone to accident.

2. Using experienced men, this will produce good results, but it is open to the danger of overcutting much more than (1).
3. A ticklish method. We have had quite decent results from it by hiring a small crew of careful, skilled, honest choppers. Any departure from these qualities will cause overcutting.
4, 4a. We now employ (4) almost entirely and (4a) occasionally. Our men are old hands who have been on our payroll for several years and whose loyalty is established. Operating this way, there is no urge to steal an unmarked tree here and there to "top out" a rank, for there are no ranks. Our advance growth is left in the best shape yet, since chopping work is reduced to felling, limbing, and cutting off the tip.

The crew organization used today seems to be the best we have worked out thus far. We have ten to fifteen men, several horses, one tractor, and a wood-saw on the job. The timber is marked. All hands (our men have been hand-picked over the years, for general versatility) fall to cutting wood, full length, by the day for perhaps two weeks, or until about 100 cords of polewood is laid down. Where a sawlog can be taken, it is bucked and the balance of the bole trimmed for the wood-saw. At the end of this cutting period, three teamsters take charge of the three horses, one man goes on the tractor (if the haul be long enough to warrant; we find it pays to use the machine where the haul exceeds 200 yards). Six to seven men go on the wood-saw and the balance, always the top-rank choppers, continue the felling.

PLATE V. SIDE VIEW, CLOSE-UP OF WOODSAW. NOTE STURDY TRACK CARRYING SLIDING TABLE; SLOTTED, EXTENSIBLE LEGS, AND GENERAL COMPACTNESS, ESPECIALLY OF THE 5 HP I.H. ENGINE.

The wood-saw requires one man as operator, one man as offbearer, and one or two men, depending on conditions, to do what occasional splitting is needed, and to help rank. The rest of the crew feed the poles to the table. Our saw operates so rapidly that it is necessary to load the sawn wood on a truck or a scoot and draw it a few rods to a piling ground.

Discussion of Cuttings

Cutting 1a. Upper Reservoir Sample Area, Compt. VII

Our initial operation, covering only a trifle over one acre. The stand was a good example of the "hardwood slope" described briefly by Tryon, 1930, *loc. cit.*, and in more detail by Raup, 1938, *loc. cit.* as the "red oak association."

The more detailed type nomenclature developed by Raup (1938) is employed throughout this paper. These are:

Beech-maple association
Mixed hardwood association
Hemlock-hardwood association (swamp phase)
Hemlock-hardwood association
Red oak association
Chestnut oak association
Alpine meadows
Scrub oak—pitch pine association
White oak—hickory association
Old field association

About 80 per cent of the trees were of sprout origin. The average form was fairly good, the average age about fifty-five to sixty years. The stand per acre totaled 27 cords.

It is interesting, even amusing, to review today the statement of the objectives originally sought and the treatment tentatively outlined for this purpose. We quote from the first report on this operation.

"The objectives sought are:

1. To increase the annual increment of the remaining stand

2. To improve the average tree form
3. To improve the species mixture
4. To increase seedling reproduction
5. Gradual elimination of coppice growth

"Cutting instructions:

Mark for cutting all dead, diseased, and crooked stems, all scarlet oak, such intermediate, codominant, or dominant members as should be removed to gain the foregoing ends. Chestnut oak and red maple may be cut heavily; red oak, yellow poplar, white ash, white oak, and yellow birch are to be favored where possible. Apply the German method of thinning from below.

"Recommendations for Cultural Treatment:

The present plan is to thin the anticipated sprout growth beginning about 1930; establish a uniform stand of straight, thrifty sprouts of desirable species, in mixture with similar seedling species." A subsequent note under this heading (1930) reads: "Apply the coppice with standards treatment, seeking the gradual elimination of the coppice."

The first cleaning left a fairly good-looking stand. The total yield was 15 cords. Two seasons later it was clear that any selective cutting in the new crop of sprouts would, with the amount of shade cast by the remaining overwood, be time wasted. It appeared very doubtful whether the sprouts would develop the desired quality of bole under this type of cover. There was already evident the familiar "craning" of the sprout stems to obtain sufficient light. There was also to be considered the danger of breakage when the remaining overwood was felled.

So our original cultural program for this project has been reduced to zero. The sprout growth is now somewhat dense; it includes stems sent up from stools of all sizes and conditions. The height growth has not been especially rapid, owing probably in part to the shaded

conditions. Several good seed years have occurred, and a good setting of seedlings is now present. Our tentative plan for this small area is to let it go until saw timber size is reached, when the understory will be mowed clean just before removing the main stand. It is expected that this operation will produce a dense sprout growth of the more valuable species, and that of these sprouts the great majority will originate from small stools. These stools should heal quickly, and the general performance hereabouts leads us to expect that the height growth under full sunlight should be rapid. These sprouts will be carefully weeded when they are about 8 to 10 feet high.

Cutting 1b—Upper Reservoir Cutting, Compt. VII

Nineteen and four-tenths acres of 60-to-70-year stock, chiefly mixed hardwoods, swamp phase. The form of the stand was no more than fair; the area involved was once a clearing, and a number of wolf-trees were present. Both the silvical condition and the commercial outlook indicated that a reproduction cutting would be the most practical treatment, for natural seeding was taking place slowly, and there was little in quantity and nothing in quality to be gained by letting the stand remain any longer than was necessary to insure sufficient reproduction for the next crop. It was a cordwood stand at the time, and clearly would never be anything else. Hence a rather heavy "thinning from below" was made. All elm, gray birch, popple, ironwood, hornbeam, and much of the red maple were cut; white ash, red oak, white oak, yellow poplar, sugar maple, hemlock and basswood were favored. We sought to leave as uniform a stand as possible of the best-formed trees of good size and species to give some assurance of good seed source; and to break the main canopy in rather sharp fashion to stimulate seedfall and germination.

The future treatment contemplated was to cut clean

as soon as adequate reproduction was present. This was carried out in 1934.

Cutting 8a (the same area)

In the autumn of 1934 the wood market was strong and active. An examination of the cutting showed that natural reproduction had come in sufficiently to form a fair setting. Since the reproduction cutting operation of 1927 there had occurred two good oak seed years, an unusually heavy fall of white ash (1930), and two fair crops of yellow poplar. There was quite a good setting of red and sugar maple with some chestnut oak, a goodly amount of white ash and a surprising number, although not large in a comparative sense, of yellow poplar. As this area is easily accessible, and the market brisk, it seemed wise to take advantage of this combination.

The Fisher system of mowing in advance of felling was applied. Bush-scythes were used. Fifty-six man-days were required for the 19.4 acres. Everything small enough to be severed with the scythe was cut off clean and close to the ground. Since the overwood contained an occasional sawlog, the mowers were followed by four choppers who dropped and bucked all trees of saw timber size and grade. The tops were left for the cordwood crew, which came after the choppers, cutting, splitting, and ranking everything left by the mowers and fellers.

On 2.9 acres at the north end the brush was burned. On the central portion (7.5 acres) it was lopped and scattered. Over the remaining nine acres we left the slash as the choppers finished with it—in shallow piles or long windrows. These three areas were to test whether these several methods of brush disposal would make much difference in the number, the quality, and the rate of growth of the coppice produced by the cut stools. Some interesting data on the speed of rotting of the brush were later obtained here.

By the end of the following summer (1935) a fair array of sprouts had started. The average height was not up to our expectations. On May 14, 1936, well after the start of the growing season, an unusually severe late frost blanketed the entire area, killing back hundreds of promising shoots of white ash and red maple. The sprouts of other species were not so hard hit except for yellow poplar, where a number of leaders were set back.

In the early winter of 1937, ten years after the first operation, the project appears promising as to composition and density. There is present a good setting of white ash, sugar maple, red oak, and white oak with slightly more yellow poplar than was present in the original stand. The majority of the sprouts are of good origin —*i.e.,* from small clean-cut, and by now partially healed stools. We feel reasonably certain that thoughtful cultural treatment will produce a stand of valuable saw timber. Guided by our previous experience, we shall not begin this work until the average height is about eight feet. The area is sufficiently large to require one man's time for five or six full days—possibly one week—and we naturally wish to avoid the time-wasting effort made on Cutting 1d.

In one respect, this project varies sharply from nearly all of our other cutting operations. The average height growth made thus far is markedly below the general average for this Forest. Save for the red maple, the height today (March, 1938) is only about five feet. We have no adequate explanation; but we have scheduled this project for detailed laboratory examination, as we assume that this subnormal performance may be caused by a nutrient deficiency either in the form of a definite elemental scarcity, or perhaps as a low degree of nutrient availability.

Cutting 1d—Hall Cutting

This 13.5-acre section was a good specimen of the mixed hardwoods, swamp phase. Some scattering hemlocks, ranging from 6 to 12 inches d.b.h. were present, with advance-growth hemlock from 2 to 12 inches in height showing counts as high as 11,000 per acre in some areas. Although the canopy was rather heavy, forming a shady stand, the hardwood advance growth was good. The raw humus was pleasingly shallow. The ages were uneven, varying from forty to sixty years.

A combined reproduction and release cutting was laid out. We believed that we could produce a good setting of valuable species, and the effect of release on the many small hemlocks appeared to be a subject for profitable study.

At the north end of the area our marking was heavy. The severity decreased as we progressed southward. We thinned from below as well as in the canopy, taking all dead and dying trees, misshapen and diseased stems, and such intermediate, codominant, and occasional dominant trees as our plan required. Gray birch, poplar, red maple, beech, sugar maple, ironwood, and dogwood were the chief weed species but; red oak, chestnut oak, white ash, white oak, yellow poplar, sugar maple, hemlock, and hickory were the species favored. Our marking was somewhat heavier around all potential hemlock seed trees in accordance with our avowed aim of creating mixed stands so far as possible.

The sprout growth following the operation was profuse, especially from stumps of dogwood, ironwood, red maple and hornbeam. While such growth from the preferred species was good, the former seemed possessed of malevolence, for they outstripped the latter with disturbing rapidity. Fearing the smothering effect of the weed sprouts, in 1930 we gave the entire area a release lopping

with the machete. This taught us the folly of doing such work while sprouts are too young.

The original stand was distinctly uneven-aged; and our cutting produced a "patchy" forest which fell into the following three classifications:

A. Areas which had been thinned, but less severely than (B) or (C) and which could still be accurately classed as high forest, although not always fully stocked.
B. Areas which had been cut heavily, leaving only scattering standards.
C. Areas which had been clean-cut.

For three seasons after the operation little seemed to happen save the rapid sprout growth. In 1931, however, an intensive examination revealed a good setting of natural reproduction which had come into the openings since the cutting. White ash, yellow poplar, sugar and red maple and white oak were the chief species. Further study, with especial reference to the comparative growth rates of the species represented, suggested that additional machete work would be far more effective were its application delayed for some time longer. So we waited until the summer of 1935, when the entire area was carefully gone over, varying the treatment to fit the conditions as outlined below on each of the three classifications just described.

The (A) portions, which had been most lightly cut, showed some reproduction and only patchy sprouting. Practically no weeding was done here, since the conditions closely resembled those developed in Cutting 1a. We deemed it wise to let well enough alone.

The future of these "islands" is not problematical. By the time they reach saw timber size they will have sown an adequate crop of reproduction, and they can then be removed in a series of group fellings. The advance growth may be either mowed close and then sprouted and

given selective thinnings at the proper time, or it can perhaps be managed chiefly as a seedling stand. We presume the former method of treatment will be better as weed species are common, and the more rapid height growth of sprouts of valuable species should afford them a better chance.

On the (B) areas we first considered leaving the standards to be harvested when the sprout crop had matured, but a little study showed this to be impractical. We already had the needed reproduction; many of these isolated stems were severely "feathered" with water sprouts, owing to excessive exposure; in a number of cases their crowns unmistakably would dwarf or stunt the crowns of a number of promising sprouts; their total volume was insufficient to warrant immediate felling and hauling; and felling alone would damage our young crop severely. So we girdled these, and the sprouts about them were given an intensive weeding. The indications were that these heavily cut areas no longer had need of the partial shade cast by these standards.

Today, the (C) areas form one of our most successful operations. The composition of the stand differs sharply from that of the original forest. There is much more white ash, yellow poplar, and white oak, and somewhat more red oak, sugar maple, and black gum. As yet we do not know to what degree we are causing an upset amongst the various delicate interations alleged to exist; this can only be worked out after due process of time, and with the perfection of our method of evaluating site qualities on the basis of quantitative determination of nutrient takings. This method is approaching the form of a finished yardstick which will lend itself admirably to just such a problem as this cutting will shortly present. We regard it as highly probable that the laboratory will give us the answer to this many years before the trees themselves will have stood for the rather lengthy period needed to afford a basis for the somewhat hypothetical

conclusions reached when stand conditions are analyzed by the methods now usually employed. Our projected correlation of ground-cover associations with the proper tree mixtures should, when well under way, give us added assistance in the shape of site indicators.

In making our selection and release cuttings in the young stand here we took the time to prune carefully a number of promising crop trees of various species standing on the north quarter. This work was done with the machete. A sharp edge is necessary; and the cutting stroke must be made upwards, or bad bark tears will result. Thus far the scars so made have shown every indication of prompt and complete healing. This added work did not greatly increase the time expended, and if such extra care raises the yield of Select and Better stock it would appear to be worth while. Future utilization in this cutting will give us valuable leads on this practice.

Suffice it to say that this young stand looks to be full of promise. If it fail of fulfillment, we shall then have proof that a rearrangement of species to this degree on such a site and managed as described does not produce the desired optimum yield.

Cutting 2a—Glycerine Hollow, Compt. XIV

Nine and one-half acres of mixed hardwood association, about seventy years old, were marked for cleaning in the autumn of 1928. Our original plan was to follow this operation with two, or perhaps more, improvement cuttings with the object of encouraging reproduction of the better commercial species. The original stand was (and still is) about the best timber in the Forest. Form and height are unusually good.

But advance growth was hard to find. Our cleaning operation, which removed the dead, dying, overtopped and deformed stems, with an occasional intermediate or codominant, tallied, to our great surprise, 16.8 cords per

acre. The appearance of the area was at first unusually clean and neat, but the inevitable sprout growth soon altered this.

Here as in Cutting 1d, nothing appeared at first but sprouts. By 1934, however, a setting of young white ash, red oak, sugar maple, and yellow poplar was showing. The density of this new growth made us wonder if our projected additional cuttings would be needed. By 1936 the reproduction of these species was so numerous that we abandoned entirely our idea of extra cuttings and decided to leave matters temporarily as they were.

This stand can be left to grow for at least fifty years longer. It is a crop of medium-sized, valuable sawlogs now, with easy accessibility. The additional volume increment will raise the money return from the final cutting; the overwood appears to be in excellent health, with no danger of decadence for a long period, and the reproduction is becoming well established. A final cutting could be made tomorrow; but we see no merit in that. We believe the best plan will be to delay harvesting this area until a strongly favorable market becomes available. It is interesting to note that the thinning applied here in 1928-29, while apparently heavy on a volume basis, did not admit sufficient light to stimulate water-sprouting to any marked extent.

Here, too, future investigation may reveal that our "tinkering" with the species association of this particular site has caused an upset. Conversely, we may perhaps find that our slight rearrangement of the composition (for here we expect to increase but slightly the percentage of white ash and yellow poplar) is precisely what nature has been seeking to accomplish. In contrast with Cutting 1a, the anticipated composition will not differ as sharply from the old mixture. Cutting 2a is another test plot in our search to determine what species mixture will give the highest yield on this particular site. We may

learn that we are wide of the mark or perhaps we shall be agreeably surprised.

Cutting 3a—Jim Pond to Continental Road, Compt. XXII

A larger area than any of the foregoing operations. A portion was mixed hardwood association, but the greater area was red oak association. Age averaged about forty to fifty years. Excepting a bench lying along the north edge of Jim Pond outlet, the average bole form was poor, the height mediocre, and cat-faces, sometimes 6 to 8 feet high, caused by a severe fire in 1911, were frequent. The appearance of the stand indicated a general stagnation. Borings showed the average annual diameter growth of the several species of oak to run between 0.11 to 0.14 inches. Stump counts made during the cutting confirmed this figure.

We have no complete explanation of this stagnant condition. The only positive evidence to hand is the established fact that the area was scorched with unusual severity in 1911; and that soil profiles made in 1931 showed the organic layer to be from 1 inch to 2.5 inches in portions of the coves, and barely 0.5 inches on the ridges and upper slopes.

Somewhat contrary to our expectations, little or no increment increase has taken place. Even the accustomed sprout growth has been perceptibly less vigorous than is usual. We believe we are dealing here with an area whose biologic and edaphic equilibrium has by no means recovered from the severe upset of 1911. This failure in response has completely changed our original plan of treatment.

Our first operation was a thinning from above, save for a small portion in the south corner of the section where the old German method was applied. The underwood was virtually untouched; all dead and dying

trees were marked; the bulk of the cutting was in the intermediate and codominant classes, leaving released crop trees as far as possible. The economic element governed marking to a perceptible extent. We sought to favor the good oaks, yellow poplar, yellow birch, white ash, basswood, hickory, and hemlock; we deemed it only sound business provision for the future to mark heavily amongst red and sugar maple, elm, and black and gray birch.

We sought to leave a rather close stand of the better-formed trees of the more valuable species. We did not plan on a reproduction cutting; our intention was to raise the diameter growth by freeing the crop trees but without making breaks in the main canopy which would require more than four years to close.

Our original prescription for subsequent treatment suggested three successive cuttings. One was to be another thinning from above, probably quite similar to the first operation; the next was to be a reproduction cutting, in case the second operation did not produce the desired advance growth, and the last was to be the usual final cutting, to be applied when the reproduction had become well established.

Conditions existing here today have completely changed this program. There is plainly nothing to be gained from another increment cutting. The need is for fire protection over a lengthy period, during which, given adequate leaf-fall with favorable climatic factors, we should see the beginnings of a gradual rebuilding of the obviously impoverished soils. This rebuilding can be no more than barely started with the existing overwood. It would not be commercially practicable to extend this period of waiting beyond about 1950. To do so would bring the stand, even with its slow growth rate, to an average d.b.h. far too big for an efficient cordwood operation. The stand on the bench mentioned is a sawlog crop,

and could easily be left to grow to very good advantage until 1950 or even longer.

So our present, tentative plan is for a reproduction cutting about 1945, followed by an underplanting and by a clear-cutting perhaps five years later. Here, owing to our lack of detailed, quantitative knowledge of the site qualities involved, we made an improvement cutting in rather blind fashion. Continued, careful observation of this area, coupled with planned nutrient analyses should indicate the next steps. It now seems inevitable that some artificial planting must be resorted to here, and we shall probably scatter a percentage of European larch through the mixture to improve the soils.

Cutting 3b—Brook Trail North, Compt. VI

Thirty-five and two-tenths acres, which included specimens of mixed hardwoods, swamp phase, mixed hardwoods association, hemlock and hardwood association, and red oak association.

The organic layer was uniformly thin, the total depth averaging only 0.5 inches on the upper slopes and ridges. In some of the coves and swamps 4 to 7 inches of rich black soil was found, but this figure dropped abruptly on leaving these moist areas.

The original cutting schedule paralleled that laid out for Cutting 3a, and the results were nearly identical. In some portions, chiefly the coves and lower slopes, there has come about a stepping-up in the diameter increment growth, and some reproduction has appeared. On the higher, drier sites, conditions are practically unchanged. Future treatment cannot be definitely prescribed now. Periodic observations and analyses should point the way.

Here, however, we are not dealing with as low-grade a site as in the case of Cutting 3a, and we anticipate the expected diameter accretion to materialize inside of another ten years. By about 1940 this area should be ready

for a reproduction cutting. One important factor is that the average d.b.h. is larger than in Cutting 3a, which means that the operating costs will be high if the present stand is permitted to reach too large a size.

Cutting 4a—Brook Trail South, Compt. VI

Fifty-seven and one-tenth acres were treated. The types represented were:

Mixed hardwoods, swamp phase
Mixed hardwood association
Red oak association

Contained within the area were four subsidiary experimental parcels as follows:

I. An uncut control strip 100 x 1000 feet (2.3 acres)
II. An underplanted strip (2.2 acres; see Ref. 4c)
III. A "park" area (4.1 acres)
IV. A clear-cutting (2.5 acres)

The remaining acres were given a careful thinning. We sought increased seedfall and germination, and a recent examination indicates that we are getting them. The generally good condition of this part of the operation leaves us in a complacent frame of mind, especially with regard to the coves and lower slopes, where the promise is now high.

The subsidiary parcel (4a I) is an uncut control area. Parcel (4a II) is discussed under Reforestation, Parcel (4a III) was marked more for appearance than for accretion or seedfall. It is really one of our show spots, being close to a parking space near the Aleck Meadow Reservoir. The few mature hemlocks were carefully liberated, the understory was cut clean, and the area was later underplanted with red pine and white spruce.

In Cutting 4a II we set 1.1 acres to red pine and an equal area to white spruce, using 2-2 stock. We wished

to see if such stock, set under carefully cleaned high forest would offer any promise for the future. To date the response has been discouraging. The maximum height growth is seldom greater than 2 to 4 inches on the spruce, and rarely over 7 inches on the pine. We made another and similar test in Compartment VI, near the junction of the White Oak Trail and the Continental Road, using 2-2 stock. The results have been the same. This procedure may prove useful in establishing mixed stands. We propose now to test the effect of further light thinnings in the overwood. It may be that the plantation has not been receiving enough sun.

Parcel (4a IV) deserves more detailed explanation. Something more than one-half the area was red oak association. The balance was a wet flat traversed by the outlet from Arthur's Pond. It is classed as mixed hardwoods, swamp phase, with a narrow strip of chestnut oak association along the south edge. As a whole, it gave us a suitable representation of types for a small-sized experimental cutting.

A complete clear-cutting was made, the brush burned, and the wood hauled off. Our object was to set up a good example of the old, traditional local method of clear-cutting for fuelwood, and then to determine whether some slight added expense, in the form of a few extra man-hours of cultural work on the sprout growth would justify the expenditure in the form of increased yield of bulk wood. No effort was to be made to improve the quality; what we wanted was added volume production in cords per acre, with perhaps a speedier crop turnover.

After two seasons it was clear that the wet flat and the high ground to the south would require wholly different treatments. The latter was a less responsive site. A portion of the flat was weeded in 1932. A number of white ash seedlings, with some white oak, yellow birch, and yellow poplar were found under the dense heads of red maple, white ash, and alder. Some "nicking and

breaking'' was tried out, but it again proved a fruitless expenditure of time on the species represented here. Observation of the flat in 1936 showed that the 1932 weeding, as with Cutting 1d, had been applied too early. At least four years should elapse between clear-cutting and the first selective lopping of the sprouts. In July, 1936, we gave this a careful machete treatment. The occasional very wet spots are blanks, carrying only sedges and viburnum. The arborescent growth consists of well-established groups of sugar maple, white ash, yellow birch, some red maple, yellow poplar, and basswood, with a few rather small red oak. This cultural treatment liberated the crop sprouts to the extent of some two years' height growth or better. The promise is now generally good.

The high ground to the south was first examined in 1932. Great, bushy heads of oak sprouts were present, with scarcely any seedlings whatever. The largest stumps had produced sprouts quite as large as those from the medium-sized and presumably more vigorous stools.

Various possible treatments were discussed. It was evidently too early to attempt anything as yet, but we first considered a weeding process whereby the undesirable stems would be cut close to the stump collar. This appeared to be expensive. In 1934 it was decided to split the area into three equal, N-S strips. The central strip was to be left untouched for a control. The sprouts had reached about 8 feet in height, the time seemed right, so the east and west strips were carefully gone over with the machete. No attention was paid to species, nor to the size or condition of the parent stumps, but each clump of sprouts was scrutinized and on the east strip the ''crop sprouts'' were selected (usually quite a good number, ranging from four to seven per stool) and pruned up to the base of the main crown. The overtopped sprouts were lopped off just below this point. Our idea was that the pollarding of these stems would produce a sufficiently

dense sprout understory which would shade the crop stems, prevent water-sprouting, and perhaps help to force height growth. The average handicap thus imposed on the cut stems varied from 2 to 6 feet.

The west strip was handled less intensively. No pruning was done; the overtopped sprouts were lopped, and at a somewhat higher level than on the east strip.

At present we do not plan any further cultural work here. Future developments may indicate some need for this, but in accord with our objective of producing bulk fuelwood quickly and at the minimum cost per acre, we propose to avoid additional expense so far as possible. So far, no conclusions may be drawn, but it is of record that both the treated strips show a higher average height than does the control strip.

At present the average diameter is about the same on all three strips. It is of interest to note that on the east strip the scars left by the 1934 pruning are healing well.

Cutting 5a—Reservoir Trail to West Point Road, Compt. III

This 89-acre operation lay wholly within Compartment III. A good cross-section of types was represented ranging from chestnut oak association down through the red oak, the mixed hardwood, and the hemlock and hardwood association. The general thrift was high and of good promise, from the cove areas up to the upper limit of the hardwood slope type. The stand was somewhat patchy, running in fairly even-aged groups. Some spots averaged forty years, some eighty to one hundred.

In planning the silvicultural treatment, we here made it part of our general cutting policy to refrain from pushing the upper limits of our operations beyond the average upper edges of the hardwood slope type. It seemed best for the time being to omit entirely from our cutting

schedule any effort above this altitudinal limit during our first cleaning-up trip over the Forest. We further decided to give the method of thinning from below one more trial, although the operation itself was more of a cleaning than a thinning. Overtopped trees were removed, as well as the usual dead, dying, diseased and defective stems and an occasional intermediate or codominant. No dogwood, ironwood, or hornbeam were cut save where room was needed to work. Examination of previous operations showed us that the moderately high shade cast by these species can be a more helpful factor in maintaining factors of local climate than is the lower shade cast by the dense heads of sprouts which these species produce soon after cutting.

Certain of the slope areas yielded surprising amounts of dead, blighted chestnut. The total yield of this species was 150 cords. Much of this was easily marketed, either as wood or charcoal. Our marking had been planned to remove about 6 cords per acre. The actual unit yield was 9.17 cords. Deducting the chestnut dropped this unit figure to 6.8 cords.

Five years later (1931) a scrutiny of the conditions assured us that for this region the method of thinning from above is far more applicable than the German system. Cutting the underwood, under the latter method, merely produces vast heads of sprouts which appear to hinder natural reproduction, and for which we see as yet no possible and reasonable method of nursing through to anything but a crop of low-grade fuelwood.

This examination also brought out that sturdy patches of reproduction of good species (white oak, red oak, yellow poplar, and white ash) were appearing in the coves and the lower slope areas. Our main cutting had been planned as a cleaning, with no definite objective of stimulating added reproduction. So, the conditions found here, combined with the reproductive response put forth in some of the other operations, has increased still further

the seeming practicability of cleaning the existing stands on a basis of three operations or less; a cleaning, perhaps a reproduction cutting and a final cutting.

Cutting 6a—Reservoir Trail North, Compt. II

Ninety-five acres lying in the southeast quarter. The growth ranged from the short-bodied, almost pure chestnut oak stands of the upper levels (where our cutting ceased) down to the mixed hemlock and hardwood association of the brook beds. The age was fifty to sixty years.

The stand was very typical of this section, the association being almost pure chestnut oak along the upper edge of the cutting, chiefly mixed oak on the slopes, and shading off into red and sugar maple, white ash, yellow birch, basswood, and yellow poplar in the swales and coves. We found more yellow poplar here than in any previous cutting. Nearly all the specimens of the latter species were potential seed trees. The red and white oak, white ash, maple and basswood showed generally good condition, but, as is explained below, the chestnut oak was clearly unhealthy.

This compartment was roughly quartered by laying off two strips each, 200 feet wide, at about right angles to each other. These strips were left untouched to serve as controls.

Marking was done ahead of cutting. After examining the conditions, and after bringing to bear all that the previous operations had taught us, we decided merely to clean the stand.

All gray birch, poplar, and elm were marked, also all dead, dying, diseased, and ill-formed stems, and an occasional intermedite or codominant. We did not plan to enter the field of thinnings any more than might automatically become necessary. But, as usually happens, we found ourselves in some areas where conditions

obliged us to thin rather heavily. Chief among the disturbing factors was the condition, in certain spots, of the chestnut oak. We found a great many trees of this species which were either dead, or which showed the characteristic persistent dead leaves, the heavy water-sprouting, or the patches of loosened bark with the cambium turning brown, any one of which seems to presage death to this species. Since it is easier, cheaper, and pays better to work up a green tree than a dead one, we felled all of these apparently dying stems that we encountered, even though this policy left some large breaks in the canopy, especially along the upper limits of the operation where chestnut oak was most frequent.

The first section of the operation—about 17 acres just east of the Black Rock "Over" Trail—carried a surprising amount of rather small, dead chestnut. Here appeared an interesting example of natural replacement of blighted chestnut by pignut hickory. The area contained more seedlings of this species (averaging about 6 to 10 feet high) than any portion we have thus far operated. Besides the hickory seedlings, there was present a deal of excellent natural red oak reproduction. Where the stand ran heavily to living trees, with less deciduous chestnut, such reproduction was markedly less evident.

The yield, including the dead chestnut, ran 6.4 cords per acre. Deducting this species, it totalled 4.6 cords.

Today the area appears to be thrifty. The main canopy is filling out into many of the smaller breaks made by the cleaning, the sprout growth has not been as vigorous as usual, the hardwood seedling understory (with some scattering hemlocks) has every indication of good health, and some seedling reproduction has begun to appear.

Cuttings 7a, 8b, 9a, 10a, 11a

In planning out these operations we sought to apply what we had learned from the previous cuttings. Our

purpose was, in each case, to clean the stands to prepare them for our intended future program of more intensive silvicultural handling. In defining our general cutting instructions we made no attempt at a thinning or a reproduction cutting. The great bulk of the yield came, in consequence, from dead, dying, and diseased trees, and from malformed or otherwise defective stems. In accord with our hypothesis regarding chestnut oak and its seeming tendency to die out, we cut this species heavily.

In certain spots, usually the coves, where the stand was frequently above the average quality, almost all of these operations automatically developed into a light thinning. In other portions, chiefly on the higher, drier sites where chestnut oak was more abundant, our treatment became a reproduction cutting. But the majority of the acreage involved was merely given a thorough cleaning.*

Future Treatment

As yet, we have no hard-and-fast silvicultural program for the future. We feel that our present plan of cleaning the existing stands is probably the correct initial step. But our supply of data is too meagre to afford us an adequate basis for outlining which of the various recognized silvicultural systems, or which modification, or perhaps which combination thereof will produce our desired result of sustained, high quality yield.

* It should be again emphasized that one of our chief objectives is the reduction of our sprout population and an increase in our percentage of seedlings.

Cutting 8b (Compartment XII) contains one area which is of especial interest to us. This, the "Brush Patch" lying along the east edge of the compartment and immediately south of the east end of the clear-cut-and-planted strip (Ref. 9b), is the usual mixed hardwood stand. It was cut clean in 1910 and is today younger and more malleable than are many of the areas which we have treated thus far. A small portion has been carefully cleaned, and it is our plan to utilize some of the remaining unimproved area in a series of thinnings to determine when is the proper time, for the species represented, to alter the treatment from thinnings for form to thinnings for maximum crown development and proportionate diameter increment.

Our experience indicates that, following the first cleaning, various combinations might perhaps gain this end. While we do not offer it as a final conclusion, we are willing to hazard the suggestion that some form of the shelterwood system seems now to be the most practical. It will be tested. Coppice with standards will be given a trial; selection cuttings will have their day in court; the various adaptations of clear-cuttings (strip, wedge, etc.), and careful application of group fellings will also be tested out. We feel confident that, given time, we shall solve this problem in accurate, quantitative fashion.

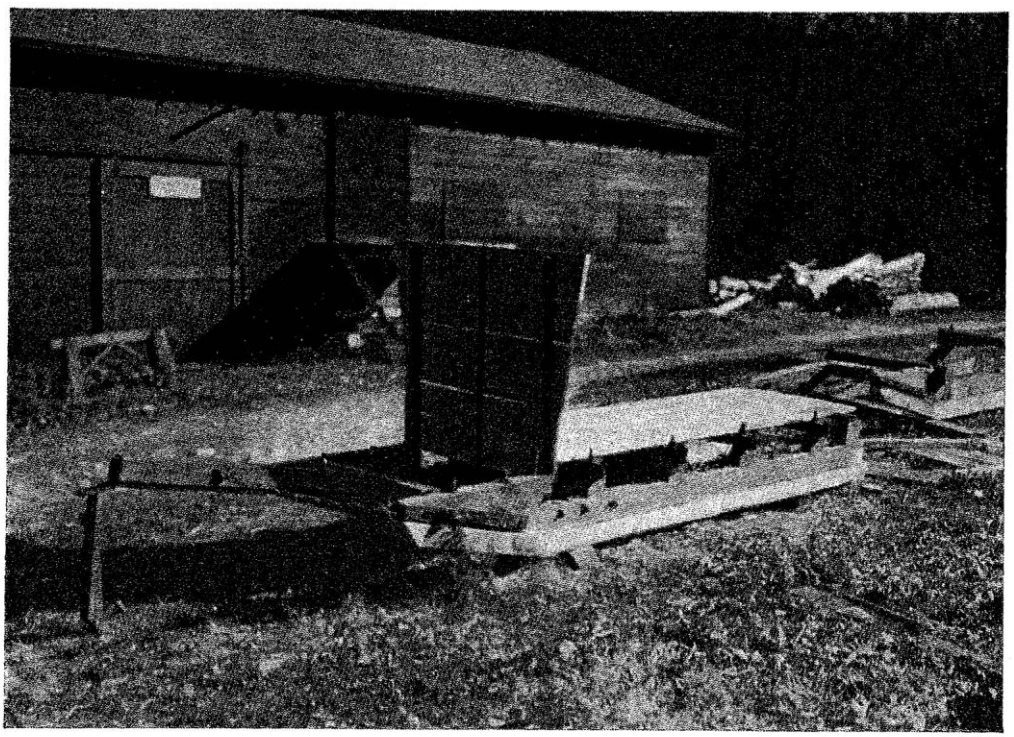


PLATE VI. WOOD-SHOD SCOOT, BUILT 1938. CAPACITY 1.5 CORDS. DESIGNED FOR TRACTOR HAULING. BUNKS FITTED WITH STAKE-IRONS AND MOUNTED ON BLOCKS.

REFORESTATION

Reforestation has been one of our minor activities. Our plantations total 125 acres. A portion of this was the usual, artificial stocking of abandoned farmland to establish a stand of desirable species before these open spaces became wholly pre-empted by volunteer weed growth; another objective was the attempt at complete type conversion from mixed hardwoods to pure conifers; and some acres were set with the thought of developing a quantitative value of the soil-improving effect of the establishment of stands of mixed hardwoods and conifers.

Owing to the presence of both blister rust and white pine weevil we have not used white pine save for a small test of root-pruned stock along the west shore of Arthur's Pond near the north end. Our chief species have been red pine, white spruce, and European larch. A few patches of Japanese larch and Asiatic chestnut have been set, and a small sugar-bush planting was made in 1929. The principal operations are listed below.

Old Field Plantings

Ref. 1f. 1928; 2-0 red pine and Norway spruce (Mailley Farm) Compartment III.

Ref. 1g. 1928; 2-0 red pine, European larch, black locust (Chatfield Place) Compartment X.

Ref. 2a. 1929; 24-inch sugar maple (sugar bush planting) Compartment XI.

Ref. 3a. 1930; 2-0 red pine and Norway spruce, (Ryerson Farm) Compartment XVII.

Ref. 6b. 1932; 2-0 red pine, 18-inch yellow poplar, (John Odell Farm) Compartments IX, XVI, XIX.

Type Conversions

Ref. 1e. 1928; 2-0 red pine, European larch, Norway spruce, (Honey Hill) Compartment III.
Ref. 4a. 1931; 2-2 red pine, west edge Continental Road, Compartments V and X.
Ref. 4a. 1931; 2-2 white spruce, west edge Continental Road, Compartments V and X.
Ref. 4b. 1931; 2-0 European larch and Japanese larch (Buckwheat Lot), Compartment X.

Soil Improvement Plantings

Ref. 5a. 1932; 2-0 European larch, strip job, Compartment XX.
Ref. 6a. 1932; 2-2 red pine, strip job, (Tower Hill) Compartment X.
Ref. 9b. 1936; 2-2 red pine, 2-0 European larch, clear-cuttings, Compartment XII.

Exotic Plantings

Ref. 4a. 1931; Asiatic chestnut (*Castanea japonica*) in mixture with 2-2 red pine. Compartment XI.
Ref. 11a. 1938; Asiatic chestnut (*Castanea japonica*) in various small wells made in Compartment XII.

Underplantings

Ref. 4c. 1931; 2-2 red pine, Compartment VI.
Ref. 4c. 1931; 2-2 white spruce, Compartment VI.
Ref. 4d. 1931; 2-2 red pine, Compartment VI.

Discussion

Several definite conclusions may be drawn from the behavior of these various operations. First, 2-0 red pine

and Norway spruce do not do at all well here on heavily sodded old fields. Stock of this class will often pull through, but it is a long and expensive wait. In fact, in 1932 we deemed it worth while to re-set with 2-2 red pine the failures of such trees on the Mailley and Chatfield plantings. Our other old-field jobs, where larger trees were purchased, have performed fairly satisfactorily. We feel that such old-field plantings might show far greater success were the usual volunteer weed growth permitted to develop over the area for five to ten, or perhaps for fifteen years previous to the planting. The light shade cast by such stands should reduce the turf density; underplanting such stands, if they be eight to ten feet high, is not too difficult; and this overwood should probably be removed just before its whippy leaders are about to inflict physical damage on the conifers. It is our belief that much may be learned from the study and practical utilization of the initial vegetational phases.

Second, while slit plantings (using the Harvard Planting Tool), are faster and less expensive than those done with the mattock, we are beginning to feel that in this rocky region the latter tool makes for better results where 2-2 stock is being used. Small stock, such as 2-0 larch, can be planted in slits with good success, but we believe the larger root-systems of 2-2 stock can be much more comfortably arranged in a fair-sized hole. The German practice of using the mattock to make a fairly large hole having one solid, vertical face against which the roots may be carefully "fanned" and held while filling in, may be more costly but it seems to be warranted in view of the high survival thus obtained.

Our four attempts at type conversion have been costly, but the evidence is strong that we shall gather the data sought. These operations, involving clear-cutting followed by planting, have required in each case a deal of machete work to keep the hardwood sprouts from smothering the conifers. We undertook these projects to

ascertain whether pure coniferous plantations could be established in this region to any extent whatever, since a future part of our research program contemplates the possibility of establishing coniferous protection forests on some of our numerous dry ridges and hilltops. Over much of these conversion plantings we expect to obtain small pure stands of white spruce, European larch, or red pine; but there are of course spots where failures have occurred, and on such we are handling the numerous hardwood sprouts so as to produce either groupwise mixed hardwoods of high quality or a stemwise mixture of conifers and hardwoods.

In restocking cutover hardwood lands with conifers, we have found it excellent practice to let the cleared area sprout for one season before planting. This defines the location of the clumps of sprouts, making it a simple matter to plant the new stock in the open spots, away from, rather than close to, or beneath the new hardwood growth. Also, these sprouts evidently supply some of the light shade necessary. This procedure has yielded worthwhile results.

Our soil improvement plantings were made on sites of notably low grade. Compartments X and XX were very severely burned in 1911; Compartment XII has not been burned of late, but the existing growth rate is generally low. Our settings were rather close, using 2-2 stock (except for the European larch, where we have always purchased 2-0), but we did not plan to establish pure stands. Rather did we seek a stemwise or groupwise combination of conifers and mixed hardwoods. On projects, "Soil Improvement Ref. 5a" and "Ref. 9b" the sprout growth has been of normal vigor, causing about the usual percentage of loss. On project, "Soil Improvement Ref. 6a" (Tower Hill) where the soil is thinner and the slopes steep, the sprout competition has been distinctly subnormal, calling for a proportionate reduction of lopping. All three of these projects show good prom-

ise of producing the desired mixture of coniferous and deciduous leaf-litter. In this connection, it should be remarked that under the European larch planting on Honey Hill (Ref. 1e) there is now present from 3 to 5 inches of dark crumb soil, while under the adjacent indigenous hardwood stand we find no more than a thin film. This development is scheduled for detailed laboratory analysis when time permits.

In years to come, these plantations will undoubtedly present the problem of how to maintain at least a percentage of these conifers in the future stands. We are not yet prepared to make more than the suggestion that some form of the shelterwood wedge cutting (*Schirmkeilschlag*) or the shelterwood strip cutting (*Blendersaumschlag*) might perhaps be applied to good advantage in this connection.

Asiatic chestnut and European and Japanese larch are the only exotic species planted here thus far. In 1931, in cooperation with the United States Department of Agriculture, we set 2.4 acres to the former in mixture with 2-0 red pine, planting one row of chestnut to every two rows of pine on what was formerly an open field in Compartment XII abutting on the east edge of the Continental Road just south of the White Oak Trail. The volunteer weeds were cut, the brush burned. Today practically all of the chestnuts on the north half are dead, owing we believe, to the rather heavy soil. The south half, where lighter soils occur, is in good shape. The pine is excellent throughout. Three complete release cuttings have been required. The chestnut stock was about 18 inches high when received and made but little height growth the first two seasons, while the cut hardwood stumps sprouted with their usual vigor. But by now the remaining chestnuts are about on a level with the sprouts, and we believe that one more partial lopping should complete the cultural work. This species bore a few mature fruits in 1936, and several dozen in the fall of 1937.

In 1936 we obtained a few hundred more chestnut seedlings. A few were spotted in on Cutting 8a and the balance on sites in Cutting 8b where the cleaning had occasionally expanded into a small clear-cutting, owing to the presence of large numbers of dying chestnut oak.

The sugar bush plantation is in Compartment XI and is bounded by the Continental Road on the west, and by the 2.4-acre Asiatic chestnut planting on the north. It was once a pasture. The small weed trees which had come in were cut clean, the brush burned, and the ground ploughed twice and harrowed. The turf was very heavy. Sugar maple stock, 6 to 10 inch, was set 4 x 4 feet on something under one acre.

In this region, sugar maple is a hardy, tolerant, rather slow-growing tree. We have cultivated lightly twice, (1930 and 1931) around each living tree, and lopped the competing sprouts once. The stand is pushing up slowly but steadily and today is in first-class shape with few failures. Cottontail rabbits have deformed a number of trees by nibbling the leaders.

Our first plan was for an 8 x 8 foot spacing, using fillers of some more immediately profitable sort, and in time making one or two cordwood thinnings in the main stand. We contemplated using peach trees, these being neither large trees nor rampant growers, having the thought that several crops might be harvested, thereby helping somewhat on the expense during the early, non-paying years. But the location was against providing the detailed care which fruit trees require here, so we adopted the 4 x 4 foot spacing. We estimate that at least two cordwood thinnings may be made before tapping size is attained.

No more extensive planting work is contemplated at present. The comparative ease with which natural reproduction can be obtained makes this seem unnecessary.

SAMPLE PLOTS

Our procedure in establishing sample plots follows, as a rule, the accepted lines of laying out, marking, witnessing, numbering, measuring, recording and photographing. A number of these have been set up in our various cutting operations, using some 0.1 acre in size, but chiefly 0.25 acre. Our chief object has been to obtain a check on the behavior of the annual increment following a cleaning, thinning, or other form of improvement cutting. In the majority of cases we have laid out both check and control plots; but in a few instances we have omitted the latter. The analysis of such "uncontrolled" plots will be made following the final cutting of the area represented. We believe that thorough stem analysis of the trees then felled should give a complete and quantitative picture of the increment performance both before and after the improvement cutting.

Our period of intensive operation here has been too brief to afford a basis for final discussion of the effects of our cuttings. One point, however, is quite clear; in this region the influence of improvement cuttings such as we have been carrying on rarely becomes evident before five growing seasons have elapsed; and as a rule, ten years is far more likely to be necessary to obtain clear-cut volumetric values.

RECORDS

Surveys

The external boundary has been mapped by closed azimuth survey referred to true north. Distances are in feet and tenths. On the ground, the boundary is cut clean to about 15 feet wide. These lines require trimming back about once in three years. Our corners are marked chiefly by 2-inch G. I. pipes having a tee on the lower end, the pipe is filled with cement, surrounded by rocks, and plentifully witnessed. A few corners are marked by blazed trees properly witnessed, some by iron rods sunk in boulders or ledges, a few by x-marks on rods sunk in boulders on ledges, our two or three common corners with the United States Military Academy by inverted cannons set in the ground, and where we adjoin the new 9-W by-pass and the reservoir properties belonging to the Village of Cornwall, by small concrete bounds.

Thus far we have utilized existing roads, trails, or waters as compartment boundaries. This has given us twenty-five compartments of assorted shape and size. These subdivisions will serve for our first "housecleaning," but when the later intensive work begins, many of these compartments will be far too large, and artificial subdivision lines of some sort will be necessary.

Maps

Our base plane map is on a 400-foot scale. We have excellent topographical maps on a 10-foot interval on both 1,000 foot and 500 foot scales, and airplane maps on a 1/4,000 scale. The description of the external boundary has been very carefully checked and filed. We have also

a growth plan on a 1,000-foot scale which was made before any cuttings were completed. On this is plotted the stand volume obtained from our first inventory of the forest.

Each compartment is mapped separately, and to as large a scale as is feasible. These are plane maps, done in detail. On them all woods operations are plotted in color, with the file reference number of each operation.

Parallel with these compartment maps we are compiling, so far as possible, a narrative history of the land tenure and use of the various parcels. Owing to the scarcity of accurate records hereabouts, plus the steady decrease of the "old-timers" it is doubtful if we can ever fully complete this part of our records. But what we have gathered thus far has fitted nicely into our knowledge of recent type succession.

Operating Records

All woods operations are recorded in detail. Duplicate write-ups are compiled, surveys and maps made when necessary, photographs taken, indexed and filed with the report itself, together with statements of cost, equipment, or method.

We take photographs somewhat freely. All good negatives and prints are numbered and recorded. The negatives are filed in a fireproof building with the prints and all operation records.

Financial

The Forest bookkeeping is relatively simple. A cash book and a few ledger accounts serve our needs.

ACCESSIBILITY

Roads

Plate III shows the present road system. It is not likely that we shall build much more "main road." A few additional spurs now seem to be about all that will be needed in the future.

All our roads are of crushed stone, with a wall-rock base. Good gravel is non-existent here, so we installed a small stone-crusher which greatly simplifies the problem of proper surfacing. Maintenance here (as anywhere) depends chiefly upon controlling the run-off. It pays well to lay a well-drained base, and to install adequate gutters and culverts.

Nearly all of our existing roads are reconditioned woods roads. In a few cases this has resulted in excessive grades and curves. All the roads built since 1932 were run out with center line and grade stakes. None of these newer stretches exceeds a grade of 7 percent. A retaining wall is occasionally needed; these are laid up loose. Gutters are gouged out with the bull-dozer; culverts are usually concrete or corrugated pipe. Road shoulders are wall rock. The new surface is spotted between these, and this addition to the crown is the equivalent of deepening the gutters. We rarely build bridges, preferring concrete culverts. All roads are built to a generous single-track width. Occasional turnouts and parking spaces are cleared, drained, and surfaced.

Our main road system has been planned to give the maximum degree of accessibility in case of fire and for the movement of products and the saving of travel time for field parties.

Our problems of road construction and maintenance

vary only in degree from those of any demonstration forest. We strive to limit our grades to 7 percent or less. In our hilly, steep country, switchbacks sometimes become necessary, and here we are sometimes forced to use curve radii as short as 50 feet to avoid expensive excavation. Since our roads are practically all private and carry little traffic other than our own, we are seldom concerned with problems of sight distance.

Complete control of drainage is the keynote of low road maintenance charges here. The run-off is very quick —occasionally torrential—and it is essential to use plenty of coarse ballast, to lay a sufficient number of adequate culverts, carefully located, and to construct adequate gutters and keep them clean. No one of these three items may be neglected or even slighted without a prompt effect on maintenance cost.

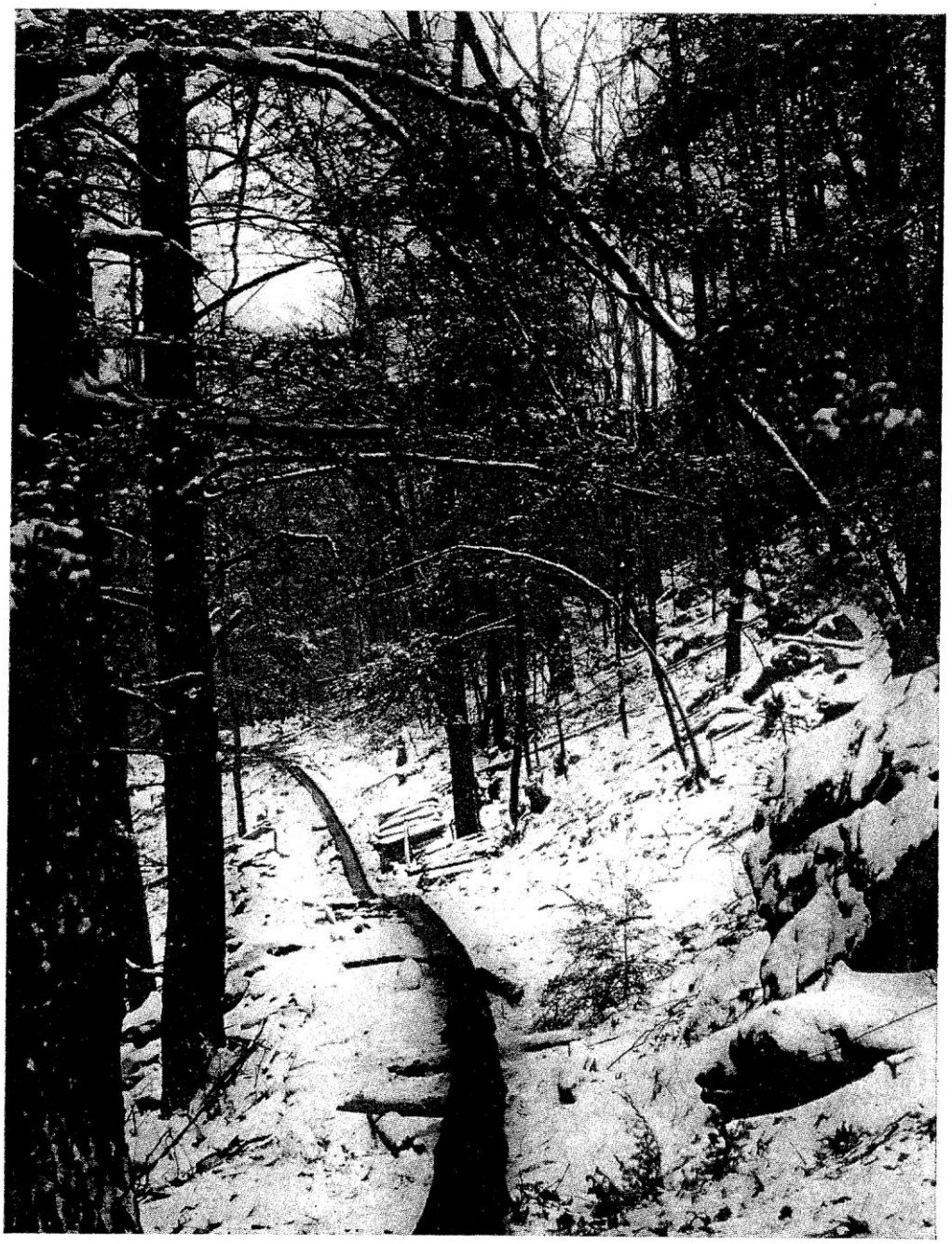


PLATE VII. WOOD CHUTE. COST ESTIMATE OF PUTTING THIS ROAD IN SHAPE FOR TEAM HAULING WAS $300.00; WITH THE CHUTE, THE TOTAL COST OF GETTING THE WOOD OUT TO THE NEAREST TURN-AROUND WAS $36.00. THIS INCLUDES BRINGING CHUTE IN AND LAYING IT, CHUTING THE TRIBUTARY AND MAIN LINE RANKS AND DISMOUNTING CHUTE AND CARRYING IT OUT TO THE HIGHWAY.

PROTECTION

Fires

Our fire record is, fortunately, a happy one. We are somewhat removed from main traffic arteries, and our practice of closing all of our private roads to wheeled vehicles helps, we believe, to reduce the danger. Signs are maintained requesting smokers to be careful, and explaining our few simple regulations anent fire-building.

Since 1927 we have had five small fires. None was very severe; the total acreage was 8.4. Three of these were set by smokers; one spread from an improperly abandoned camp-fire on adjoining lands, and one was the result of carelessness by a C.C.C. crew.

Our chief danger seasons are about as usual. April 20 to June 15 and October 1 to November 15 are our worst periods. Late September occasionally brings a high hazard.

We keep our roads and trails as thoroughly brushed out as our budget will permit. It is neither necessary nor possible to clean the full mileage annually. We try to allocate this preventive work to the most heavily traveled sections in their order of risk. Where a cutting operation borders a road or trail we frequently burn the slash over the adjacent 2- to 3- rod strip.

Six of the seven ponds in the Forest are touched by our road system, and the seventh (Spruce Pond) is not far from the Continental Road. Wherever our roads pass near a suitable spring, it is our policy to install a catch basin, properly deepened, rocked, and large enough to take at least one knapsack pump.

A 75-foot steel tower, erected on Tower Hill just back of the Chatfield House, commands the entire Forest ex-

cept the extreme northwest corner. But overlooking this area lives a cooperative neighbor with a telephone, whose house covers this "blind spot," and who will call us should anything be amiss. There are two state towers near-by, one to the south in the Palisades Park, one to the northeast on Mt. Beacon, across the Hudson. During the dry seasons these two are occupied steadily, and our own tower is fairly constantly in use, especially over week ends.

Our fire-fighting equipment includes a supply of shovels, rakes, hoes, brushes, and knapsack pumps. The combination of our road system and four trucks makes it possible to put a crew on suppression in short order. When it becomes possible, we plan to acquire a suitable woods fire truck, equipped with rakes, shovels, knapsack pumps, 40-quart milk cans, and a small power pump. We believe our numerous ponds, springs, streams, and catch-basins would make this an effective piece of equipment.

Pests

The Forest harbors about the usual array of pests. The shoe string fungus is present, and doubtless other species of which we are not yet aware. So far, insects have not troubled our plantings save for mound-building ants and some larch sawfly.

Ants and Dead Pines

The mound-building ant (*Formica exsectoides* Forel) is common here. The familiar domed houses are frequent in sunny spots along trails and roads. They are quick to appear where a heavy thinning or a clear-cutting has been made. Our red pine plantations, many of which were set on open land, have shown frequent invasions, always followed by the death of an increasing number of the planted trees surrounding each nest. We have used

carbon disulphide with marked success in destroying these colonies.

Cottontail rabbits, deer, and the several beaver colonies which have been formed here since the latter animals were introduced into Bear Mountain Park, cause us some annoyance. Rabbits and deer eat the tips of red pine; deer do a fair amount of damage by eating the leaders of young white ash, red pine, yellow poplar and European larch. By rubbing their horns when emerging from the velvet, bucks frequently cause serious injury to young seedlings.

The beaver are an unmitigated nuisance. They dam our streams, flooding valuable areas and killing the stands thereon, they have drowned portions of our plantations, and, with a singular lack of discretion, they fell and bark numerous trees of valuable species of merchantable size. We have tried, without success, to persuade the State Conservation Department to trap them out.

GENERAL

Climate

We sometimes have high winds, with occasional overthrow of trees, especially those rooted on ledges where soil is thin. Wet, heavy snows and now and then an ice storm bring us our share of broken crowns and stems. Frost occasionally goes very deep—48 inches is our known record thus far—causing occasional frost-crack and some spring heaving of our roads. But the latter is rarely severe where adequate subdrainage has been provided.

Signs

It has been our policy to erect simple, semi-technical descriptive signs on our different operations. We have a supply of good chestnut posts; but what sort of sign material made the best combination of low cost, readability and durability has annoyed us. We tried various methods of painting and lettering; these appear below in the order of preference.

1.—Black enamel lettering on aluminum paint base.
2.—Black enamel lettering on aluminum paint base and varnished.
3.—Black enamel lettering on white base.
4.—Black enamel lettering on white base and varnished.
5.—Black stencil ink and varnish.
6.—Black stencil ink on enamel on plain wood.

Four by four No. 1 common D4S white pine or western red cedar are the most satisfactory woods we have used. We have yet to find a varnish which will stand up more than two or three years. Plain wood signs, lettered, are

prone to become weathered and gray, with a great decrease in the readability. We are making tests on certain DuPont products, but these have not yet been carried on long enough to warrant conclusions.

Gates

The Continental Road, which bisects the south two-thirds of the Forest, is a public road and is intersected by

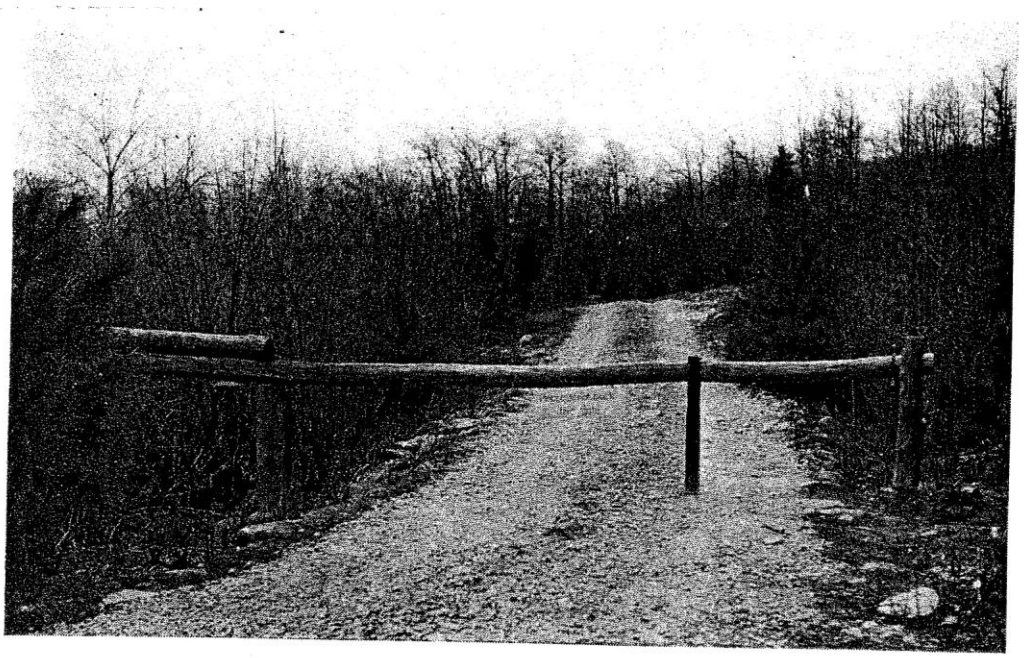


Plate VIII. SHOWING THE TYPE OF GATE USED.

our main road system at two points. We do not allow automobiles on our own roads except by special permit, hence it is necessary to close such other entrances. We use both chains and swinging bar-gates. The latter are more picturesque and quite serviceable. A stout, flat-topped post is set on one side of the road, a forked one opposite. A rail (preferably chestnut) of sufficient length to reach from about five feet back of the flat-topped post into the opposite forked one is pinned vertically to the top of the former. A "crutch" is bolted to

the cross-rail near the forked post. A strong eyebolt should be put through the latter for chaining the bar fast. Our gate locks are a standard combination. It helps to bolt a counterweight to the five feet projecting behind the flat-topped post. (See Plate VIII)

Fauna

The Forest supports a fair quota of wildlife, including deer, cottontail rabbits, some scattering grouse, an occasional pair of woodcock and a few mallard and black duck. The tract is not closed to hunting and each open season it is quite throughly combed, with the result that game is by no means plentiful. We have about the usual array of hawks, crows, owls, mink, red and gray foxes, red and gray squirrels, bobcats, songbirds, and an occasional otter. In this connection, it may be of interest to relate that redwinged blackbirds, who have a favorite nesting-place on the island in Spruce Pond, make a regular practice in the early summer of flying over to the European larch plantation at the Chatfield Place on the mainland near-by, picking up a beak-full of the sawfly larvae and carrying them back to their youngsters.

As time permits, we shall make occasional roadside plantings of various hardy fruit trees, such as the Japanese crab, to serve as a source of food for our fauna.

Public Use

The Forest is closed to fishing and trapping, but not to hunting. Camping and camp-fires are allowed at very rare intervals, by permit only, to responsible parties at certain specified spots, and when the fire hazard is sufficiently low. The entire forest boundary is marked with tin signs, 10 x 7 inches, lettered in black on yellow, "Black Rock Forest Boundary." Equestrians and hikers who observe our few simple regulations are welcome.