

THE BLACK ROCK FOREST

BULLETIN NO. 14

HENRY H. TRYON, *Director*

TWENTY-YEAR PROGRESS REPORT 1928-1948

By

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INTRODUCTION

THIS report, emerging after twenty years of comparatively intensive study of the Black Rock Forest, will deal in some detail with artificial reforestation as tested out here. Various settings of red and white pine, Norway and white spruce, Asiatic chestnut, and European and Japanese larch have been tried.

There will also be discussed, at considerable length, some twelve separate experimental cuttings of various types. Two of these (Ctgs. 1b and 1d) were given a heavy preliminary cleaning which later proved to be a reproduction cutting, a final cutting and, later, one or more release cuttings aimed at freeing the new stand. One area (Ctg. 4a) was cut clean at the outset and the ensuing regeneration has since been given careful releasings. Another (Ctg. 3b) has been cleaned twice and is now nearing the time for a final felling. One other (Ref. 14a) was cut very hard, then underplanted and later given a releasing. The other five projects (Ctgs. 2a, 3a, 13b, 14e and 16a) have been carefully cleaned once. These selected items appear to offer the maximum amount of interesting data to be derived from a study of completed or partially completed silvicultural treatments. It is believed that a detailed scrutiny of these few operations will give a far clearer picture of conditions here, of the treatments applied and of the results obtained than could possibly be presented by any general survey. In addition, of course, any projects which have reached completion since the appearance of our last progress report will be presented in adequate detail.

It is perhaps timely to recapitulate briefly the history of this Forest. It is a hardwood area with various oak species predominating. Lying within easy reach of a

busy railroad, an array of brickyards, Hudson River steamer traffic and iron deposits, all providing markets for lumber, charcoal, fuelwood, railroad ties, hoop poles, staves and other minor forest products, it has endured a long period of abusive exploitation. This, coupled with the frequent woods fires of earlier years, has combined to produce a stand today largely coppice, often defective, and not infrequently growing on a badly scorched soil.

Our chief objective is, naturally, to restore these highlands to the productive conditions prevailing some 165 years ago. The conditions now visible on the "case" areas herein described indicate that the attainment of this goal will be neither overly difficult nor too time-consuming.

Looking back over the twenty years which have elapsed since this Forest was placed under technical care, it is difficult to avoid the conclusion that operations here during the first half of this period were very much of a groping, feeling-our-way character. It must also be admitted, and in all humility, that we still have much to learn. As the years have passed, certain breaks have opened in the fog surrounding us, and occasional fragments of realistic silvical and silvicultural knowledge have been accumulated, yet the picture is by no means complete. There is still much to be learned. Each day brings it home more vividly that mixed hardwood forests give us to deal with a series of singularly complicated, yet utterly fascinating biological units.

A partial prescription for meeting some of the problems encountered here might be defined as a voracious appetite for silvicultural and ecological knowledge combined with the ability and the avid desire to ascertain and evaluate the numerous existing inter-reactions.

But little quantitative data will be found in this report, for this Forest is at present in a transition state—it is passing through a cleaning process which, if sound judgment be granted to us, will in due time transform the ex-

isting sprout stands into a seedling growing stock. Hence the tract can not as yet be deemed ready for the construction of a detailed working plan. This can be assembled at some later date after the desired growing stock has been created.

The establishment of an array of permanent sample plots sufficient to yield adequate working data on the handling of coppice stands was begun in 1928 and has been carried forward regularly since; the first set of final values on these will be gathered in 1953. Additional plots in coppice areas are being established from time to time with the aim of gathering supplementary data on such stands.

REFORESTATION

Seventeen plantations were mentioned in our ten-year progress report.¹ Since then, others have been established to afford an added check on certain tentative conclusions recorded in 1932² and in 1938. It now appears possible to advance certain definite and final judgments on coniferous reforestation in this area. These will be briefly discussed under the same file numbers as were employed in 1938.

Old Field Plantings (coniferous and broadleaf)

Generally speaking, it is futile to attempt to establish coniferous plantings on old fields here. Such expensive battling with the local pioneer hardwood species will be required to keep the plantation alive that the costs will be prohibitive. Where the soil site is suitable for conifers, this could be accomplished; but such sites have not yet been found on this Forest. It is true that we have today several plantings of red and white pine, white spruce and European larch which, thanks to unremitting and aggressive releasing work, are now about "on their own"—but at what expense! The costs of the releasing work have been so large that such projects may be quickly dismissed as being wholly uneconomical. Then too, there arises the question of management of such stands. Costly thinnings and prunings will also be needed if the full value is to be realized, and experience here now shows conclusively that it is hopeless to look for natural regeneration of such planted species. If the plantation canopy be broken—even slightly—the fast-growing indigenous hardwood species will invade such openings with truly malevolent rapidity. Two of our three hardwood plantations (Reforestation 2a and Reforestation 4a) are pro-

ceeding nicely, though here again the releasing costs have been too great to warrant the recommending of this practice. In brief, better results can be obtained at far less cost by applying such simple releasings as may become necessary to hasten the development of a volunteer stand of the local commercial species. Nature, if accorded an occasional bit of shrewd, observant help, will create the



PLATE 1

Ref. 4a; 2-2 red pine set in 1932 in heavy turf on an old field at the Joe Hulse place.

best crop—the most valuable and the most easily managed association.

Asiatic Chestnut (Ref. 4a)

Our oldest plantation of this species was established in April, 1931, setting two rows of chestnut alternating with one row of 2-2 red pine, using five-foot spacing

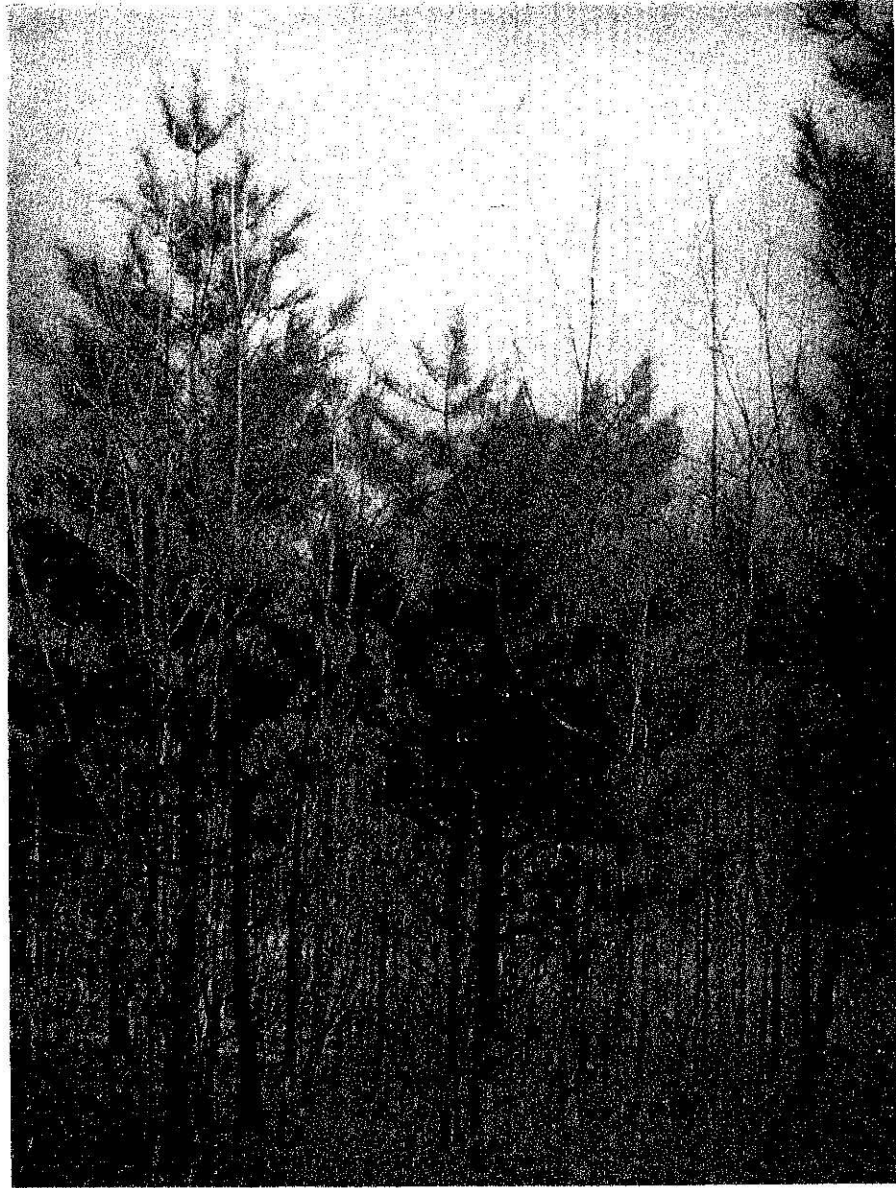


PLATE 2

Ref. 6b; the John Odell Farm; red pine set in stripwise mixture with yellow poplar. Observe how the native sugar maple, white ash and red oak are racing to overtop the conifers.

throughout. The planted area, bordering the Continental Road on the east, was an old field, part of which had been used as a borrow-pit for material for the Arthur Pond dam. The growth was chiefly gray birch, red maple and cherry.



PLATE 3

Ref. 4a; red pine, 2-2 stock, set in 1932 in an old orchard carrying heavy turf. In background, right center, appears the edge of a planting of European larch, 2-0 stock, set 1928. It is a pretty picture; but far too many man-hours have been expended in keeping down the aggressive native hardwoods.

This project has had a hard life. The area was cut clean in advance of planting, and the subsequent sprout growth promptly overtopped the planted species. Four separate weedings have been applied, all of which were aimed at releasing either chestnut, red pine or seedlings of desirable native hardwood species. No sprouts of any species were retained. This procedure left a deal of organic matter on the ground.

Today, 1948, perhaps 20% of the chestnuts are alive, with an average d.b.h. of 3 inches and height of 25 feet. The trees are generally quite sturdy, with some of the bigger ones beginning to show some shade pruning. A few trees have been killed by the blight. It is not now easy to identify them by species but, inasmuch as the area carried a scattering of native chestnut, it is assumed that these were the casualties.

Perhaps an outstanding example of what not to do is found in Reforestation 6b, the John Odell farm, where an old field was set to red pine and yellow poplar in strip-wise mixture. Today a large number of the planted species are present and growing well, thanks to a good bit of releasing work with the machete, but there is present an understory of strikingly vigorous and well-formed white oak, sugar maple, red oak and white ash which shows every indication of overtopping the planted species before many more seasons have passed. A number of man-hours have been thrown away in the planting and releasing work done here. It would have been far better forest economics had we put our trust in the native species; so, in general, it is recommended that the making of coniferous plantings in this area be discouraged and dependence be placed on the local hardwoods, for these will ultimately invade the area anyway.

Coniferous Underplantings

As added good evidence against the practice of setting up coniferous plantings here, we may cite the under-

planted strip (Reforestation 4c in Compartment VI). To review: a strip 100 ft. x 1400 ft. was lightly thinned in 1931; the north half was then underplanted with 2-2 white spruce, the south half with 2-2 red pine. It was to be a test of the possibility of producing a mixed hardwood and coniferous understory destined, it was hoped, to take over when the remaining hardwood overstory was removed. The sprout clusters were cut back twice in rather extensive fashion and the over-wood was again thinned in 1936. The project has been a complete failure. Today there are still present some scattered conifers, but they are puny and obviously doomed unless the overgrowth be completely removed—a step hardly warranted and of very dubious efficacy. Similarly, the underplantings along the White Oak Trail at its junction with the Continental Road and on the old Bearmore Place have failed. About the same procedure was followed here; a heavy thinning, then underplanting with 2-2 red pine, followed by cutting back the sprouts and later a final felling of the hardwood overstory. A few “successful” red pines remain. Such a venture can only be called futile.

Where the canopy is well opened the former project now contains pines 20-25 feet in height and 3-4 inches d.b.h. The foliage on such trees is abundant and of good color. Where, however, there is partial shade over the pines the average height and diameter runs around 10-15 feet and 1.5-3 inches respectively. Where complete overtopping has occurred, the heights run well under 10 feet with diameters lying between 1 and 2 inches. The sprouts are thick here; a high percentage of them are white oak, indicating a soil unsuited to red pine.

On the Bearmore area, where the thinning was far less severe, the over-wood is today almost completely closed and the pines are of poor thrift, averaging 6-7 feet high and 0.5 inches diameter. The foliage is sparse and of poor color.

The Sugar Bush Planting

Established in 1929 on an old field just west of Arthur's Pond. Gathered stock was set 4 feet x 4 feet. August of this year saw a bad drought. Following this, 88% survived.

The trees were cultivated twice, in 1930 and 1931. In the latter year the competing weed species were lopped, using the Fisher system. Some of the maple leaders had been eaten off by rabbits.

By June, 1942, the average height was 9-10 feet, with a maximum of 18 feet. In this year another, and very carefully planned, releasing was applied. All interfering species were removed around the edges of the plantation except where we met a good white or red oak which could be utilized as a filler. The interior was thoroughly released, most of the weeds being cut back to about 4 feet. Where the maples were short, the cutting was made proportionately lower. No evidence of insect or fungus injury was found. Where trees had been browsed, causing forked leaders, the less likely forks were carefully pruned off. The last releasing was in 1944.

By the summer of 1948 the indications were that but little additional work would be necessary. Three shrewdly-spaced releasings have been sufficient to produce an interesting stand of straight clean trees averaging about 2-3 inches d.b.h. and around 20 feet high at 17 years. The policy of favoring such good native hardwood seedlings as were found was evidently sound, for today there are in the mixture a number of beautiful young oaks of fine form.

While the present climate in this area is not too good for sugaring, in the past it was a widespread practice here, which was one of our reasons for embarking on this project. It is obvious that a "bush" can be set up here by artificial means. This plantation has cost, to date, \$160.00 an acre, in terms of a pre-1941 dollar. It is

planned to make a cordwood thinning as soon as the original 4-foot spacing outlives its purposes.

Miscellaneous Plantings

A curious instance of climatic ill luck came to light in a small old field planting consisting of black walnut, red oak, and European larch in mixture with a young stand of the local pioneer species bordering the Ben Lancaster trail just southeast of the Upper Reservoir. Today, after periodic releasings, only a few dozen larch are left. The oaks and walnuts have completely disappeared, the former apparently wiped out by excessive shading and the latter owing to the area being a perfect and quite unsuspected frost pocket.

By 1938, the idea had partially crystallized here that coniferous protection forests might perhaps be established on the non-commercial dry ridges and hilltops. In the light of our findings since the foregoing date, such a program has been completely abandoned. Dependence in gaining such objectives as protection forests will probably hereafter be placed on the native hardwood species.

Three plantations of European larch, and one of black locust were established in 1928, 1931, 1932 and 1938 respectively. A brief summary of performance thus far may hold some interest.

Ref. 1c: the old orchard at the Chatfield Place; 2-0 larch set in 1928 in very heavy turf.

Today the larch here range from 4 to 9 inches d.b.h. with a mean of about 5 inches. The average height is around 35 feet. The stand is generally in fine condition and is fully closed over. About 1 inch of litter is present. The scattered red pines which were set in 1932 (2-2 stock) where portions of the larch had failed are today hopelessly overtopped. This is the best larch stand on the Forest.

Ref. 3b: the old field just south and east of the Chatfield House; 2-0 larch set in 1931 in thick turf, then coming in to gray birch and red maple.

The average d.b.h. is 3-4 inches, with a minimum of 2 and a maximum of 6 inches. Heights average around 30 feet. Here again the trees standing in the open have made by far the best growth while those under partial or total shade are small in both diameter and height.

Ref. 4b: the Buckwheat Lot; 2-0 larch set in 1932 in an old borrow pit, then coming in to a profuse growth of gray birch, red maple and cherry.

Here are extreme variations in both height and diameter, due to partial or complete shading from standards left or from the dense sprout and brush growth. Under shade, the diameters run from 1 to 2 inches while in the open 4 to 5 inches is the general rule, with the average about 3 to 4 inches. The largest tree in the area measures 6 inches. Heights average 25 feet with a maximum of 40 feet, with some individuals showing no more than 5 ft. Some snow breakage has occurred and some few trees have been tipped over by wet, heavy snow. The litter is about $\frac{3}{4}$ -inch deep.

Ref. 12b: the Isaac Odell Farm; 2-0 black locust set in 1938 in the remains of an old orchard with rather thick turf.

Diameters average 2.5-3.0 inches with a maximum of 3.5. Heights run between 25 and 30 feet. The stand appears to be of good thrift with quite straight boles and no evidence of borer damage appearing as yet. A number of stems are forked near the top. Possibly a planting of shipmast locust would have been free of this. Very little litter is present, owing in part to the comparatively small

amount of foliage produced by this species and in part to the relatively high nitrogen content of the leaves. Moreover, a good bit of sunlight gets through the rather thin canopy causing relatively high soil temperatures resulting in rapid decomposition.

CUTTINGS

It is in the field of applied silviculture—in the making of improvement cuttings of various types—and noting, by means of careful records, both written and photographic, what happened in the seasons following the operation, that the research silviculturist experiences the greatest thrill. Any competent forester will be quick to admit that no two acres of forested land are precisely the same; and it is this never-ending challenge to one's resourcefulness, silvicultural understanding and ingenuity—what Fisher and Rommel have so aptly called that “biological feel for the Forest”—that one meets with one of the most baffling yet fascinating branches of our profession.

To digress momentarily into the somewhat personal field, this writer is thoroughly convinced, in the light of his experiences during the past quarter-century, that successful silvicultural practice must be based chiefly on definite, accurate and, if possible, first-hand knowledge of the forest cover type successions indigenous to the region wherein one is operating, combined with all available information on silvical requirements, nutrient needs and soil conditions. Many of us are working in stands which are the result of fire, windthrow, over-cutting or other abuse or catastrophe. It is a prime requisite for the forester to be able either promptly to allocate such stands to their correct niche in the successional stages—or by careful study and observation to piece together the answer to this question. The professional literature of today carries ample suggestions for such successional studies, and it is felt that thorough familiarity with these methods should be a part of every silviculturist's kit of tools.

Such basic data are not difficult to accumulate. Careful, observant studies of the various successional stages as they are found in your particular district will yield valuable returns in the form of a deeper understanding of your forest. For a thorough job one should examine each stage, beginning with the pioneer old-field association up to and including the local climax. Such a line of attack will make it possible to isolate each forest cover type for your particular locality. And, equipped with such data, it then—and only then—becomes possible to view these various stages in their true relationships and to adjust your cutting operations to a harmonious fit with the natural local vegetational trends. In short, such knowledge so equips the forester that he can mark with confidence and in full and complete accord with the long-term aspects of the situation.

The circumstances prevailing here as regards stand condition, form and composition have been set forth in earlier publications of the Forest.^{3, 4, 5}

Let it be emphasized that in this region where the oaks are so much in the majority with the resulting deposit of leathery and rather impervious leaf litter, reproduction in untended stands appears but slowly. Even under managed conditions where seed production and germination are, it is hoped, perceptibly augmented and where the leaf litter is lessened in depth through accelerated fungal and bacterial action, natural regeneration has thus far proven to be a slow, leisurely process.⁶ It is but human to indulge in the hope that as our silvical knowledge ripens, as the “biological feel for the forest” broadens and deepens, so will the more rapid obtaining of adequate natural regeneration become increasingly a matter of course.

Ctg. 1d (the Hall cutting) and Ctg. 15a

A fairly detailed description of this area and the treatments given it was published in 1938.^{1, 6} The project is to-

day in an extremely interesting stage of development. First treated in the winter of 1927-28, it was a discouraging spectacle for the ensuing first years. By the autumn of 1931 a pleasing setting of natural regeneration of the chief commercial species had appeared and was growing nicely. One light and two vigorous releasings, using the machete, have since been applied.

In the winter of 1942 the remaining overwood was cut (Ctg. 15a) yielding a small lot of handsome hardwood saw-logs with several thousand feet of good hemlock timber. The balance was fuel. Care in felling and hauling held breakage of the new growth to a minimum.

Today much of the area carries an adequate stocking of valuable species, chiefly, in order of occurrence, white ash, red oak, yellow poplar, white oak and sugar maple, with an occasional basswood. The concomitant species are chestnut oak, hickory, yellow and black birch, aspen, beech and hop horubeam, while the multitude of small hemlocks which has been appearing has taken quick advantage of the added sunlight afforded by the release cuttings and is displaying an unexpectedly rapid height growth which is, in most cases, somewhat below that shown by the young hardwoods. It may become necessary later on to remove a few of these conifers. For the present they are functioning beautifully as trainers.

Where the 1927-28 operation was too severe there are still present patches of either ironwood, sumach or black gum, but these are now either on the way out or are resuming their rightful position as members of the understory climax, while a sparse setting of the good species is beginning to appear beneath these pioneer invaders.

The composition of the new stand is of interest. It is vastly different from what stood here in 1927. The varying growth rates and degrees of tolerance displayed by the new stand offer food for considerable thought. A two-storied forest appears to be in the making, with white ash, red oak, tulip, red maple and an occasional black

gum, hickory, chestnut oak, and some black and yellow birch forming the overstory, and white oak, hemlock, sugar maple, and now and then a beech making up the underwood.

It would seem probable, from the present state of things, that the correct handling is to let matters go until the faster-growing overwood approaches commercial maturity. It is not unlikely that a light cordwood and perhaps a small log thinning can be applied to good advantage before this period arrives. Only time and periodic scrutiny of the area will decide this point. But whether or not such added attention becomes needful, the future of the project promises first a crop of high-grade logs and fuel from the overwood, succeeded some years later by a similar crop from the slower-paced species now forming the understory. While it is today only a conjecture, we suggest that this parcel might well be handled in the future so as to bring forth repeated crops in the same order of species as the two cuttings just outlined are expected to yield. In short, it seems doubtful that the white oak-sugar maple-hemlock association can be persuaded to succeed itself on such a soil site. It is here held to be far more likely that the future removal, when mature, of what is now the understory will again see the area coming back to the association forming the overwood of today. Such a successional rotation (i.e., the white ash-red oak-red maple-tulip mixture followed by the white oak-sugar maple-hemlock association) could be a pleasant affair financially, and at the moment it would seem to be sound silviculture as well.

Ctgs. 1b-8a (Upper Reservoir cuttings)

This project, located in Compartment VII, was started in the autumn of 1927. The first treatment was a rather heavy reproduction cutting which opened the canopy in severe fashion, leaving only the best-formed trees of the more valuable species to throw seed.

By the fall of 1934 a satisfactory setting of natural reproduction was present over the area except on the very wet spots where alder was dominant, and on the dry slope along the north edge. Here little or no seedling growth had appeared, owing to the small size, extreme density, and immature age of the sprout oak stand which had come in on this slope. The initial cutting had been followed by two good oak mast years, one unusually heavy white ash seed fall and two good crops of yellow poplar. The regeneration ran to white ash, red and sugar maple, red oak, some chestnut oak, yellow birch and some yellow poplar. There was also a heavy setting of brush and weed species. The wood market was brisk, the area was easily accessible, and it was deemed logical to make the final cutting. The Fisher plan of mowing the advance growth ahead of felling was used.

By the end of the 1935 growing season, a good array of sprouts had started, but the following year, in mid-May, there occurred an unusually severe late frost which covered the entire area, killing back thousands of promising shoots of ash and maple. The other species were hit less hard, save for yellow poplar.

By the end of 1937 both the composition and the density of the new stand seemed promising. The former included white ash, sugar maple, red oak, white oak, some chestnut oak, and yellow poplar. These were in some measure stool sprouts from small stems resulting from the mowing. Healing of the cut stems was progressing nicely, and a thick scattering of small black birch seedlings was appearing.

In May, 1940, the entire area, excepting the dry slope along the north edge, was given a thorough selective lopping to release the commercial species. The chief weeds encountered were moosewood, red maple, alder and some gray birch. It is of interest to note that moosewood predominates as this is, in this locality, a demanding tree, requiring a good, moist yet well-drained site. Its pres-

ence may be taken to indicate a fertile soil. This is further strengthened by the presence of beds of maidenhair fern.

· Today (1948) the area carries promise of a good yield. The commercial species present include red oak, white ash, black and yellow birch, some yellow poplar, bass-



PLATE 4

Ctgs. 1b-8a; the area immediately south of the Upper Reservoir. A fine example of the pure black gum thickets which may be occasionally produced by clearcutting on a moist site.

wood, chestnut oak, white oak and an occasional hickory. There are also several small dense patches of pure black gum; and in some parts of the southerly portion of the area there is appearing an infiltration of young sugar maple. The beneficial effect of the 1940 releasing is now clear. This condition is added proof of the need to delay



PLATE 5

Ctgs. 1b-8a; the same area as Plate 4, but less moist and carrying the typical yellow and black birch, white ash, red and white oak and sugar maple mixture appearing after two cuttings—reproduction and final.

such work for perhaps half a dozen seasons following a felling. The density of the young stand is high and competition is strong, producing straight, clean boles.

As to future management, no further treatment is planned until the quicker-growing pioneer species reach merchantable size. At this time a combined cordwood and releasing thinning might be profitably made. Such an operation should bear heavily on the black and yellow birch, black gum, and red maple. The suggestion might be offered that this thinning could be followed some years later by a fairly vigorous felling aimed chiefly at taking a crop of logs and fuel composed of white ash, red oak, and tulip. This should release the slower-growing crop species to form the final cutting.

The question immediately arises as to the possibility of rotating the timber crops on this, or similar areas, from yellow and black birch, black gum and red maple to white ash, red oak and tulip poplar and finally to white oak and sugar maple with some red oak and hemlock. It is believed that given shrewd marking the foregoing associations can be created in satisfactory rotation.

Ctg. 2a

The Glycerine Hollow area. This received a fairly heavy cleaning in the winter of 1928-29, some twelve cords per acre being removed. This sum does not denote as drastic a cutting as might at first be assumed, as the stand was of unusual height and the stems held their bigness well. Not many trees were required to make a cord.

By September of 1934 there was present a fair setting of yellow poplar, white ash and red oak with some red and sugar maple. By the summer of 1939 the regeneration on the central moist flat was strongly in evidence; in addition, the upper side slopes were showing some red and chestnut oak reproduction. The borer revealed that the increment of the main stand was holding up fairly well and it was felt that the period of commercial ma-

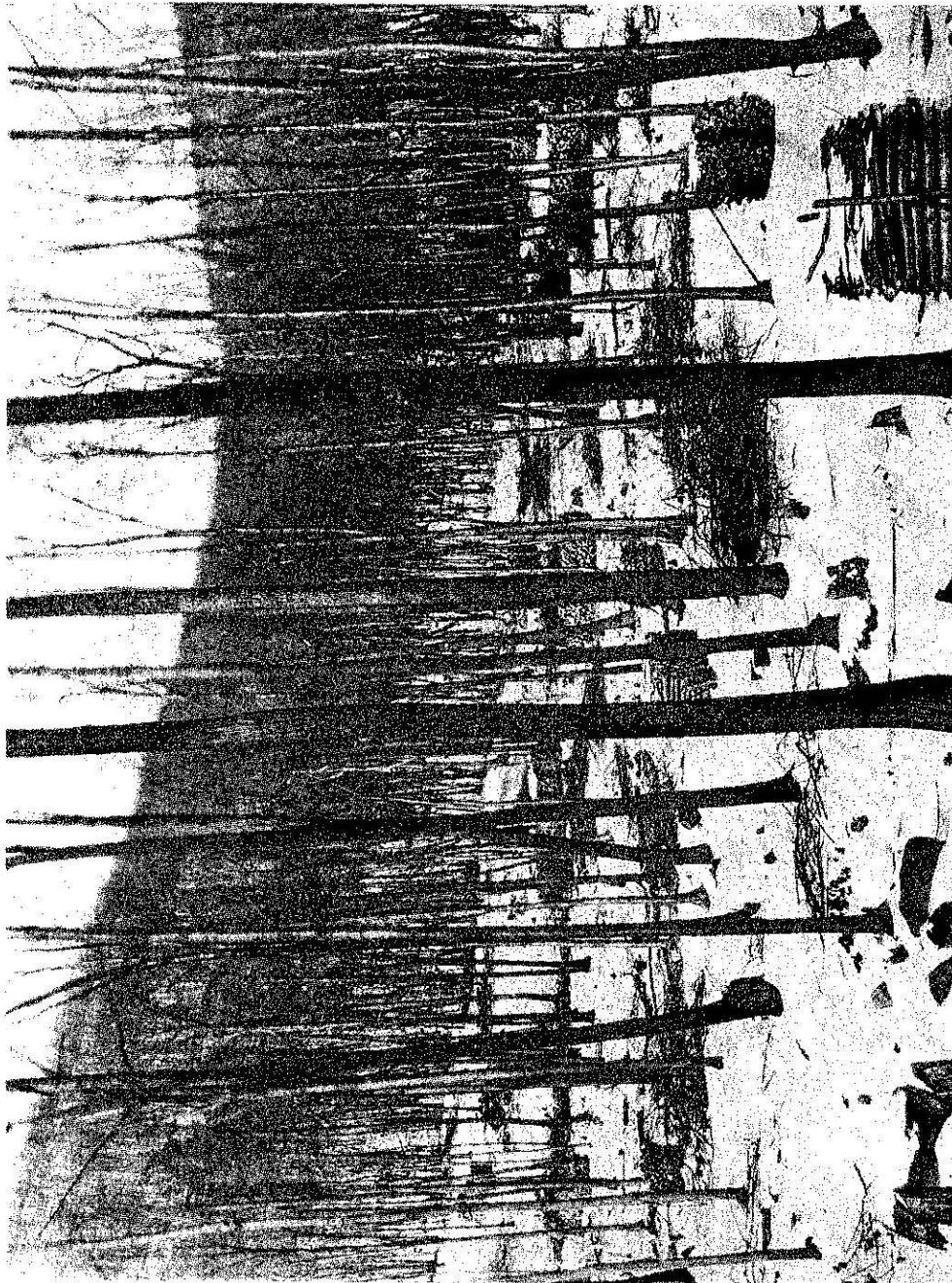


PLATE 6

Ctg. 2a; the Glycerine Hollow operation following the removal of 12.0 cords per acre.

turity was still a bit in the future. The stand per acre was about 300 stems. Little water-sprouting had appeared except on such yellow birches as had been left. Many of these were badly feathered out and the idea began to take root that this species should not be classed as a climax tree. The site quality was clearly of a high order; there was little crowding in the main canopy amongst the crop members.

By 1943 there was a good setting of red and chestnut oak on the higher levels bordering the central area, while many of the yellow poplar, ash, and red oak found on the flat in 1934 and 1936 had disappeared.

A detailed examination in the spring of 1948, twenty years after the first thinning, brought to light one item which warrants some changes in the tentative decisions expressed in 1938.¹

The behaviour of the forest in this project, as well as that observed on other choice sites, leads to the firm conclusion that to convert the sprout stands now found on such good sites to a proper seedling stocking will call for more than two operations. Where good soils are present, the crowns will be of such vigor as to close together in a short time following a cleaning or light thinning, which of course makes for a darkened stand interior, with a reduced chance of getting natural regeneration. For example, in this Ctg. 2a, while there is present today a truly impressive array of fine seed trees, there is little good reproduction. During the early years following the cutting, reproduction did come in and was well in evidence up to 1939. But thereafter the augmented shade thrown by the vigorously increasing crowns apparently served to decimate the new growth.

To-day this area is ready for a second cutting. The condition of the stand gives clear indications of the type of treatment required. The main canopy is well closed over; a number of trees, chiefly yellow birch, are beginning to stagnate and to develop water sprouts, while the

struggle for light has resulted in the development of a high understory of overtopped trees of low vigor. These individuals have definitely lost out in the race and should be removed. There are also present several yellow poplar of fine form but which have lost their tops through ice or snowbreak and which are, in addition, badly pitted with woodpecker holes. These should also be taken.

Such treatment will open the main canopy in rather drastic fashion—a step necessary, it is felt, to invigorate the remaining stems and to stimulate added seedfall and germination. Our first cutting here clearly proved that this can be done. This lesson can now be applied in beautiful fashion. The stand should be opened sufficiently to insure against a too early closing over with stunting of the expected natural regeneration. Following this operation the area should be carefully watched and when the new crop of reproduction is set and well rooted (this may require two or three season's delay) the main stand can be removed. This period of delay is advocated to give the new stand ample time to become well established since it is believed that natural regeneration on such a high quality site can be mowed close (the Fisher system) with excellent results. It may be entirely possible to delay this final felling even longer than the interval suggested above; this will depend on how rapidly the canopy remaining after the second cutting closes over. So long as the new stand receives good light, for so long can the final cut be withheld. The longer this can be postponed without undue shading of the new stand, the better response will be had in the form of proportionately more vigorous seedling sprouts originating from the mown stools.

In such mowing work it would seem wise to cut only seedlings of commercial species. Weeds, such as blue beech, hop hornbeam, dogwood, witch hazel and the like should be left undisturbed. In all probability the anticipated rapid height growth of the new seedling sprouts

should enable the latter to overtop the weeds in fairly short order.

It is believed that the new reproduction will be of a composition markedly different from the existing stand, just as occurred in Ctgs. 1a, 8a, and on the clear-cut strip in Ctg. 4a. In support of this, below appear the tallies of four milacre reproduction plots counted here in 1939 before the shade-killing occurred. (See Table 1)

TABLE 1

Ctg. 2a (milacres)

<i>Plot #1 (good light)</i>	7/10/39
Yellow Birch	12
White Ash	16
Yellow Poplar	4
Red Maple	1
Sugar Maple	1
<i>Plot #2 (good light)</i>	
Yellow Birch	16
White Ash	18
Yellow Poplar	1
Red Maple	2
Sugar Maple	0
<i>Plot #3 (under deep shade of sprouts)</i>	
Yellow Birch	22
White Ash	0
Yellow Poplar	1
Red Maple	2
Sugar Maple	7
Hemlock	1
<i>Plot #4 (deep shade)</i>	
Yellow Birch	4
White Ash	0
Yellow Poplar	3
Red Maple	0
Sugar Maple	4
Red Oak	1

Clearly, regardless of light conditions, the new stand will at first run heavy to yellow birch, white ash, with some yellow poplar, red oak, hemlock and sugar maple. It now seems reasonable to expect these successions on the better soil sites. Future management of this area will apparently parallel that suggested for Ctgs. 1d, 8a and the clear-cut parcel in Ctg. 4a—that is, after the final felling is over and the new crop is set, to operate with the idea of taking first a crop of the faster-growing species, chiefly white ash, tulip, yellow and black birch, red maple and red oak. This harvest will probably be followed some years later by a cut of sugar maple, some red oak, hemlock and perhaps some white oak. The foregoing are not to be taken as firm and final conclusions; rather might they be called confident expectations, for today all the ecological evidence points to this outcome.

Such stands, on such soils, look to lend themselves with readiness to a series of croppings rotating from the white ash-yellow birch-red oak-yellow poplar association to the white oak-sugar maple-hemlock facies. Again, this is no final dictum; we have not been here long enough to see the process through to completion. It is best to work out the successional trends as accurately as possible, being constantly receptive to new bits of evidence and fitting the cutting policy to accord therewith.

Increment cores taken here in October, 1948, revealed that for the first ten to twelve years following the 1928 cleaning, there was a definite stepping-up in annual increment which reached its peak in 1939-40. Thereafter the ring growth showed a steady decline. By the latter date the annual increment had fallen below that shown in 1928. In the file record of this operation there appears the following sentence: "Cores taken (1939) from red oak, yellow poplar and white ash indicate that radial increment is about static." Evidently this project would have benefited by a second cleaning at about this time.

It seems meet to insert here the results of a simple test

aimed at confirming the suspicion that deer browsing was largely responsible for the almost complete disappearance of natural yellow poplar regeneration. On several areas here there has appeared, subsequent to cutting, a good setting—i.e., one seedling per milacre or better—of this species. These have flourished bravely for perhaps four seasons and have then almost completely disappeared. In each case such regeneration has appeared on fresh soils of high quality. Various angles of attack were explored in extensive fashion, such as the possibility of a soil nutrient deficiency or of a lack of water during the summer months, but these led to nothing definite. But suspicion had been directed at the deer population, so several four-foot, cylindrical small-mesh wire cages were built and carefully set in 1940 to enclose and shield from animal damage some eight groups of small two-year yellow poplars. Counts were taken and today over 60% of these seedlings are still alive and flourishing. Two of the cages have been knocked over. These contain no living trees. The inference is that the deer are the chief offenders.

Ctgs. 3b-14b

Some 35 acres of various hardwood types lying between the Brook Trail and the Black Rock Trail in Compartment VI were given a moderate cleaning in the winter of 1929-30. The stand was left in what appeared to be a healthy condition. Cores taken in 1936 revealed a step-up in diameter increment in the coves and lower slopes. Some reproduction had also appeared in these areas. On the higher, drier portions conditions showed little change. The Forest files recommended that a reproduction cutting be made about 1940.

In the winter of 1940-41 the major portion of the area lying north of the Brook Trail received a second cutting. This was a somewhat drastic treatment, leaving only the very best trees. In the red pine underplanting lying

northwest of the old Bearmore Place, a lighter thinning was administered.

A considerably heavier cut was made in the red pine underplanting which adjoins the Asiatic chestnut area on the north. A number of heavy-crowned oaks were carefully dropped, leaving the area quite open in the hope that the pines would respond. Ring counts on several of these oaks revealed that in some cases on the better sites the annual diameter increment had increased as much as 43%. This last underplanting was thoroughly released in 1942. Only the very best of the pine were favored; the young hardwood growth received the most attention as this is obviously the proper cover here.

Ctg. 4a (The clear-cut strip)

A strip 200 feet wide and running from the Brook Trail to the White Oak Trail (about 450 feet) was cut clean and the brush burned in the winter of 1931-32. The south half of the strip was the red oak-chestnut oak association, growing on high, dry, ledgy ground. The balance was mixed hardwoods, swamp phase,⁴ standing on a wet flat traversed by the Arthur Pond outlet. The parcel presented a suitable array of types for a small experimental cutting.

The idea was to establish a good example of the old traditional method of clean cutting for fuel, but omitting the usual subsequent woods fire. The plan was to determine whether some added expense in the form of a few extra man-hours of cultural work applied to the resultant sprout growth would justify such extra outlay in the form of an increased yield of bulk fuel. No special effort was to be made in the direction of higher quality; added production in cords per acre plus a speedier turnover were the main goals.

The Wet Flat (North Portion)

The north part of the wet flat received a thorough weeding in 1932. Considerable advance growth, 10-20 inches high, chiefly white ash with a few white oak and black and yellow birch, was found beneath the vigorous clumps which followed the cutting. The practice of "nicking and breaking" was given a fairly thorough workout at this time, and it was decided that the results did not appear to justify the extra time required. This first weeding was a straight releasing job, aimed at freeing the seedlings of merchantable species.

By 1936 it was clear that the very wet portions of this flat would be slow in coming into bearing trees as, by this date, these spots were occupied largely by sedges and viburnums. The tree growth was quite spotty and uneven, with several well established groups of seedlings of white ash, yellow and black birch, sugar maple, red maple, yellow poplar and a few basswood.

Also by this date it became distressingly clear that the initial weeding of 1932 had been completely ineffective. The work had been applied far too soon following the clean cutting; the desirable advance growth and the new reproduction had not been afforded sufficient lead over the inevitable sprouts. Almost immediately did these catch up with and begin again to overtop the good stems. It would have been far more effective strategy to delay this work for at least four years, or perhaps longer, following the cutting.

By 1939 the new stand averaged 10-12 feet high, forming a curiously dense stocking on the flat area, yellow birch being well in the lead with a tally of several thousand stems per acre in some spots. In mixture with the birch was a pleasant array of white ash, sugar maple, red maple, and yellow poplar with alder, witch hazel, blue beech and a few gray birch being the chief concomitant species. The crop species were of good form, and natural

pruning was going forward in fine fashion owing to the heavily-shaded interior. The general appearance was a stand of very good vigor.

A light releasing was applied this year, consisting chiefly of decapitating such stems, weeds or otherwise, as were displaying such rampant characteristics as to be-



PLATE 7

Ctg. 4a; the north portion (the moist flat) of the clearcutting bordering the Brook Trail. A dense, well-formed stand of yellow birch, white ash, sugar maple and yellow poplar seedlings is now established. The future promise is high.

come "wolfish" and thus cause, or threaten to cause, injury to the leaders of good trees. A few large and out-of-line oak and red maple sprouts were girdled.

Today the growth here is excellent and there is a good scattering of white ash, sugar maple, yellow poplar and a few red oaks in mixture with the predominating stand of yellow birch. The average height is around 30 feet and the average d.b.h. is about 3 inches. All stems appear to be in good health, although crowding is clearly taking place amongst the crowns. Possibly a small cordwood thinning is indicated in the near future.

The majority of the weed species have disappeared with the exception of red maple which is still fairly frequent.

The Ridge (The South Portion)

By August, 1932, the ridge area was well sprouted into great, angry clumps of oak sprouts. No seedling reproduction was found. The conditions were somewhat puzzling; and it was decided to let the project lie over for two seasons and await developments.

In October, 1934, it was obvious that some sort of treatment was essential to reduce the stiff competition between the too-numerous stems. So the area was split into three equal north-south strips. The central one was held untouched as a control. The east strip was thinned rather carefully with the machete. Each clump of sprouts was scrutinized and all overtopped members were lopped just below the main crown level of the stems which were retained. It was anticipated that this would in time, by shading, kill off these cut stems, their demise being preceded by a period of pollarding which would not harm the crowns of the trees left, but would shade their boles, thus reducing somewhat the size and frequency of knots. In this releasing operation these crop sprouts were heavily side-pruned. It took about three man-days to perform this rather novel assignment.

By comparison, the west third was thinned in quite light fashion. No pruning was done; only the overtopped sprouts were cut and this at a rather high level. One man-day did it.

An examination of the area in 1935 revealed that water



PLATE 8

Ctg. 4a; the south portion (the ridge) of the clear cut area bordering the Brook Trail. It seems likely that this area will be ready for a small cordwood cutting in not over 10 years. That would mean a rotation of 27 years against the 35-year interval required for a similar, but untended stand.

sprouts were showing to a slight extent (not enough to cause concern) and the scars left by pruning work were healing very well. Some of the cut stems were beginning to stagnate.

The average height here today is 20-35 feet; diameters run around 3-4 inches. The boles on the east strip are cleaner than those on the middle and west strips. No difference in freedom from lower branches could be detected on either of the last two strips. Chestnut oak appears to be heavily infested with scale; this species is, for the most part, sickly looking. On the other hand, the red oaks show good tight, bright bark and appear to be in high thrift.

Very little evidence remains of the attempt to coax the cut stems to pollard. In truth, little trace of the former machete work remains today save on the east strip where pruning was done with some severity. On this strip nice, tight callouses have formed and most of the wounds are completely healed over.

Ctg. 13b (adjoining the Hall cutting on the east)

This project was carefully modelled on what had been learned from the Ctg. 1d operations. It was hoped to profit by the latter experience. Basically, the new operation was a careful cleaning designed to remove the crooked, diseased, and wolf trees together with stems whose crowns were causing or were about to cause mechanical injury to more valuable trees. Careful consideration was accorded to the question of keeping the west and south sides of the remaining boles shaded to prevent side sprouting. The best seed trees were carefully examined, and the adjacent canopy was broken a bit to stimulate germination. The occasional wolf trees present, whose crowns were overtopping stems of valuable species, were felled. In such cases, be it noted, such individuals were taken where both light and shade would sweep the newly-exposed area during the day. Where such a

TABLE 2
 DESCRIPTION OF CUTTING 13b
 (Dominant and Codominant Trees Only)

	Before Marking	After Marking	% Change
<i>Sample Plot #1 (1/4 acre)</i>			
Average D.B.H.	13"	13"	None
Average height	75'-90'	75'-90'	None
No. of stems per acre	80	64	20%
Species	Red oak, chestnut oak, sugar maple, white oak, hemlock.	Same	None
Condition of stand	Crooked, wolfish trees. Quite a lot of butt-rot.	Residual stand consists of fairly well-formed trees. Not much butt-rot in remaining stems.	
<i>Sample Plot #2</i>			
Average D.B.H.	14"	14"	None
Average height	70'	70'	None
No. of stems per acre	72	52	28%
Species	Red oak, sugar maple, white oak, hemlock	Same	None
Condition of stand	Some crooked, sick, and butt-rotted trees	Clean, well-formed stems, somewhat open	

TABLE 2—(Continued)

Sample Plot #3

	Before Marking	After Marking	% Change
Average D.B.H.	16"	13"	19%
Average height	70'-75'	70'-75'	None
No. of stems per acre	72	56	22%
Species	Red oak, white oak, sugar maple	Same	None
Condition of stand	Wolfish trees, many suppressed, quite a few young stems. A number of 25' hemlock	Open in spots; clean, well-formed trees	
<i>Sample Plot #4</i>			
Average D.B.H.	11"	10"	1%
Average height	60'-65'	60'	None
No. of stems per acre	92	72	22%
Species	Red oak, sugar maple, ash and hemlock	Same	None
Condition of stand	Mostly a cleaning. Quite a bit of butt-rot; trees in fair form	Remaining trees pretty fair for form, vigor. Quite an understory of sugar maple and a scattering of young hemlock.	

felling would admit direct sunlight to the area for the whole day, such wolf trees were kept. Where perceptible holes were opened in the canopy a good supply of shade from the south and west was assured. This was a much less drastic treatment than that applied to Ctg. 1d.

The accompanying Table 2, carrying the tallies of four



PLATE 9

Ctg. 13b; the old growth bordering Ctg. 1d-15a. This stand is very similar to the one originally found on Ctg. 1d, but the treatment given it was far less drastic. It is believed that the more gentle method employed here will produce better results.

$\frac{1}{4}$ -acre plots, gives a good summary of the stand conditions here and in Ctg. 1d before and after cutting. It is of interest to note that the composition of the stand has not been changed. The greatest shift has been in the decrease in the stems per acre.

Ctg. 14e

A 2--acre operation in Compartment III and covering the roughly triangular parcel bounded on the south by the Upper Reservoir and on the north and east by the Matthiessen-Peck lands. Some fifty cords were removed in 1940-41. This extremely large cut seemed to be justified at the time as the old stand was in poor shape, the



PLATE 10

Ctg. 14e; a good example of the dense sprouts which may be confidently expected to follow overcutting. An error of this character can produce stand conditions which are both difficult and expensive to correct.

area is a warm south slope of good quality except at the high point, a scattering of good seed trees, chiefly red, white and black oak, could be left and a fair amount of seedling advance growth was already present.

Today the project presents a pretty problem. It can be accurately designated as a clear cutting with seed-trees; but the sprout response from the cut stumps has been extraordinarily vigorous, resulting in extreme shading of the advance growth. An expensive liberation cutting, yielding no saleable product, might be applied, but the reasonable course to follow seems to be to leave the area to its own devices until it attains small fuelwood size, at which time it may be possible to release the good seedlings and, simultaneously, derive sufficient product to cover the costs. The area is very accessible.

Here we have a fine example of the dangers of over-cutting. It is a prime essential, in making improvement cuttings here, that one be constantly alert against affording an opening to the aggressive sprouting capacity of the native species. The old rule, "Thin light and often," is a wise precept.

Ref. 14a (The Carpenter Ridge)

The following project involved a sizeable cutting job together with the planting of some 11,000 coniferous seedlings. It is herein listed as a reforestation operation, but it should be noted that the project records are, in this case, carried in duplicate—in both our Cutting and Reforestation files.

During the winter of 1939-40 a 12-acre block in Compartment VII and lying about one-quarter mile due east of the Hill o' Pines was heavily cut, leaving 10-12 first-class seed trees per acre. The latter were selected with considerable care as to form, crown, butt condition, general health and, in addition, location and spacing, for here we deliberately took a leaf from the German practice of leaving "Schutzbaüme" so spaced and in such numbers that no part of the area would be subjected to full sun-

light for any entire day. About 200 cords were removed. A very good array of mixed oak advance growth was present.

The planting (*Ref. 14a*) was subsidiary to the cutting; the chief object was to test the practicability of such a heavy cutting as a means to quickening the response of the advance growth. The planting was aimed at filling the gaps where advance growth was lacking. Two thousand 2-0 jack pine, 4500 2-1 white pine, 3000 2-1 red pine and 1500 2-0 European larch were set in appropriate locations.

A recent examination reveals that the sprout growth is very dense while the advance growth (chiefly red, white and chestnut oak) appears to be in sturdy condition. Excepting the larch, all the planted species have been badly deer-bitten and are in hopeless condition, save here and there where an isolated individual has been missed. It is of interest to record that this usually happens when a conifer has been set either in or very close to a brush pile. Seemingly such piles are too prickly for the tender noses of the deer.

By late 1945 nearly all of the seed trees left were dead or dying. Apparently the brutal destruction of the main canopy on such a high, dry ridge just parched these trees out of existence. This project is further corroborative evidence of both the dangers of over-cutting and the futility of seeking to establish coniferous plantings here, especially on such an untravelled and deer-infested section as the Carpenter Ridge.

Ctg.16a

Increment cores taken in October 1948 on red oak in a portion of Ctg. 16a showed an average rise in diameter growth of 0.046 inches over and above the same figure for the five years preceding the cleaning operation of 1942-43. While this is not a large figure in itself, it should be remembered that these cores were taken on dominant

trees averaging 10 inches d.b.h. or larger; and in the case of trees of this size the annulus represented by such a figure can mean an annual radial increase of around 5%. This is here regarded as a bit of quantitative evidence of the favorable effect of such a cleaning in such a stand.



PLATE 11.

Fig. 16a; a portion of the area just south of the junction of the Carpenter Rd. and the old "S" Rd., 5 years after a careful cleaning. The stand is red, chestnut and white oak with a few shagbark hickories. This is regarded as a good job. The cut was about 4 cords per acre.

General Discussion

By now it should be clear that the job here boils down to a series of cleaning operations, virtually all of which are some variation of the shelterwood system. Such definite departures therefrom as have been made, as in the case of the small clear-cut area in C'tg. 4a, were undertaken deliberately and with the avowed intention of testing the efficacy of such departures in furthering our general program of replacing the existing coppice stands with a seedling growing stock. The following tables, as adapted from Baker,⁷ summarize in compact fashion the chief points to be considered in adapting the shelterwood system in one form or another to the district of which this Forest is representative.

TABLE 3
SHELTERWOOD SYSTEM

Form of Stand Produced	Length of Reproductive Period	Percentage of Stand taken in each cut	Class of trees left on cutting area after each felling or series of fellings
Nearly even-aged	*Approximately 30 years	(1) Preparatory cuttings, 16%	(1) Chiefly dominant and co-dominant with some intermediates; all sound, wind-firm, and of desirable species
		(2) Reproduction cutting, 30-50%	(2) Sound, wind-firm, desirable species, larger diameters, mostly dominant and co-dominant
		(3) Final cutting; balance of stand	(3) None

* Estimated from growth performance to date since 1927.

This same form of presentation lends itself in excellent fashion to a further compact tabulation of the estimated ecologic and economic aspects of the local application of the shelterwood system.

TABLE 4
ECOLOGICAL

No. of seed-trees left on area after each cutting	No. of trees other than seed trees left on area after each cutting	Kind of trees best suited to each cutting operation	Protection of site against erosion and invasion by weed species	Damage to reproduction in later cuttings
(1) Many (2) Good number (3) None	(1) Many (2) Good number (3) None	All suitable species	Good to excellent	To be expected unless strip subsystems are employed

TABLE 5
ECONOMIC

Degree of skill and supervision required	Cost of logging	Av. cut per @ (1-2-3) single operations	Frequency of return to one area	Valuable large trees left on cutting area	Most desirable type of market	Aesthetic value
Much, and of high order	High	Moderate to low	Several; (2-plus) during re-generation; thereafter not until maturity	(1) Many (2) Many (3) None	For all classes and sizes of material	High

The primary objective of practically all the varied applications of the shelterwood system is the gradual harvesting of the crop over an interval which is, in most cases, a portion of the entire rotation yet which is sufficiently long to insure and to maintain a benign atmos-

phere for the desired regeneration. The removal of the mature crop should be a gradual process.

In this area, future applications may take the form of either preparatory, reproduction, removal and final cuttings. Each of these, an admitted sector of the shelter-wood system, is capable of considerable modification. Each such felling can be carried out at once over the entire forest unit should this seem desirable, which would result in the regeneration of the entire unit at one time. The system may also be applied in the form of stripwise cutting units or in the form of gradually expanding circles of such units. In any case over-cutting, with attendant subsequent upsets to the forest in the form of over-exposure and parching of the soils, the encouragement of lusty sprouts and the introduction of weed species with their concomitant smothering of desirable reproduction, is to be sedulously avoided. It is a far easier job to return for a second light cleaning than to replace trees removed in an over-zealous operation.

In the wake of virtually any final cutting made here will come an interval when the treated area will wear a discouraging aspect. Great, angry sprouts will appear, seemingly overnight; and the reproduction so carefully induced by a series of thoughtful operations may appear to be almost wholly outclassed and bound for disaster.

The temptation will be strong to embark on some form of releasing operation. But patience is needed. It has been thoroughly established here that such work, if applied too early, is only time thrown away. The best procedure (v.s. the Hall Cutting and Ctg. 4a, the clear-cut wet flat) is sternly to refrain from any such action for some five to seven years, or until the desirable reproduction is at least eight to ten feet in height. Such a height will be attained; be assured of that, despite the uncouth appearance of the stand. The great point we seek to establish and to emphasize is that in such stands there always comes a crucial interval—a period when a careful

release cutting will work wonders. It is this period for which one must constantly watch, for releasings made too soon are of little or no avail, and those made too late are merely a case of locking the stable door after the horse is gone. The forester must be constantly alert to seize the moment when such releasing work will free the desired stems and will, at the same time, impose the maximum possible handicap on the competing sprouts or weed species.

On the Hall area the first releasing was applied when the new reproduction was perhaps three to four feet high. The undesirables then had but a scant four feet at most to go to reinstate themselves as competitors, and in no time at all the previous harmful situation again confronted us. The time spent in this first operation was a total loss. Another improvement cutting was made when the sprouts were six to eight feet tall, which was again virtually unproductive of good results over much of the area. The last treatment, which was delayed until the crop stems were ten to twelve feet high, produced good results in that the unwanted competitors had to regain some eight to ten feet of height loss—and this in the face of the steadily increasing shade cast by the released crop trees. In short, be guided more by the height of the crop trees than by the height of the undesirable stems.

One factor which cannot be controlled or regulated is the weather. Occasionally this Forest is blanketed by a wet, clinging, heavy snowfall or by an ice-storm of varying severity. The latter occur nearly every winter, sometimes doing but little harm, sometimes causing extreme damage. Either visitation can cause havoc in the form of broken leaders, broken limbs, split boles, permanent distortion or complete uprooting of valuable stems. There is little to be done about this but to salvage the damaged trees as soon as possible.

The reader will recall that in the discussion of Cuttings

1d and 2a it was suggested that such sites might be successfully rotated from a white ash-red oak-red maple-yellow poplar association to a white oak-sugar maple-hemlock-basswood mixture and back again. Final proof of the validity of this assumption is lacking as yet, although such operating policy does not now seem unsound. But an alternative outcome suggests itself—namely, that the expected white oak-sugar maple-hemlock-basswood community may turn out to be a true climax for such a site—a stable type which, barring injury through external factors, can regenerate itself under its own shade. The ultimate development of these existing stands should be of great interest and should be followed with faithful attention and study.

Should such a climax type develop, the question immediately arises whether, for the sake of the soils, it would be wise to maintain an association such as the proposed climax offers, or should the area be rotated between the two associations above given. It is felt here that such a rotating schedule offers the more sound tactics. It will be recalled that in the Pederstrup district of Denmark, Mr. Mørck-Hansen rotated his cutting areas from beech to spruce and back, with resulting high soil quality.

There are present here enough stems to insure what is now regarded as adequate stocking. Many of these are seedlings but a fair number are seedling sprouts. Various species are represented, but the bulk of the stand is white ash, red oak, hemlock, yellow poplar, sugar maple and white oak with an occasional hickory, red maple, or black gum.

The current management plan calls for the harvest of the faster growing and less tolerant ash, yellow poplar and red oak in about forty to sixty years, and for the cutting of the white oak, sugar maple and hemlock as the final crop of this rotation. And the question now arises as to the expected composition of the reproduction which

is to follow this final operation. The overwood removed in the initial operation of 1927-28 contained a considerable amount of ash; the area abutting on Cutting 1d on the east (Ctg. 13b) duplicates this situation. This situation gives one to feel that the above cycle will be repeated. There exists one point of difference, however, which may change the picture in radical fashion. The present stands on this Forest are wild stands in which clear-cutting was the universal practice. All the species here represented sprout very readily; hence in a clear-cutting operation the composition of the stands was not changed radically from one rotation to the next. Under the system of management now contemplated the faster growing, less tolerant species would be removed after forty to sixty years while the white oak, sugar maple, and other slower, more tolerant species would be retained for some eighty to one hundred years or longer. It therefore appears likely that the bulk of the reproduction on the ground following the proposed final cutting will be chiefly oak. Here we have found that oak stands can be reproduced beneath their own shade when the stand is opened up a bit.⁶

Furthermore, there appears to be a decided trend toward an increase in the population of hemlock and sugar maple. These two, being very tolerant, could well survive through the rotation and aid in seeding down the area. Intermediate cuttings could reduce their numbers and either reduce or eliminate this threat. If white ash is to be a permanent member of the stand some method must be devised to open up small areas to encourage germination of this species. If the more tolerant species seeded in simultaneously the faster growth rate of the ash would soon put it out of the reach of competition from the more tolerant, slower species. But to get ash reproduction some mother trees must be retained.

After several hundred years of clear cutting and burning it seems easy to assume that this area now under

management will behave in regard to the succession of species as it did when it was in a wild and unmanaged state. It may even be that the demise of the native chestnut in a strongly oak forest was followed, on good sites, by an increase in the ash population.

With skilful management it may be possible to retain ash as a component of this stand, but the trend, as viewed on the ground today, indicates that ash, if left to itself, will either disappear or be greatly reduced in numbers. More and more does the stand appear to be shifting in the direction of a more stable, long-lived association of white and red oak, sugar maple and hemlock. Oak and maple are generous seeders, especially the latter, and on this site, classed here as one of high quality, both species will probably gain a firm foothold. The oaks, being heavy seeded, have the advantage of being able to send a long radicle through the leathery litter and into the soil and thus establish themselves in advance of the spring drouth. Hemlock can hold on wherever it becomes established because of its great tolerance, and, if not too old when liberated, will make rapid height growth. Finally, the northerly aspect of this area makes it a site highly favorable to hemlock and sugar maple, but the relative dryness of the area, owing to the perceptible northerly slope, balances the situation somewhat in favor of the oaks. Without doubt certain portions of the area will be most favorable to hemlock and sugar maple while other portions will be kindly disposed toward the oaks.

Diameter Increment

While the current chief objective here is the conversion of the existing sprout forest to a seedling growing stock the question of the effect on diameter increment of thinnings and cleanings made thus far takes second place in the general scheme of attack. Not that this field has been neglected; an adequate array of paired sample plots has

TABLE 6

Plot	Stand Composition 3" DBH and over	Mortality by Species		Area of Plot, Acres	Number of Growing Seasons	Number of Stems		B.A. (Sq. Ft.) 1st Tally	Net B.A. (Sq. Ft.) Increase	% Net B.A. (Sq. Ft.) Increase	Mortality B.A. Loss (Sq. Ft.)		Mortali- ty B.A. Loss %
		3" DBH and over	Under 3" DBH			1st Tally	Last Tally				3" DBH and over	Under 3" DBH	
6a-1	BG YP RO CO RM	CO RO	RM SM	0.25	15	66	50	9.399	6.472	68.8	0.255	0.219	5.0
6a-1c	CO RO	CO RO	RO RM	0.25	15	95	74	16.096	6.644	41.3	1.499	0.246	10.5
6a-2	RO RM	RO WA	RO RM	0.10	15	46	40	10.092	4.373	43.3	0.343	0.099	4.4
6a-2c	RO CO	CO RO	RO W O RM	0.10	15	59	42	8.213	1.909	23.2	1.391	0.152	18.8
6a-3	RO YP RM	RM	WA BG	0.10	15	32	29	10.764	4.173	38.8	0.153	0.071	2.1
6a-3c	RM RO CO	CO RO RM	RM	0.10	15	45	34	8.746	2.409	27.5	0.693	0.103	9.1
6a-4	RO CO	RO	None	0.10	15	24	24	5.486	3.301	60.2	0.171	None	3.1
6a-4c	RO CO	CO RO RM	RO RM	0.10	15	35	26	8.347	1.786	21.4	0.722	0.089	9.7
5a-2	RM SM CO	CO RM	WA	0.10	15	40	37	4.918	3.317	67.4	0.115	0.014	2.6
5a-2c	W.A. CO RO	CO	CO RM RO	0.10	15	53	47	3.271	2.528	77.3	0.422	0.143	17.3
4a-1	BB YB CO SM Ba	Ba SM	None	0.25	15	67	64	11.900	5.833	49.0	0.869	None	7.3
4a-1c	SM Ba CO YB RO RM	CO RO Ba	RM SM YB BB	0.25	15	219	57	22.563	4.699	20.8	3.058	0.565	16.1
1a-1	RO SM Ba RM	Ba RO	None	0.23	18	42	33	11.748	2.619	22.3	2.105	None	17.9

The letter "c" denotes a control plot.

been established and periodically re-measured. The analysis of these records reveals that in nearly every case the diameter increment on the treated areas has been definitely accelerated. The data from six of the older paired plots and from one unpaired plot have been broken down and re-assembled in the accompanying Table 6. Attention has been given to a fairly large assortment of quantitative figures and the results, as set forth below, should be of interest.

Since the stands on these plots were easily of 85% sprout origin these figures should not be held applicable to seedling stands. Data on such should be collected later as the growing stock becomes converted to the desired origin.

Ctg. 6a; Compt. II, SE $\frac{1}{4}$. A large operation, covering some 95 acres and yielding 6 cords per acre. All gray birch and aspen were cut, together with all dead or dying stems and a few co-dominants and intermediates. Much dead chestnut was present, also considerable water sprouted chestnut oak. The area covers a wide range of altitude, site and aspect.

Ctg. 5a; Compt. III. More of a light cleaning operation than a true thinning. All dead, dying and diseased stems were cut and the overtopped class was completely removed excepting dogwood, iron wood and hop hornbeam. These species were retained for the low shade and added leaf litter they can supply. A few co-dominants and intermediates were felled. The cut averaged slightly in excess of 9 cords per acre, owing to the abnormal amount of blight-killed chestnut present. Omitting the yield of this last species, the cut ran about 6.8 cords per acre.

Ctg. 4a; Compt. VI. Also a German thinning including removal of all dead or dying or diseased trees. The yield totalled about 6 cords and a dozen railroad ties or tug-boat fenders per acre.

Ctg. 1-1; Compt. VII. A rocky and rather steep north

exposure. The operation was a thinning from below after the German system. Yield was 15 cords per acre. The stand was the red-chestnut-white oak association with some maple, ash and birch. All dead, dying diseased and overtopped stems were cut, plus a few intermediates and co-dominants.

The first plot in each of the pairs of plots as shown in Table 6 were thinned; the second plot of each pair was left unthinned as a control. Diameters at breast height outside the bark were measured when the plots were laid out and three times afterwards at intervals of five years. In all but one case the net percentage increase in basal area was greater on the thinned plots. The exception, 5a-2, shows a smaller percentage basal increase than its companion plot, 5a-2c. This may be explained on the basis of stand composition. The thinned plot contained a higher proportion of red maple, sugar maple, and white ash. The latter two of these species require a good cove site for best growth. The general site conditions here are definitely mid-slope on which chestnut oak and red oak are best suited. The control plot contains these last two species in greater numbers than does the thinned plot hence their growth rate would be greater than the growth rates of sugar maple and white ash.

Thinning produced a greater net percentage increase in basal area even on plots which had a larger basal area after thinning than did its accompanying control plot. Two reasons probably explain this. On the thinned plot each individual tree was given maximum growing space through judicious removal of interfering trees. Along with this, trees showing signs of poor health or vigor were cut. By cutting these poor trees the mortality was reduced on the thinned plots so that each tree left contributed its share to the general increase in basal area. Since chestnut oak is an important member in the stand composition of most of the plots and since it is markedly af-

ected by the shoe-string fungus its removal reduced the mortality on the thinned plots. An inspection of the table shows that mortality was greatest for chestnut oak three inches diameter breast high and over on most of the pairs of plots as would be expected. Mortality loss was greatest on the uncut plots.

The overall picture shows a net percentage gain in basal area of about 50% for the thinned plots in a fifteen year period and about 30% gain for the unthinned plots. The mortality in basal area on the thinned plots was about 6% while 14% represents the mortality for the unthinned plots.

In the light of the data on mortality the policy here of removing all chestnut oak of suspicious health is apparently justified. On lower slopes and in the coves basswood breaks up at a comparatively early age hence this species has been removed in thinning operations. The high mortality of this species as shown by the data in the table seems to bear out the correctness of the policy followed here of removing this species.

In general all of the species in the table profited from thinning operations of the character carried out here. To be sure in many cases these operations changed the stand composition markedly, which may have far reaching effects as yet not discernible. But the present evaluation of the operations seems to indicate that we are moving in the right direction.

Sprout Problems

There will often come a time in the management of mixed hardwood stands when the ultra-rapid height growth displayed by stump sprouts during their early years may lure the forester into a misplacement of confidence which can cause much worry later on. It is of course common knowledge that the majority of hardwood seedlings, in contrast with sprouts of the same species,

grow fairly slowly during their early years and make a much more rapid growth from about the end of the first decade until about their fiftieth or sixtieth year, showing thereafter a slow decline in the growth rate. Seedlings are, of course, the most desired elements in the stand; and, while their progress is slow during the early developmental stages, they will almost certainly come abreast of their sprout competitors and wind up as dominant or co-dominant trees if a little light releasing work be applied at the crucial point. It is not wise to place one's trust in hardwood sprouts save those from small stools.

Such releasing work will pay handsome dividends; but the costs thereof can be sharply decreased if the cuttings in the parent overwood be not too severe. Given a cutting policy of "light and often," the sprout problem rarely becomes acute. The degree of seriousness of this problem is directly proportional to the severity with which the main canopy is broken by improvement cuttings.

Chemical Control

In 1940 several methods of killing hardwood stumps with either sodium chlorate or ammonium thiocyanate were tested.⁸ Two of these proved highly effective; the remainder were partially or wholly ineffective. Spraying the foliage of hardwood sprouts with a chlorate solution proved a waste of time.

The treatment which gave the best results consisted of hacking the stump deep into the cambium close to the ground line and completely around the circumference. The poisoning solution was poured into this hacked ring. Either solution produced 100% results, even on red maple and red oak—both prolific and vigorous sprouters here. Another variation which produced excellent results was to wet the ground thoroughly with the solution, making a ring around and close to the stump. This last method is much easier and cheaper than the hacking procedure. It

appears to be the more desirable procedure. Red pine planted in amongst the stumps poisoned by this method showed no sign of harm.

Girdling

On the Hall Cutting (Ctg. 1d), it became necessary to remove or at least decrease the crown competition furnished by many of the formerly suppressed members of the original overwood. Since these stems offered only a small, and widely-scattered yield, girdling was employed. This revealed that severing a narrow ring of cambium killed most species fairly quickly, especially white, red, and chestnut oak and gray birch and aspen. On the other hand, white ash, red maple and dogwood were found to bridge very quickly a gap of as much as six inches. On these last species the job must be done with extreme thoroughness if proper results are to be enjoyed.

“Girdling has been shown to pay for itself in certain stand improvement operations in New Brunswick and the Northeast. Although growth of the released trees was not considered in this study, it is evident that the operation can be successfully accomplished in northern hardwoods without undue expense. Ninety percent of the girdled trees were dead in five years, there was little sprouting and there was very little damage done to the understory. If there is reasonable growth acceleration afterward, the treatment may well be a profitable investment.”⁹

FUNDAMENTAL SILVICS

Mycorrhizae

A bulletin ¹⁰ by Hatch and a paper ¹¹ by Mitchell et al. constitute the contribution of the Black Rock Forest to the subject of mycotrophy. A portion of Hatch's experiments were conducted here.

Hatch has shown that the habit of mycotrophy in forest-grown trees is both prevalent and widespread. Most forest-grown trees are equipped with mycorrhizae which constitute the normal absorbing organs of such trees. Few or no mycorrhizae form in soils of very high fertility or in bog or heath soils. In the latter, the formation of mycorrhizae is proportional to the ability of mycorrhizal fungi to survive.

Undoubtedly normal forest soils contain sufficient inoculum to provide for ready formation of mycorrhizae. But in soils where trees have not grown for long periods of time, such as prairies or in artificial nursery soils, the situation is quite different. Experiments on prairie soils and certain nursery soils have shown that in these cases certain seedlings cannot survive unless suitable inoculum is added to insure the formation of mycorrhizae.

Apparently such formation is the reflection of a deficiency in availability of a given element or a lack of balance between the essential elements. The efficiency of mycorrhizae in extracting nutrients from a given soil is believed to be due to the very greatly increased ratio of surface area to volume of mycorrhizae as compared to roots, and only secondarily to the peculiar physiology of fungi which enable them to use complex organic compounds.

Soils

In bringing the Forest under management, it was immediately clear that the correct long term view to be taken was to restore the Forest to a healthy condition by replacing the existing sprout growing stock with stems of seedling origin and, concurrently, to increase the percentage of desirable commercial species. In furthering this aim, a great many questions came to light. For one thing, a better knowledge of our soils would be most helpful in planning future silvicultural operations. The physical properties of the cove and slope soils, the most important soil types, were the subjects of a study¹² conducted on the Forest in 1931.

This study revealed that the physical properties of the soils have not undergone any drastic change as a result of previous abusive treatment. The humus content is not abnormally low, nor is there evidence of any significant erosion either vertically or laterally. The soils contain such a high percentage of rock and gravel, however, as to make them suitable only for forest use. Most of them are heavy and somewhat compacted, a condition which retards erosion but makes for poor tilth, and soil texture affects tree growth. Red and chestnut oak made more rapid growth¹³ on clay loam in the cove areas than on either heavy clay or clay soils. Further, the addition of leaf mulch,¹⁴ from which most of the nutrients had been leached, to three plots on heavy soils stepped up the growth of red oak much more than did the addition of an inorganic fertilizer on similar plots. This response was due in part to improved physical properties of the soils in question. Hence it is important to lighten the heavy soils. This can be accomplished by maintaining the proper composition and density of the stands. Certainly the physical structure of a soil is as important to the silviculturist as is its chemical fertility. The changes in the physical structure of a soil are too slow to give any im-

mediate indication of the subtle changes occurring in the supply of available nutrients as a result of management practices. Analysis of the soil itself can reveal the potential supply of nutrients and, by certain extraction methods, may approximate the extractive force of the trees themselves. The fact remains, however, that the trees themselves are the best indicators of the supply of available nutrients present on a given site. A knowledge of the fertility of a given site is vastly important to the silviculturist, as will be seen later on.

Nutrients

Some information on the present chemical fertility of our soils was needed. Such knowledge would be useful as a guide in attempting to build up the available nutrient supply in deficient soils. A plot culture experiment¹⁵ disclosed that the soils on the Black Rock Forest are deficient in available phosphorus. Calcium and potassium are relatively abundant except in the non-productive ridge soils. As was suspected, the cove soils are highest in nitrogen, followed in order by slope and ridge soils, the latter having the least amount of available nitrogen.

The need for building up the supply of available phosphorus in our soils is clearly indicated from the foregoing experiment. The method of doing this was worked out in a study¹⁶ which revealed that red maple and sugar maple have approximately twice the feeding power for soil phosphorus as have red, chestnut or white oak. This means that the former two species can extract more phosphorus from the soil and can return to the upper soil layers a larger quantity of this element in the sum total of their foliage than can the oaks mentioned. Furthermore, red maple is a ubiquitous species which adds greatly to its usefulness as an agent for increasing the available soil phosphorus. Hence, in any system of management here, red and sugar maples should be retained for some years.

Pot culture experiments yield valuable information, but they are costly and time-consuming. Some method was needed to evaluate chemical fertility of the soil, which is cheap and relatively rapid.¹⁷ The concentration of nitrogen, phosphorus, and potassium in the leaves of white, red, and chestnut oak, red and sugar maple, shag-bark hickory, and Norway spruce is relatively constant and the total mineral content is near the maximum a few weeks before the leaves begin to yellow. By analyzing the leaves at this time for these elements, an indication of the available nutrient supply will be obtained. But some standard is necessary to determine whether or not the nutrient supply is ample for best growth. Such standards can be set up by means of fertilized plots. A series of such plots have been established in the Forest and a study¹⁸ of the results of these experiments, together with the results of pot culture experiments, have shown that there is a very high degree of correlation between available soil nutrients and the concentration of these nutrients in the leaves at the time mentioned, also that nitrogen and phosphorus are closely correlated with growth. Here, then, is a sensitive, rapid, accurate and comparatively inexpensive method of evaluating the chemical fertility of a given site. Periodic analysis of leaves from check and control plots will disclose the influence of a given cutting practice on the chemical fertility of a given area. Such chemical analysis in conjunction with analyses of growth should enable the silviculturist to predict the effectiveness of a given cutting practice.

Leaf samples from trees on plots located over the northeastern United States were analyzed for nitrogen and correlated with the growth on these plots. On the basis of these analyses, three groups are recognized: 1) tolerant of a nitrogen deficiency; this group includes red, white and chestnut oaks, red maple and aspen. The second group is termed intermediate and includes beech, sugar maple, pignut hickory and black gum. The third

group, styled nitrogen-demanding, includes yellow poplar, white ash, and basswood. Within each of these groups, on the basis of growth response, the range of relative nitrogen supplies for this experiment were divided into the following regions:

1. region of minima—here nitrogen is definitely limiting.
2. working region—about equivalent to good natural soil.
3. optimum region—best growth in this range.
4. region of tension—increments in nitrogen result in little or no growth response.

Rating species according to their nitrogen requirements on a quantitative scale should be a great aid to the practicing forester, since it assists him in deciding *what species to favor on a given site after the chemical fertility of the site has been determined*. This project should be continued along similar lines to evaluate the requirements of the several species not only for nitrogen, but also for phosphorus, potash and calcium.

“The chief contribution of plant physiology and physiological methods to forest research is in answering the question, ‘why.’ Why, for instance, does a given silvicultural practice or a given environmental condition produce a certain effect in terms of tree growth? Only plant physiological studies can answer this question because the only way in which environmental factors such as light or soil moisture, or silvicultural practices such as thinning or pruning can affect tree growth is by changing various internal processes and conditions of the tree. The function of plant physiologists in forestry research is to study and measure these internal processes and conditions, to observe the manner in which they are affected by changes in environmental factors, and to use the information thus obtained in assisting foresters to explain the growth behavior of trees.”¹⁹

This research into the general field of available soil nutrients was initiated by the late Professor Richard T. Fisher, Director of the Harvard Forest, assisted by Professor P. R. Gast. The actual field and laboratory work was carried on here by Mr. Harold L. Mitchell, now Director of the Central States Forest Experiment Station, ably assisted by Mr. Raymond F. Finn, now on the Central Station Staff, the late Dr. Russell O. Rosendahl and Dr. R. F. Chandler. It is difficult to express adequate appreciation of the ground covered by this group. The results of their labors have appeared in print, but it is felt here that the true significance of accurate, detailed, quantitative knowledge of soils and their available nutrient content, as well as similar knowledge of the nutrient requirements of the important tree species, is not wholly grasped by some of the silviculturists of today. It is only a matter of time until proper recognition will be accorded such information; but this writer feels that the sooner such recognition can be made widespread, the sooner will our general silvicultural practice be based on sound, quantitative data and less on what today sometimes appears to be rather loose thinking.

FOREST ECOLOGY

One of the most interesting yet difficult problems arising out of the investigative work here has arisen from the virtually complete dearth of knowledge of the various local forest cover types, especially the climax. Within the forest boundaries there is not a single acre of old growth available for scrutiny, for every rod of this area has been either cut clean or severely burned (or both), well within the memory of man. It has been necessary to work out our own tentative concepts of the various successional stages. Until recently, the search for proper silvicultural methods of treatment has been carried on somewhat in the dark. It has been a trial and error program with a fair percentage of hits and misses.

The method of study of these successions has been to examine in considerable detail a sizeable number of acres both within and without this Forest, seeking wooded areas of different ages and compositions and growing on a variety of sites. The usual notes on age, height, diameter and condition have been taken; and these various associations have been tabulated and carefully scrutinized with some particular reference to the advance growth appearing thereunder. In some cases the owners have been helpful in filling in the gaps in these stand histories.

Out of this has been evolved the first tentative array of local forest type successions.⁵ These are by no means regarded here as final; there remains a deal of added study to be carried out before these stages can be listed as conclusive.

Excepting hemlock, sugar maple, basswood and beech (an uncommon tree here), all of our commercial species are somewhat on the intolerant side and do not, in conse-

quence, regenerate too readily under heavy shade.⁵ Hence some extraneous factor or combination of such (man, fire, windthrow, ice storm, snowbreak, or possibly insect or fungus attack) must operate to break the canopy and thus stimulate germination and growth. Other phases of biological activity, such as quickening the decay of the leathery leaf litter found here, are also hastened and improved thereby.

Hence, to maintain the tract in the production of commercial species, it becomes essential to know with accuracy and precision what the germination response will be to a thinning of given severity on a given site and applied to a given association. Here arises a whole series of fascinating problems in the field of the theory of successions. Only constant and thoughtful observation can supply this added knowledge.

In time, of course, when acquaintance with this area and its biological idiosyncrasies ripens more fully, it should not be an overly difficult matter to maintain the production standards desired; but one must not expect to reach this goal with great speed. Patience, great patience must be displayed.

The cutting operations initiated and analyzed here furnish strong evidence that by careful cleanings a setting of seedlings of pleasing growth habits and of valuable commercial composition can be obtained.

In our previous progress report ¹ (page 62) occurs this sentence: "It is our belief that much may be learned from the study and practical utilization of initial vegetational phases." This rather simple utterance in 1938 is today supported, buttressed, and reinforced by a considerable array of corroborative material. Some of this can be written up in simple form, but the great bulk thereof, and by far the most convincing portion, is to be found in the Forest itself, especially on the several areas where has occurred intensive application of the policy of fitting the cultural treatments to the natural successional stages.

By a wide margin, the principal obstacle to the consummation here of a successful silvicultural policy has been the lack of accurate information on the various forest cover types native to this region. Since the intent is eventually to bring this tract into something approximating that Utopian condition of sustained annual yield, the isolation and description of such types and the determination of their chronological niche in the successions has been of primary importance. During the past twenty years much scrutiny has been directed at this target.

The question of local type composition and nomenclature presents a field for special study. The list of native species given in this paper is an indication that this forest lies in a region of overlapping ranges with portions of the Central, the Northern and the Sprout Hardwood Forest regions appearing. It will probably become necessary to refine the existing classification^{4, 5} somewhat, although it is suggested that this process be not carried to extreme lengths. The listing of forest cover types of the eastern United States as defined by the Committee on forest types of the Society of American Foresters²⁷ follows a middle course between a broad grouping and a highly intensive classification. This listing, purposely capable of either expansion or contraction can, with certain mild modifications, be deftly fitted to this section.

Such a clarification and definition of the local type composition and nomenclature should be carried out here in the near future. Up to now the type names and their component species listed in Black Rock Forest Bulletins 1 and 7 have been employed in somewhat loose fashion. The time is now at hand definitely to determine these local questions for all but the several climax associations native here. It is felt here that considerably more time must elapse before such final allocation can be made for these climax types. The climax associations given in previous publications¹² were admittedly of a tentative character; they represented the best estimate possible, using

the data then available. Some time must pass before it will be possible to describe these associations with suitable accuracy.

Such a project, properly carried through, will be of distinct ecological, silvicultural and management value and importance. This is true of all types, even of the short-lived pioneer associations found on burns, clear cuttings or otherwise abused areas. For the significance of ecological relationships, especially in the field of successions is well appreciated and widely recognized.

The Abbott Plot

Acting on current knowledge of the behavior of the local successional trends as previously outlined, linked with the theory that it is but sound business practice to accelerate as inexpensively and as painlessly as possible the disappearance of the pioneer or weed stages for the benefit of the commercial species present, in 1940 a small plot was set up on the adjacent Abbott lands.

Here was an area, formerly a pasture, abandoned since circa 1912. When this study was initiated the stand was, in numerical order, gray birch, red maple and white ash, plus some sugar maple, pignut hickory, cherry (sp.) aspen, white oak, red oak, black oak and white elm. The first three species were well in the majority. The reproduction beneath the then 24-26 year overwood was white ash, red maple, white oak, sugar maple, red and chestnut oak with white ash leading at 1800 seedlings per acre, and red maple running second with a count of 1100 per acre. Save for the removal of two small white ash and a few red cedar for fence construction, the area had lain undisturbed since abandonment.

The soil is heavy and fresh to moist, with an average Ph. of 5.50. The preliminary examination revealed clearly defined developmental trends. The community was obviously at the successional stage where the commercial species were appearing in good numbers and

where the pioneer overwood was beginning to show the first signs of disappearing.

Beginning in October, 1941, six annual "accelerative releasings" have been applied. A number of stems, all in the overwood, of either pioneer, weed, or commercial species showing either butt-rot, broken tops, bent trunks (usually caused by ice storm or wet snowfall) or individuals whose crowns were either causing or were just about to cause mechanical injury to the leaders of valuable species, were taken out in each of these six operations. Gray birch was the chief victim in each case. Conversely, here and there several badly bent gray birch were left, since their crowns, although spindly and thin, were not causing mechanical hurt, yet were casting a perceptible amount of needed and welcome shade on portions of the two or three rather open portions of the stand where the already existing mat of *Rhus*, *Lysimachia*, *Vaccinium*, *Azalea* and *Geranium* was giving definite warning that too much light was seeping through portions of the main canopy.

All of the felled stems were limbed clean and the trunks were knocked into several short lengths so that the whole tree might be placed close to the ground to hasten decay and subsequent soil nutrient amelioration. It is notable that this policy of frequent, cautious fellings, no one of which open the main canopy in severe fashion, has operated to restrict the growth of dense sprout clumps. Such sprouts as have appeared—chiefly gray birch—have all been small and sickly, rarely reaching over 24 inches in height.

Present in the stand were a few "overlaps"—i.e., commercial species, usually white ash or red oak, which evidently seeded in with the pioneer stage and whose subsequent rampant growth has kept them abreast of their contemporaries. These trees are now getting markedly out of line with the now nicely-developing commercial underwood. Such stems must be carefully exam-

ined. It will doubtless be necessary to remove many of these for the sake of the general welfare. Obviously such individuals cannot well be left to develop the inevitable huge spreading crowns with proportionate retardation of the younger commercial advance growth.



PLATE 12

The Abbott Plot; volunteer hardwoods established on a somewhat fresh old field, showing the gradual break-up and disappearance of the gray birch and other pioneer or weed species as accelerated by an occasional light releasing aimed to free the commercial species from overtopping and crowding.

At this writing the picture is a pleasant one. Under this system of continual "nudging," the weedy overwood is disappearing far more rapidly than would be the case were matters left wholly to themselves—and a joyous array of thrifty, valuable seedlings is seeping into the underwood. As with so many of the projects here, it is as yet too early for final conclusions, but it is felt that this practice of "accelerative releasings" in young volunteer hardwood stands can hardly avoid producing pleasing results. The costs per acre need not be large if the practice be initiated before the stand is too old; and the final yield, barring of course fire or some other extraneous catastrophe, is confidently expected to consist of sawlogs of a good grade plus several cords of well-formed, choice, easily-cut fuelwood. Were the stand left to its own devices the yield, we predict, would be chiefly rather scraggly cordwood with perhaps a few medium-grade logs. And the turnover speed—the interest factor—will be much accelerated in a tended stand.

The Ash Patch

Following the same line of thought, a second abandoned field which had lain fallow for some twenty to twenty-five years was selected for treatment. The details of the volunteer stocking found hereon have been previously set forth.²⁰ The following tables give the picture.

A glimpse of these figures reveals that:

- a. the density of stocking was nearly identical
- b. the total basal areas before thinning were not far apart
- c. the lower plot (having the lesser basal area) was cut slightly harder
- d. fewer stems and a lesser total basal area were left on the lower plot
- e. white ash was easily the dominant species on both plots

TABLE 7
STAND COMPOSITION BEFORE AND AFTER TREATMENT

Plot	White Ash		Sugar Maple		Red Maple		Ehm		Cherry		Sumach		White Oak	
	C	L	C	L	C	L	C	L	C	L	C	L	C	L
Upper	68	85	42	18	26	—	—	—	—	—	—	—	—	—
Lower	109	89	—	1	28	—	5	—	2	—	1	—	—	1

C = cut. L = left.

TABLE 8
STOCKING OF STAND, BEFORE AND AFTER TREATMENT

Plot	Total Stems	Total B.A.	Stems cut	B.A. cut	% B.A. cut	Stems left	B.A. left	% B.A. left
Upper	239	5.531	136	3.273	59	103	2.258	41
Lower	236	5.108	145	3.432	67	91	1.676	33

- f. the upper plot contained a healthy percentage of sugar maples
- g. about 30% of this last species was removed from the upper plot.

Nothing completely definite can be concluded as yet. But a number of interesting surmises may be drawn. First, one should quickly discard the theory that an area,



PLATE 13

The Ash Patch; a dense young stand of pure white ash which has come in on an abandoned field of high fertility.

even of Site I quality, can be profitably maintained in a stand of pure, or even nearly pure, white ash. Everything appears to militate against this; all the signs point elsewhere. Such an objective might conceivably be carried by resorting to expensive planting; but if such practice be essential to success, that is in itself admission of defeat unless it be planned completely to disregard the profit motive or, as occasionally happens, market conditions may warrant such a venture. It is held here that the costs of such elaborate cultural work can be rarely offset save by extreme price developments. The slow but inexorable march of the normal successional stages can be hastened, but cannot be severely dislocated, impeded, or interrupted save at large expense.

Young stands such as these appear to offer a pleasing financial future. This is especially true of young white ash. The growth is usually excellent, the turnover should be rapid, and if the crowns be carefully studied during marking, the natural pruning should be both swift and thorough. A scattering of sugar maples throughout the stand, as in the case of the upper plot, is regarded as highly desirable as an aid to the pruning program.

Such areas, we venture to hazard, should be kept at a rather dense stocking until perhaps thirty years old. The two plots just discussed show stockings of 824 and 728 stems per acre respectively. By the end of the period allotted above the crop trees should be easy of selection, and subsequent thinnings can be applied with far less groping and uncertainty.

One point which seems to deserve a special niche in this discussion, is the amazing speed with which the canopy of the lower plot has closed over since the cutting. As noted above, this one was more drastically cut, opening the crowns in what at the time looked to be perhaps dangerously severe fashion. But today, only two seasons after cutting, the crowns are nearly 100% closed. Virtually no holes appear. It is an unexpectedly speedy re-

covery. Undoubtedly the basic reason is the high site quality—another bit of evidence in support of the conclusion reached in regard to Ctg. 2a—i.e., that stands on good quality sites will require more than two operations to bring them into the desired condition.

ROADS AND TRAILS

The proposed system of main roads is nearing completion. Some additional spurs and connecting laterals should about wind up this work. The hurricane of 1938 and the heavy "flash" precipitation of 1944 and 1945 have driven home the lesson that road drainage must be completely controlled if maintenance costs are to be kept at a reasonable figure. A good wall-rock base, sturdy shoulders, a crushed rock surface, proper crowning, plus generous gutters and frequent and adequate culverts using both pipe and surface box types are all essential items. Neglect or carelessness with regard to any one of these can result in expensive damage. Keeping the water off the road surface is the goal.

It is believed that the side slopes in road cuts should be perceptibly flatter than has been the practice thus far. This will reduce washing, and the extra soil can always be put to good use. It has been suggested that these slopes might be planted to some low-growing tolerant plant such as laurel. The almost inevitable catch of hemlock seedlings on such raw slopes might well be lifted and reset on sites where they can play a more useful part, such as hastening the formation of mixed stands.

MECHANIZATION

Mechanized woods labor is apparently here to stay. Nearly all operators must face this new trend. Wage scales are at new peaks and to offset the higher production costs, the output per man per day must be materially increased. The old time chopper, usually elderly, slow moving, faithful, thoroughly at home in the woods, highly skilled in the use of the axe and saw, is disappearing. These old timers' shoes will apparently be filled by much younger men, men who are vigorous, alert, perhaps less skilled in woods lore, less handy with the old-time tools, but ingenious, well-paid lads, interested in machines and machinery, especially the internal-combustion engine and the electric motor in their various applications. The working day will be shorter, and daily wage and output far higher; the crew will not return home at night exhausted. Such may be the woods crew of the future. That's the way it looks to us. Machinery is the answer to changing economic and social conditions. Power-operated chain saws, table saws,²¹ mechanical splitters, wood chutes,²² exploding wedges, winches, conveyors and loaders of different types, tractors, jeeps and the like are all receiving increased recognition. Higher daily production is the call.

Also, the day of the old-time rough and ready woods boss is about over. His successor, we venture to prophesy, will be a man of noticeably technical background and training. He will possess the usual personal qualities sought in a man who is to take charge; in addition he will be familiar with woods surveying; he can make a rough cruise or survey, keep cost records, write a passable report, interpret (and believe) what the increment borer reveals; and he must understand and enjoy work-

ing with and supplying proper care and maintenance to the various power machines appearing in the woods today. Above all must he be avid for learning. The "strong, silent man" of the past—frequently silent because the problem was beyond his ability to make intelligent comment—has little or no place in the picture today. In many ways it is like modern warfare—machines much of the way.

METEOROLOGICAL RECORDS

In the Forstamt Lagenbrand, Württemberg, there has been evolved a very comprehensive, yet compact, system of recording precipitation.²³ The idea has been lifted bodily and installed here. Data on rainfall are obtained from the nearby United States Military Academy and also from a local water supply record. Up to 1941 we maintained our own weather station, but since this date the scarcity of help has forced us to rely on our neighbors.

There has been noted here the existence of a possible correlation between the amount of precipitation occurring during a given growing season and the terminal growth during the following growing season. No specific study has been made here of this seeming relationship, but it is suggested that it might be a profitable research project to work this out and determine, once and for all, if such a correlation exists and, if so, how reliable is it, and can it be evaluated?

UTILIZATION

For the past forty years or more, virtually all the cuttings made here were cordwood operations. Today, logs of large diameter are not often seen but our fuelwood operations have included a painfully large footage of straight, clean logs. At times it has seemed a shameful waste to put such sticks into the wood ranks, for it is believed that such timbers, if processed a bit further, would have a pleasant effect on the financial returns.

Consider the geographical position of this forest. Within a radius of about fifty miles there lies an array of sizeable communities. It would seem as though a market for various minor forest products could be developed here and it is proposed to initiate an intensive survey of all wood-using markets in this area beginning, of course, with the communities lying nearest to us. This project, even though only partly completed, should give a fairly clear-cut picture of the marketing possibilities. That we have valuable merchantable species is beyond doubt; the problem seems to resolve itself into determining in which form the product is most saleable. It is a proven fact that the local fuelwood market will not absorb an annual cut of the volume which this forest can produce for our total annual increment is today estimated at well over 700 cords.

FUTURE MANAGEMENT

Looking into the none too clear future, the general management plan indicates a policy calling for the creation and maintenance of mixed stands of stemwise pattern. Pure stands of the local species are, as a rule, quite difficult to establish and to maintain. Pure stands of white ash do sometimes occur here on old fields, and clear cuttings on forest soils frequently show a high percentage of ash in the succeeding crop, but this (and black and yellow birch) are about the only commercial species showing this tendency, and it is doubtful that these pure stands can, or should be maintained as such.

As to commercial maturities, our present silvicultural knowledge would set 1.5 log trees as the tentative average maximum over much of this tract. Some of the higher areas would no doubt be handled on a one-log basis, while there would be a few, such as the Glycerine Hollow, Cutting 1d and Cutting 15a, and portions of Compartment I, which could aspire to two-log boles. These suggested volume limits should be given further careful examination before any hard-and-fast policy is adopted. The distribution of the thick till²⁴ could turn out to be an important factor in determining the spread of such limits. On the better areas, a carefully handled series of improvement cuttings should produce in most cases a pleasing catch of white ash, red oak, yellow poplar, white oak and sugar maple. The first three are vigorous growers and will usually overtop the last two species in short order. The practical method of handling such an association seems to be the favoring of the three rapid growing species that they may make the first crop of logs, leaving the slower members to take over and form a second crop following the removal of the lustier species. In some

cases such a mixture may result in successive crops of logs, with white ash offering the first harvest, red oak and yellow poplar the second, and white oak and sugar maple bringing up the rear.

In view of the comparative readiness with which good natural regeneration can apparently be secured here, the writers urge after the current preliminary cleanings have been completed and the desired seedling growing stock has been established, that serious consideration be given to the possibility of using some modification of the strip shelterwood system—the “Schirmsaumschlag” of the German Spessart area.²⁵

On this forest, such strips should run east and west across the prevailing wind direction during seedfall time, and should progress southward to hold soil desiccation at the minimum figure. Since several of our commercial species are heavy seeded, it would now seem wise to limit such strips to a maximum width of 150 ft. Every third or fourth year brings here a heavy crop of oak seed which, supplemented by the air-borne seed of the various associated species, should serve well in starting the desired new seedling stand. This system is a flexible affair. So far as the writers are aware, it has never been tested out here but it is regarded as being worth a careful trial.

FOREST GENETICS

While it is now fairly certain that the quality of the local stands can be somewhat improved by cutting operations, it also appears that certain other intensive techniques employed by the horticulturist could perhaps be advantageously applied here. Probably the age-old methods of budding and grafting are the most feasible. The former would seem to be best adapted; only the simplest equipment is required and the work can be successfully performed by anyone. By the use of this method a single selected individual of any species in a given area may be propagated almost indefinitely by budding it on to seedlings of the same specie in situ.²⁰

An alternative method, i.e. of introducing other strains of the desired species by the importation of seed gathered from parents of good form and thrift, this seed to be germinated in the nursery and the plants thereby obtained to be set out in selected areas, would yield good results were it established that progeny eventually derived from cross pollination of these imported strains with the Black Rock strain would produce superior trees. It seems possible that such superior trees would eventually result, although there are no criteria at present available on which to base such expectations. In theory, each tree of presumed superiority should undergo a progeny test—the only reliable means to date of evaluating its breeding quality. We can only cling to the one known fact, that in theory the chances of obtaining trees of high stem quality, good branching habit and the like are much better if the seed be gathered from trees possessing a superior phenotype.

Following a cursory study of the local situation, the conviction is strong that the improvement of the indivi-

dual tree quality here might be more directly and economically brought about by vegetative propagation of the best individual trees of the desired species now present on the Forest or on adjacent property. Could such a program of propagation be carried out to the extent that the local stands eventually become stocked with genotypically desirable individuals, it would be logical to expect that seed obtained from these seemingly superior trees would yield progeny of equally superior quality. But mention should be made of the hard basic fact that as yet we possess no criteria for accurately determining the superiority of a tree's genotype from a study of its phenotype. Such a project should some day be undertaken here.

PUBLICATIONS

Our publication program, well under way with the appearance of our ten-year progress report in 1938, was interrupted by the war. During the past ten years but three bulletins have appeared. Bulletin #11, compiled with the assistance of Dr. R. F. Chandler, carried a detailed discussion of the nutrient requirements of various important species of northeastern deciduous trees. While the importance of the data given in this paper is not yet, in our opinion, fully recognized, we believe that in time such an array of quantitative information should play a large part in management practices in the northeast, especially of the hardwood species occurring in the Sprout Hardwood Region.

Bulletins #12 and #13 presented our current concepts of the composition of the chief forest cover types occurring here, together with our established belief in (and our reasons for such a credo) the need for detailed acquaintance with all of the forest cover types or plant stages found in this or any other similar region, plus accurate knowledge of the silvicultural requirements of, and the place of each such stage in the parade of the local vegetational successions. Only by using such basic data can cultural work be intelligently applied. The business of battling with nature in attempts to establish tree communities which are out of line with the local successional trends is usually an expensive and fruitless practice.

In addition, since 1938 there have appeared ten of the shorter Black Rock Forest papers (Volume I, nos. 13-22 inclusive). No one of these was a cooperative effort.

SAMPLE PLOTS

The first final tally of our projected 25-year measurement periods will fall due in 1953. Since the establishment in the spring of 1928 of the first plots laid out here, other test areas have been set up from time to time. This work has not followed any particular time schedule; rather has the practice been to lay out such plots when a given cutting area included a set of conditions about which new data might be gathered. To establish such plots with remorseless irregularity would only result in considerable duplication. It has seemed preferable to give careful scrutiny to our operating areas and to let the conditions found thereon be our guide as to when and where such plots were to be laid out.

All plots marked out since 1938 have been in pairs, i.e., check and control. One-quarter acre is the size usually employed. When dealing with small saplings, aluminum tags are wired to the stem; where the boles are of sufficient diameter to take painted numbers we have found Duco enamel, preferably a canary yellow hue, to wear better than any other medium we have tested. This color is also highly visible. We have some plots where the Duco product has lasted seven years before retouching was needed. Plot corners are marked by posts and stones and it has been found advisable to spatter some of the enamel on both the stones and the corner posts.

The diameter tape is preferred to calipers. For total heights we regarded the Abney as the best instrument today, although we have found it quite difficult to get accurate results on hardwoods. This is no criticism of the level itself; the difficulty lies in being certain that you are aiming at the correct top shoot of the tree being meas-

ured. It will be a welcome day when some method becomes available whereby certainty of leader selection could be more assured than under present working conditions. It would seem to be a worthy project for some ingenious colleague to design such a tool.

CHESTNUT AND THE CHESTNUT BLIGHT

Today we can add very little to the information set forth ten years ago save that the two-acre setting of Asiatic chestnut (Reforestation 4a, 1931) is in flourishing shape, with a good healthy number of dominant trees in the mixture. The production of seed has increased to a point where several quarts can usually be gathered each year if one be sufficiently alert to get ahead of the grey squirrels. Some small nursery tests reveal that the nuts possess a high germination percent. The trees themselves show some evidence of *Endothia* attack, but apparently without harmful effect.

As to the general thriftiness of the native species, the current situation is quite as favorable as was reported in 1938. Fully as many seedlings are found today; and the number of burrs counted annually appears to be considerably greater than a decade ago.

RESERVED AREAS

The Forest contains no virgin stands unless one counts the scrub oak patches on the dry and rocky ridge tops. For purposes of ecological study, certain areas have been set aside as reserves. At present there are four of these including old fields in the various stages, burns, and stands of various ages and compositions. It is probable that additional acres of parallel ecological interest will be selected from time to time.

These reserved areas should receive careful periodic scrutiny. It is hoped that such studies will eventually supply us with additional information on our various successional stages from the pioneer invasion of the old fields up to and including the several climax associations belonging to the different sites found here. This will be a long term project—one which the present writers can hardly expect to see completed. It should be carried through a considerable number of years, employing thoughtful care all the way.

FIRE PREVENTION AND SUPPRESSION

Twenty years ago the Forest was virtually inaccessible except on foot. Two old wagon roads, both in disrepair, were the only means of ingress. Man entered the Forest only to camp, hike, hunt or fish. Only a few local residents knew their way into and around the tract.

Today, with a four-lane scenic highway circling the area to the north and east, with the old wagon roads made passable to modern vehicles, and with maps of the Forest trails available to anyone interested in entering, the protection problem has been sharply increased. In previous years campfires were allowed under the permit system, but this privilege had to be withdrawn.

Fishing is prohibited in the four artificial ponds within the Forest, but is permitted in Sutherland's Pond and in the streams. Hunting and trapping are also prohibited, except that the hunting rights have been leased to a local sportsmen's club. In return for this privilege, the club posts the Forest against fishing and hunting, patrols the area during the hunting season, and furnishes personnel in case of woods fires. During periods of extreme drouth it is customary to close the Forest to all persons save the regular woods crew.

The Black Rock Forest is a member of the Cooperative Fire Prevention Associates, an organization formed by local landowners including the Palisades Interstate Park Commission, the Harriman State Park, and the U. S. Military Academy at West Point, N. Y. The Associates function both as a mutual aid and as a publicity and fire-prevention group under the guidance of the local District Ranger of the N. Y. State Conservation Department. As its contribution to the mutual aid plan, the Forest and the sportsmen's club leasing the hunting rights have organ-

ized several groups of fire-fighters, thirty of whom have been commissioned by the Conservation Department as State Fire Wardens. These men, together with the personnel of the forest maintenance crew, form the trained nucleus. Each warden has a crew of men available on short notice. A training program has been instituted, covering the correct use of hand tools and knapsack pumps. Tools and pumps sufficient to equip seventy-five men are kept at various strategic points.

While the Forest has an excellent 75-foot steel tower, centrally located in the Forest area, owing to lack of communication facilities the tower has never been adequately manned during fire weather. The recent construction of a truck trail up to the tower base will enable a suppression crew, when on duty, to base at the tower.

LIST OF MORE COMMON SPECIES IN THE BLACK ROCK FOREST

<i>Common name</i>	<i>Scientific name</i>	<i>Abbrevi- ation</i>
Black ash (Swamp ash)*	<i>Fraxinus nigra</i>	BA
White ash	<i>Fraxinus americana</i>	WA
Large-toothed aspen (Balm tree)	<i>Populus grandidentata</i>	P
Quaking aspen (Popple)	<i>Populus tremuloides</i>	P
Beech	<i>Fagus grandifolia</i>	Be
Blue beech (Ironwood)	<i>Carpinus caroliniana</i>	I
Black birch (Sweet birch)	<i>Betula lenta</i>	BB
Gray birch (White birch)	<i>Betula populifolia</i>	GB
Yellow birch (Silver birch)	<i>Betula lutea</i>	YB
Butternut (White walnut)	<i>Juglans cinerea</i>	BU
Red cedar	<i>Juniperus virginiana</i>	JU
Black cherry	<i>Prunus serotina</i>	BC
Chokecherry	<i>Prunus virginiana</i>	CC
Pin cherry (Red cherry)	<i>Prunus pennsylvanica</i>	PC
Chestnut	<i>Castanea dentata</i>	Ch
Dogwood	<i>Cornus florida</i>	D
White elm	<i>Ulmus americana</i>	E
Hemlock	<i>Tsuga canadensis</i>	Hem
Pignut hickory	<i>Carya glabra</i>	PH
Shagbark hickory (Shellbark hickory)	<i>Carya ovata</i>	SH
Hop hornbeam (Ironwood)	<i>Ostrya virginiana</i>	HH
Red maple (White maple)	<i>Acer rubrum</i>	RM
Sugar maple	<i>Acer saccharum</i>	SM
Black oak	<i>Quercus velutina</i>	BO
Chestnut oak (Rock oak)	<i>Quercus montana</i>	CO
Pin oak	<i>Quercus palustris</i>	PO
Red oak	<i>Quercus borealis</i> var. <i>maxima</i>	RO
Scarlet oak	<i>Quercus coccinea</i>	SO
Scrub oak	<i>Quercus ilicifolia</i>	ScO
White oak	<i>Quercus alba</i>	WO
Black gum (Pepperidge, tupelo)	<i>Nyssa sylvatica</i>	BG
Pitch pine	<i>Pinus rigida</i>	PP
Red pine (Norway pine)	<i>Pinus resinosa</i>	RP
White pine	<i>Pinus strobus</i>	WP
Sassafras	<i>Sassafras officinale</i>	S
Shadbush (Juneberry)	<i>Amelanchier</i> sp.	SB
Black spruce	<i>Picea nigra</i>	BS
Sycamore (Buttonball)	<i>Platanus occidentalis</i>	Syc
Black Walnut	<i>Juglans nigra</i>	BW
Yellow poplar (Whitewood, Tulip)	<i>Liriodendron tulipifera</i>	YP
<i>Tilia americana</i>	Basswood	Ba

* Names in parentheses are local common names.

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