Penobscot Experimental Forest

Northeastern Forest Experiment Station

Upper Darby, Pennsylvania
Ralph W. Marquis, Director

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CONTENTS

Penobscot Experimental Forest

. . . an account of forest research in Maine

by the staff of the
Penobscot Research Center

Northeastern Forest Experiment Station
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IN 1947 A GROUP of men representing Maine wood-using industries met to talk about setting up an experimental forest in the spruce-fir region of Maine. Concerned about making the best use of their forest land, they felt an urgent need for more forest research.

They had in mind an experimental tract that would be a practical testing ground for cutting methods and silvicultural operations, to be supplemented by "test-tube" studies on a smaller scale. The research program on such a forest could deal with the various ecological, silvicultural, and economic aspects of the management of spruce, fir, and associated species.

Besides the research value of such work, on-the-ground results of various cutting practices and other tests, backed up by cost and yield records, would provide an interesting demonstration of what forestry can do. Here foresters and others visiting the outdoor laboratory could see the benefits of good forestry.

Talk turned into action. Twenty different areas were examined before a satisfactory tract was found. The group purchased it; and on February 1, 1950, they turned it over to the Northeastern Forest Experiment Station under a 99-year lease for research in forest management.

This was a unique move in American forestry. It was the first time that a group of private wood-using industries had purchased a tract of timber for lease to the Federal Government for research purposes.

The companies--nine in all--who took part in this unique transaction were the Dead River Company, the Eastern Corporation, the Great Northern Paper Company, Hollingsworth & Whitney Company, International Paper Company, Oxford Paper Company, Penobscot Development Company, S. D. Warren Company, and St. Regis Paper Company.

The owners set up a 3-man Operating Committee to represent them in working with the Northeastern Forest Experiment Station toward the orderly management and use of the Forest.

THE EXPERIMENTAL FOREST

This experimental tract was named the Penobscot Experimental Forest. The research carried on here is designed to serve the 15,200,000-acre spruce-fir-hardwood region of Maine and northern New Hampshire.

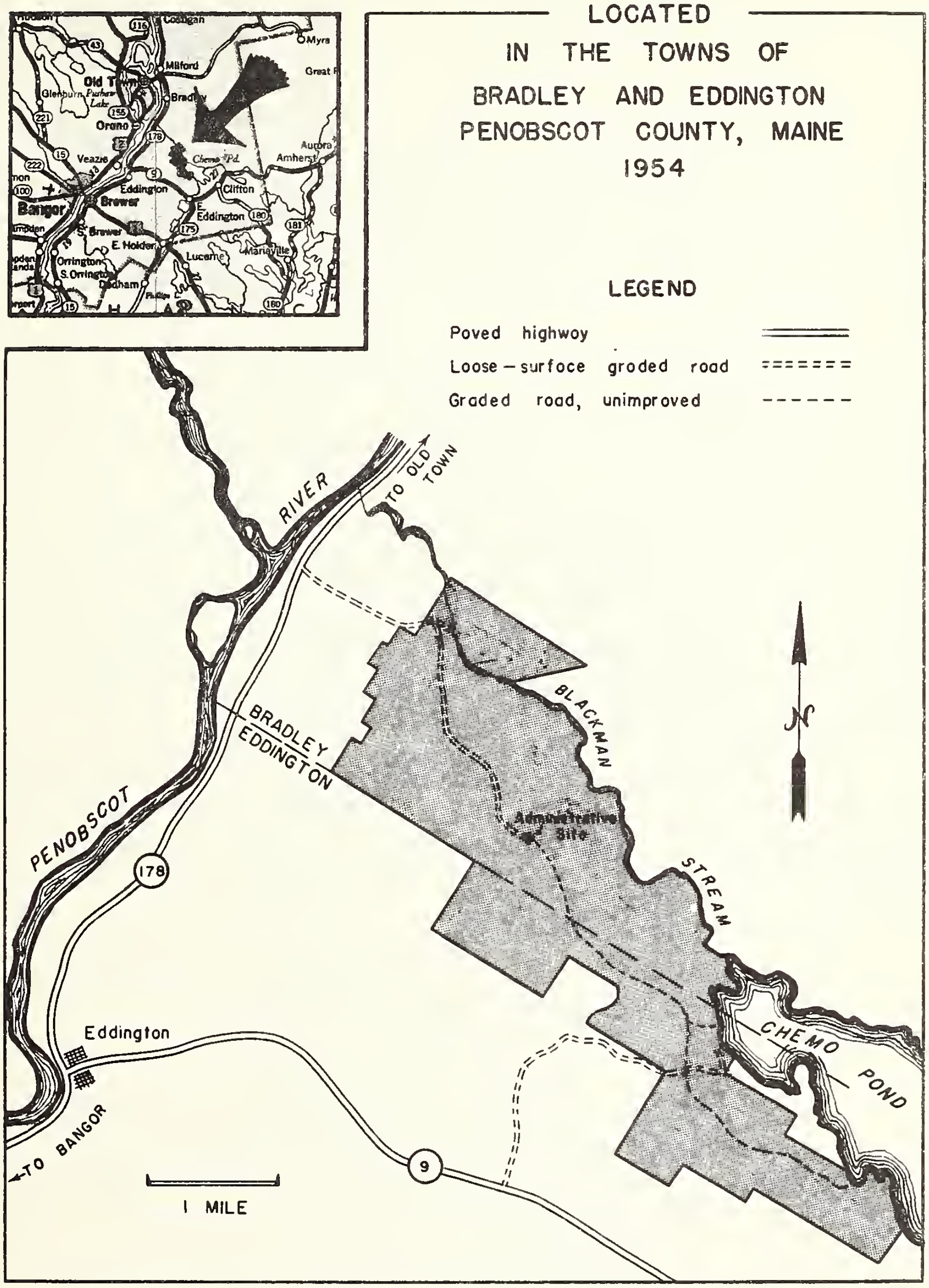
The Experimental Forest is administered by the Northeastern Forest Experiment Station through its research center at Bangor. The Station plans and conducts all research activities. It also carries all responsibility for logging operations; maintenance of boundaries, roads, and buildings; and other administrative matters. It turns over to the owners' Operating Committee the stumpage payments for products harvested, and from these receipts the Operating Committee pays the taxes on the property.

General Description

The Experimental Forest is located about 8 miles northeast of Bangor, Maine, in the towns of Bradley and Eddington. One of the boundaries is Chemo Pond and its outlet, Blackman Stream. The entrance to the Forest is from Route 178 in Bradley Township.

The Forest covers an area about 6 miles long and 1 mile wide, including some 3,800 acres. This acreage is

Penobscot
Experimental Forest



The Penobscot Experimental Forest is located about 8 miles northeast of Bangor, Maine.

distributed about as follows:

	Acres
Mature operable timber	1,200
Immature inoperable timber	1,000
Heavily cut over	1,000
Water, swamp, etc.	600

The Forest lies on the lower northeast slope of a series of hills that attain a maximum elevation of 380 feet. The over-all topography here is gently rolling. Most of the area within $\frac{1}{2}$ mile of Blackman Stream is nearly flat, with slopes of less than 2 percent. The rest of the Forest, especially the southern part, is broken up by scattered, low, irregular ridges.

The soils are mostly of marine clay origin. Occasional outcrops of shale, especially in the southern part of the forest, account for the ridges. The soils are shallow and rocky, especially in the depressions along the water-courses, which results in rather poor growing conditions. The best sites appear to be scattered knolls and rather narrow strips along lower slopes that are underlain by coarse material. Poor drainage due to impervious substrata and a perched water table during the early part of the growing season are characteristic of at least half of the forest. These soil conditions are fairly typical of the softwood types throughout most of the spruce-fir region.

Precipitation averages between 35 and 40 inches annually. It is nearly always well distributed throughout the growing season. Even in 1948--an exceptionally dry year--rainfall for the 4-month period June-September was more than 7 inches.

The winter hauling season lasts about 3 months. Woods roads are usually frozen by the end of December. The spring break-up comes near the end of March.

Cover Types & Conditions

Forest types and conditions on the Forest today reflect past use as well as site quality. Most of the area had been under one ownership for a number of years. From time to time small stumpage sales had been made to local mills and jobbers. These sales removed the larger and better pine, spruce, and hemlock sawtimber trees over the northern half of the Forest. Cordwood sales as well as sawlog sales had been made in the rest; these cuttings, which took out trees to a smaller diameter, resulted in increasing the proportion of hardwoods.

Charcoal and old charred stumps have been found in many places in the Forest. These--and the presence of aspen and paper birch stands--are evidence that fire has also influenced present stand conditions. However, one local resident says that he cannot remember any fires on the tract for the past 70 years.

The Forest is mostly of a softwood type. However, many minor variations in composition occur. These may be grouped into two principal subtypes. One is a northern white-cedar-balsam fir mixture containing small amounts of white spruce and red maple; this subtype occurs on very wet, shallow soils. The other subtype is spruce-fir-hemlock, which predominates on the Forest. This subtype occurs on the better drained flats and slopes. The common associated species in this subtype are paper birch and the ever-present red maple, along with white pine on the relatively drier sites and cedar on the wetter sites.

The types common to deeper soils and higher elevations in the region--the mixedwood and hardwood types--are found only in a few small patches scattered over the Forest.

The 600 acres of nonforest are all swamp of one kind or another. The cover on this area ranges from marsh grass (along Blackman Stream) to alder thickets, with occasional isolated trees or small clumps of larch, red maple, and gray birch.

Roughly a third of the wooded area on the Forest is operable now. The rest is inoperable either because it had been cut over recently, or because the volume of merchantable trees is not big enough for a harvest cutting.

Markets

The Forest is well located with respect to markets. Softwood and hardwood pulpwood; pine, spruce, and hemlock sawlogs; birch veneer bolts; cedar posts and stave bolts and other products find ready sale within a 25-mile radius.

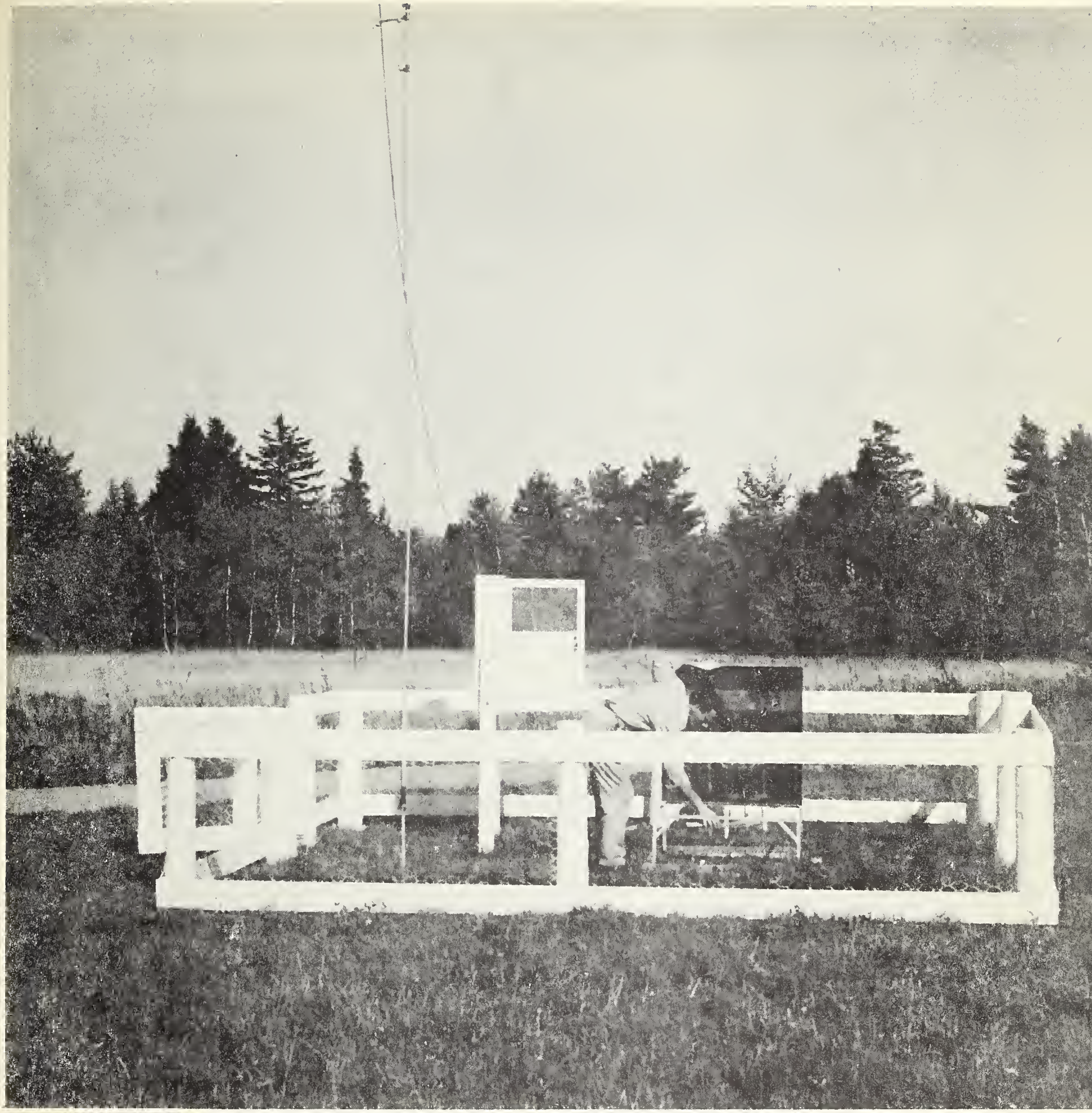
Fire Protection

Because the Forest is private land, Federal fire-fighting funds are not available for fire-suppression costs except indirectly through cooperation with the Maine Forest Service under the Clarke-McNary Act. The Maine Forest Service has an excellent fire-protection organization. The

The field headquarters building on the Forest. The Penobscot Research Center, which conducts the studies on the Forest, has its administrative headquarters in Bangor.

organized towns of the State are grouped into districts, each of which is under the supervision of a district warden. The State is responsible for detecting fires, and cooperates with the towns in suppressing them. The Penobscot Experimental Forest is in District 5, the headquarters for which are in East Corinth.

The research center has its own fire plan, which prescribes the action to be taken in case a fire occurs within the Penobscot Experimental Forest protection unit. The research center, in cooperation with the Maine Forest Service,



A fire-danger station is maintained on the Experimental Forest in cooperation with the Maine Forest Service. During the fire season readings are taken daily.

operates an open-type fire-weather station near the entrance to the Forest during the fire season.

Improvements

Besides purchasing the land, the nine cooperating companies have also contributed money for road construction. In 1950 a single-track gravel road 3.4 miles long, with turnouts, was built to give access to the Forest. During the summer of 1951 four miles of preliminary bulldozing work was done--including clearing and rough grading--as a step toward extending the main access road the full length of the Forest. The road plan of the Experimental Forest provides for the completion of this road as funds become available.

A frame building was erected on the Forest in 1950 for a combination field office, shop, and equipment shed. A small building was put up nearby to store inflammable materials.

THE RESEARCH PROGRAM

The research program on the Penobscot Experimental Forest has been influenced by the following considerations:

- A considerable fund of basic information on the ecology and silviculture of the principal species and forest types has gradually been accumulated over the past 50 years.
- The pulp and paper industry is the dominant influence in both the wood economy and the forest-land ownership in this region.
- The trend toward planned forest-management programs on commercial forest holdings has intensified in the last 5 years.
- The most important and urgent forest-management problem is how to cut operable spruce-fir stands so as to get the greatest forest income over a long period of time.

The experiments started or planned fall naturally into three categories: (1) applied forest-management research; (2) small-scale testing of treatments; and (3) biological observations and measurements.

Applied Forest-Management Research

The major research effort on the Forest thus far is the comparison of different treatments of mature stands.

Rather irregular growing stock is usually left after a diameter-limit cutting. Selection marking would have prevented the irregular pattern of large openings and dense patches of trees.

This is how a spruce-fir stand looks 4 years after clear-cutting. Many small trees have been broken or uprooted by snow or wind. It may be 50 years before another cut can be made here.

A similar stand 4 years after selection cutting. Only 20 percent of the volume was cut. Another cut can be made next year. Frequent light cuts improve the stand quality and rate of growth.

This is largely applied research. All available knowledge of the requirements of the various kinds of trees is called upon. Silvicultural techniques are employed that take advantage of the growth characteristics of desirable species. In this way greater yields of more valuable trees should be possible than with the uncontrolled cutting practices in the past.

The new knowledge developed from this research will be of two types: (1) The soundness of the basic information and the silvicultural techniques, when applied on a commercial basis, will be ascertained. (2) The value of increased yields resulting from better management, and the investment costs for better management, will be determined. The resulting cost-return ratio will help provide a sound basis for long-range management planning.

Testing management treatments

A compartment-management study, the largest single experiment planned, was started in 1951. About 900 acres of the Forest will be devoted to a series of tests of different management treatments. These range from a highly intensive single-tree selection system to a liquidation of all forest capital in one operation. Certain elements are implicit in this concept. These are cutting cycle, amount of capital in growing stock kept for future increment, amount of investment in deferred-income stand improvement, and the kind of products grown.

Generally speaking, a very intensive kind of management calls for a short cutting cycle, stand improvement, and maintenance of a substantial forest capital. This is expected to result in very high yields, both in quantity and quality. Conversely, if an owner is interested only in liquidating his forest capital as quickly as he can, he must accept a long cutting cycle. He will have no investment in either growing stock or stand betterment. But he must accept whatever product Nature grows. In this region all evidence points to low net yields from this kind of management.

The objective of this study is to find out how, how much, and at what cost increasingly intensive forest management can be made to raise the quality and rate of growth--and hence the value--of the forest. When this is known, forest owners will have a better basis for developing good management programs for their own holdings.

Twenty-eight compartments averaging about 30 acres in size will be used. They are being laid out in such a way that site quality and stand condition will be reasonably uniform throughout. This will permit comparison of the results of the different treatments. Only operable stands will be included in this study. All extensive areas of nonforest land will be excluded, as will large patches of pure hardwoods. The distribution of compartments by treatments is summarized in table 1.

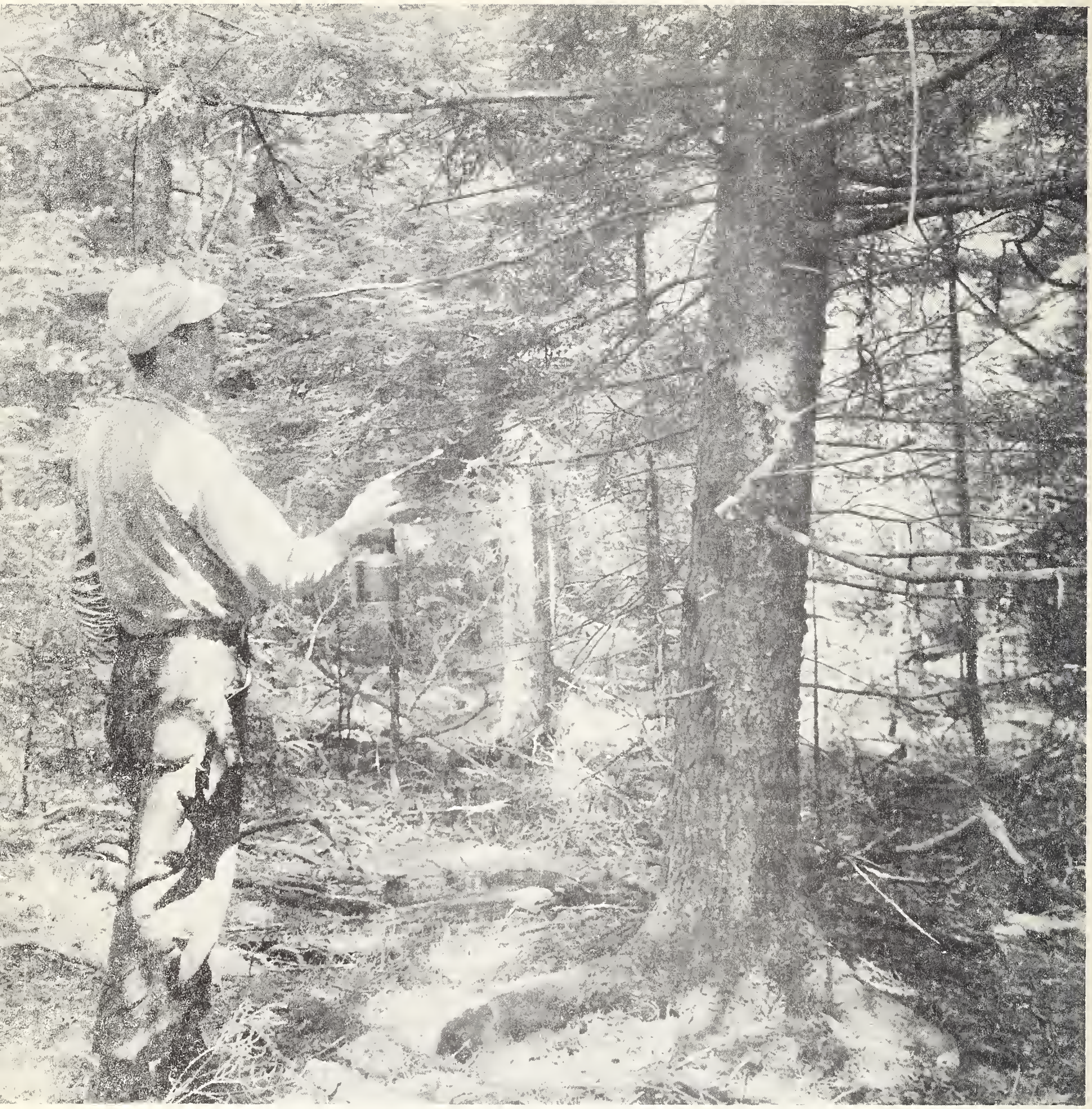
Table 1.--Summary of treatments in compartment-management study

Silvicultural system and treatment		Cutting cycle	Product objective	Compartments
		Years		No.
Selection	High intensity (high order)	5	Pulpwood only	2
			Integrated use	2
		10	Pulpwood only	2
			Integrated use	2
	Medium intensity (good)	10	Pulpwood only	2
			Integrated use	2
		20	Pulpwood only	2
			Integrated use	2
	Modified diameter limit (fair)	20	Pulpwood only	2
			Integrated use	2
		30+	Pulpwood only	2
Shelterwood	3-cut	--	Pulpwood only	2
	2-cut	--	Pulpwood only	2
None	Clear-cut	(?)*	Pulpwood only	2
			Total	28

*Indefinite.

Each compartment is cut strictly in accordance with the requirements of its particular treatment. This is insured by having the entire job done by a logging crew employed full-time by the Forest Service. As far as possible all phases of each operation are carried out in the same manner as a regular commercial job.

Small woodlot management Of the 13,500,000 acres of forest in the spruce-fir hardwoods region of Maine and northern New Hampshire, about 3,400,000, or about 25 percent, are in small ownerships of less than 500 acres. Most of these small woodlots are in a



A limby spruce on a small woodlot is marked for cutting. Although this tree may be growing fast, it is of very poor quality. It takes up too much of the growing space in the woodlot.

very favorable situation for intensive management. They are seldom far from all-weather roads. The land is generally close to population and wood-using centers. This means relatively high stumpage rates and low transportation costs, as well as good markets for diversified products. Local labor can be used, which means a "lunch-pail job" rather than a need for woods camps. Protection from fire is easier because these small holdings are broken up by fields, pastures, and roads. Many properties, especially the farm lots, can be owner-operated. Case-history studies have shown that the owner who does his own logging usually gets at least twice the cash income he would get if he sold his stumpage for a lump sum.

But unfortunately the small woodland in this region has not usually received the kind of management it should. On the contrary, it generally has depleted stands, a high proportion of undesirable species, large numbers of cull or defective trees, and growth rates far below the productive capacity of the soil. All this is nearly always the result of neglect or overcutting--or both.

A study has been started to test good woodlot practices. One objective is to determine what forestry techniques are most effective for bringing the woodlot into maximum production. The second objective is to measure the net financial yields from these techniques by balancing management costs against income and increase in value of the forest.

Three woodlots of about 50 acres each, reflecting different kinds of past treatment, are being set up. One is much better than average: it is well stocked throughout, with fairly good composition and distribution of sizes. The second is typical of the average small forest before it has been cut: stocking is irregular, composition patchy, and there is a great deal of cull, dying, and dead material. The third woodlot is in the unproductive condition typical of many small tracts after cutting: few trees larger than 5 inches d.b.h. remain except culls, and a large part of the valuable species below that size have been broken or uprooted by wind and snow, or were damaged in logging; a thick cover of ferns, raspberries, hazel, gray birch, and other shrubby or valueless species has taken over much of the area.

On the good and medium lots annual cuts will be made to remove some merchantable material. On all three lots, a certain amount of thinning, weeding, and release cutting will be done each year. Promising crop trees of spruce and pine will be pruned. Efforts will be made to develop and market all kinds of products, from Christmas trees to veneer bolts and sawlogs.

As in the compartment-management study, careful records will be an essential part of the study. All costs will be itemized, and the financial results of each year's operation will be computed. In addition, periodic inventories of the growing stock will be made; and growth, change in composition, and improvement in quality will be calculated.

Besides serving as research areas, these woodlots will be useful for demonstrating the practices employed and the results obtained from them. It is expected that a great deal of educational value will be derived from "show-me trips" as records begin to accumulate after a few years.

Small-Scale Testing Of Treatments

The first 4 years on the Penobscot Experimental Forest have been spent largely in organizational and administrative work, and in setting up the compartment-management and small-woodlot studies. However, an essential part of the long-range research program calls for small studies that involve the application of certain kinds of treatment designed to attain some specific result. A few of these tests have been started. More will be added as time permits.

Seedbed preparation Where reasonably good cutting practices are used, reproduction will become established naturally in this region. There is little or no planting problem except on heavily cut-over areas and sometimes on burns and abandoned fields. But there is a problem in regenerating the forests: balsam fir, an early and prolific seeder, on many sites replaces the spruce--and many people prefer the spruce. Since spruce is at a disadvantage in this respect, it is important to know if, given the right seedbed conditions, it could reestablish itself more readily.

Three kinds of seedbed preparation (plus an untreated "check") are being tested in 8 different locations. They are: (1) removing the thick layer of humus and exposing the mineral soil; (2) partially burning the humus; and (3) chopping the humus up and mixing it in with the mineral soil. At each location, duplicate sets of milacre plots were set up. In one set a trench was dug around each plot to determine whether removal of outside root competition will improve survival of the germinated seedlings.

A seed trap set out as part of a seedbed study. 1953 was a good seed year for hemlock: the catch from 7 traps from mid-August to early December averaged over 13 million seeds per acre.

In this stand, small spruce and fir trees are overtopped by gray birch and red maple. These conifers should respond immediately to release because they have not yet suffered too badly from the competition.

Here the small spruce and fir trees have been released from competition by cutting the gray birch and red maple. The cost of such stand improvement, and its effect on growth, are being studied on the Experimental Forest.

A young spruce-hemlock stand where release cutting was tried. A red maple that overtopped a good red spruce was girdled, treated with sodium arsenite, and later cut and peeled. The spruce was pruned and marked as a future sawlog tree.

Rehabilitation of heavily cut over lands As mentioned before, heavy cutting in spruce-fir stands often results in the establishment of a dense cover of non-commercial species. Usually the more desirable species are well represented at the start, but these trees are soon submerged under a leafy tangle of aggressive weed trees. Some may survive and others may eventually come in; but this kind of natural succession will be very slow. The long wait until the next cut can be shortened if these more valuable seedlings and saplings can be released. Furthermore, it may be that planting or direct seeding could be made to pay for itself on areas where there is little or no natural reproduction of desirable species.

The effectiveness and financial soundness of various cultural treatments are being tested. On several small blocks of apparently unproductive brushy land, small trees of valuable species will be released in various ways. Their response to release, and the cost of the treatment, will be recorded.

Pruning red spruce There is little doubt that pruning of white pine is a profitable practice in this region, and in the adjacent white pine region. For good red spruce lumber there has always been a small but strong market. But so far the demand has not been great enough to justify buying spruce logs by grade. Since spruce lumber has many desirable features, it seems highly probable that in the not-too-distant future clear spruce logs will demand a premium price.

For these reasons, the cost of pruning small spruce is being studied. Selected trees were pruned to a height of 17 feet. The time required, and the diameter and height of each tree, were recorded. Periodic re-measurements of these trees will tell us how well they grow; and the probable earning power of the trees--in terms of their theoretical ultimate lumber value--will be computed. Thus in a relatively few years we will be able to tell whether, for a given log price at maturity, it is financially practical to prune red spruce.

Thinning black spruce Black spruce yields high-quality woodpulp. But in this region it commonly occurs in dense stands on wet sites, where it grows very slowly. If such thickets can be thinned profitably, the rotation may be shortened considerably, thus increasing the value of the timber crop as well as the potential usefulness of such wet sites.

An exploratory study was started in 1952 to get some indication of the effectiveness of thinning, as well as the possible silvicultural hazards involved. Two degrees of thinning were tried in a small area of black spruce. In one, about 14 percent of the growing stock was removed. In the other 25 percent was taken out. (A third block was left untouched as a check.) After 5 years of observation it will be possible to determine whether wind and snow damage has been severe, whether the trees left have increased their growth, and to what extent individual trees responded to the release. This will then serve as a basis for deciding if more elaborate studies of this problem would be worthwhile.

Biological Observations & Measurements

Although a great deal of basic information about the growth and development of our forest species has been accumulated, there are still many gaps in our knowledge. Fundamental research cannot be neglected if a realistic program is to be maintained. The following studies now being conducted at least in part on the Experimental Forest illustrate the way in which the advance of planned forest management on industrial holdings has influenced our research program.

Optimum stand structure One of the aims of the silvicultural tests being carried out on the compartments is to find out how the different methods of cutting affect stand structure. From the results of these tests we will learn how to control the density, composition, and size-class distribution of the growing stock. And from that we can learn how to build up and maintain the kind of stand that is desired.

It immediately becomes apparent that the forester must know what kind of stand he wants. He must know what density, composition, and size-class distribution will be acceptable under the requirements of his management plan. If he does not have such a goal, his efforts to build up the productivity of his growing stock will not be fully effective.

The question of what constitutes "optimum" stand structure in the mixed, uneven-aged stands of this region is very complex. Furthermore, there is no single optimum, because site quality, intensity of management, owner objective, and other factors will have a strong bearing on the quantity and quality of growing stock that can be left, and on the rate at which it can develop. This question is basic to good forest management. A long-range study has been started to seek some of the answers.

This field crew is tallying trees on a permanent sample plot used in a study of stand structure and growth. Re-measurements will be made every 5 years. This plot has just over 28 cords per acre in trees 6 inches d.b.h. and larger.

To determine the yields that can be expected from different stand structures, about 40 permanent sample plots are being laid out on the Experimental Forest each year. Ultimately about 300 plots will be used, representing all stand conditions--from heavily cut-over to undisturbed forests. After two or three measurements at 5-year intervals, growth will be analyzed in relation to stand structure. This will show what stand conditions are required to give the greatest increment. Or--to put it another way--it will show what growth can be expected from a given stand structure.

Site index of red spruce The traditional way to measure the quality of a site for a given species has been to use the height attained by dominant and codominant trees at a given age--say 100 years. The taller the average tree at that age, the better the site. But this does not work with red spruce. It is a very tolerant species, growing in all-aged stands. It will hang on for several decades under the shade of other trees, but will make virtually no growth until it is released. So its height at any given age bears no relation to the quality of the soil it is growing on, but merely reflects the length of time it was suppressed.

In 1952 we began to look for a better way to measure site quality. A very promising and simple procedure was developed; it is now being given a thorough test. It is based on the idea that, while age and height are not related to site, diameter and height might be. It had been observed repeatedly that on apparently better sites trees attained greater heights--at the same diameters--than on poorer sites. It seemed that if this relationship were consistent enough, it could very well be used as a quantitative index of site quality. So measurements are now being made, some on the Experimental Forest and some elsewhere in the region, to test this theory.

Soil properties that affect growth Little is known about the relationships between tree growth and the soils and geology of this region. But with more and more emphasis being given to better forest management, knowledge of just what constitutes a good site or a poor site is becoming increasingly more important. Experiments are now under way on the Forest and on private lands throughout the region to provide some of the basic information that is so badly needed.

The initial effort is aimed at learning what soil and geological factors influence the growth of red spruce. Between 40 and 50 stands that contain mature spruce are being located. In each stand soil pits are being dug. Depth,

Although the Experimental Forest is fairly near Bangor, a great variety of wildlife has been seen here, including fox, deer, bear, and moose. This beaver lodge is along the stream that forms one boundary of the Forest.

profile, origin, and other characteristics of the soil are being measured and observed. Soil samples are taken for analysis as to physical properties such as texture, air capacity, water-holding capacity, and compaction. These properties will then be correlated with site index (to be determined as outlined above). The results can then be interpreted so as to provide a key to the problem of what soil characteristics must be looked for to identify potentially good or poor sites for management purposes.

OTHER ACTIVITIES

As time goes on, it is expected that more diverse activities and functions will be carried out on the Penobscot Experimental Forest.

One of the most important services such a forest can offer is to provide an on-the-ground demonstration of what forestry is and what forestry can do. During its first $4\frac{1}{2}$ years of existence, the Penobscot Forest has had more than 600 visitors. School children, foresters, farmers, forestry students, timberland owners, woods operators, and others have been taken on "show-me trips" or have visited informally with the staff on the Forest. This sort of service will undoubtedly increase and become more effective as our experiments come to completion and yield tangible results.

Studies in related fields such as wildlife management, forest insects, forest diseases, and forest utilization will gradually become part of the research program. Much of this work will probably be on a cooperative basis with other research organizations. A portion of the Experimental Forest is being left undisturbed: it will serve as a natural area for botanical studies.

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