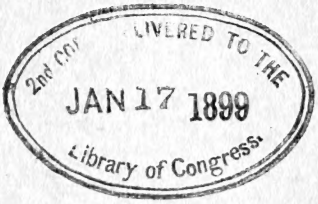
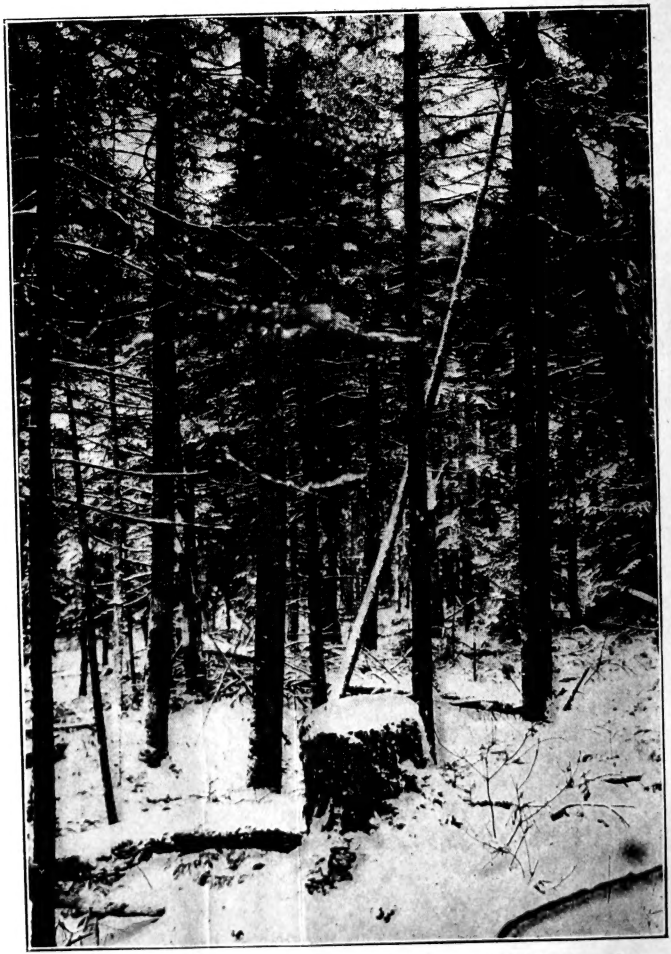
THE ADIRONDACK SPRUCE

GIFFORD PINCHOT





SPRUCE LAND ON WHICH THE LARGE TIMBER HAS BEEN CUT AND THE SMALL TREES LEFT TO GROW.

THE ADIRONDACK SPRUCE

A STUDY OF THE FOREST IN

NE-HA-SA-NE PARK

WITH TABLES OF VOLUME AND YIELD AND
A WORKING-PLAN FOR CONSERVATIVE LUMBERING

BY

GIFFORD PINCHOT

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PREFACE

THE owners and operators of Spruce lands in the Eastern United States will find within the covers of this little book a collection of facts and figures which is intended first of all to be of practical use. The information it contains is the product of a prolonged investigation conducted throughout with that intention. If its results have any merit, therefore, it must be because they are capable of assisting American lumbermen to get better returns from their investments in Spruce lands through conservative lumbering and successive crops than they could by considering the productiveness of these lands as of merely temporary interest. In the attempt to be of use in this way, some departures from established methods of study and statement have been necessary. Such changes are inevitable. As yet forestry in America is young. In its progress toward maturity it must develop new methods to meet the unfamiliar conditions with which it has to deal. Rules and practices which were devised without reference to American forests cannot always be counted on to fit American needs. Perhaps nothing has done more to retard the progress of forestry in America than the disregard of its intimate and friendly relation to lumbering—a relation which was almost wholly overlooked for years after the advocates of forest

protection first brought their cause to public attention. In the eyes of many of its early friends the lumberman was a vandal whose inordinate greed called for constant denunciation, while to the lumberman the ideas of the forest reformer had no relation whatever to the affairs of practical life. Since that early day lumbermen and foresters have been drawing together, and much progress has been made toward the right opinion, which may be expressed by saying that lumberman and forester are as needful to each other as the ax and its helve. Without the ax the helve has little weight; without the helve the ax is lacking both in reach and in direction.

As the aim of the book is wholly practical, much material of chiefly theoretical interest has been necessarily excluded from its pages. A little of it, either closely connected with the main object of the book or otherwise of special interest, has been printed in small type. Only so much of it has been included in the body of the book as is necessary to show the way by which results were reached. Hence, "The Adirondack Spruce," considered as a general discussion, is extremely defective. To mention but a single instance, no account is given of the age of the Spruce in relation to size, because the plan of work here proposed does not require a knowledge of it.

It is a fortunate fact that this plan of work is already undergoing practical trial. Dr. Webb was the first to adopt it, for Ne-Ha-Sa-Ne Park, a tract of 40,000 acres, including the land hereafter described. A statement

of it laid before the Hon. William C. Whitney and Mr. Patrick Moynehan met with their approval, and led to its introduction on land contiguous to the Park, belonging to Mr. Whitney and operated jointly by Mr. Whitney and Mr. Moynehan. An account of the detailed working-plans under which this work is being done, together with the results of the first year's cut, will be published early in the coming year by the Division of Forestry, United States Department of Agriculture, by which the plans were prepared, and under whose supervision they are being carried out. The total area now being managed in the Adirondacks under the plans of the Division is slightly more than 100,000 acres.

I wish to express in this place my high sense of the public spirit and practical wisdom which led Dr. Webb to sustain the investigation whose results are now published, and to approve and apply the plans of work which it has produced. My sincere thanks are also due to Mr. Edward M. Burns, Manager of Ne-Ha-Sa-Ne Park, for his unfailing interest and assistance, and to the men to whose constant and loyal efforts whatever has been accomplished is so largely due.

GIFFORD PINCHOT.

WASHINGTON, D. C., Oct. 24, 1898.

CONTENTS

PART I. THE SPRUCE

PART II. THE WORKING PLAN

PART I

THE SPRUCE

INTRODUCTION

THE study whose results are here presented had its origin in a conversation between Dr. W. Seward Webb and the writer in November, 1896. The arrangement then made contemplated a division of responsibility according to which Dr. Webb's contribution should consist of the funds necessary for the pay of assistants and the necessary field expenses, while my share involved the planning and supervision of the work, and the preparation of its results for publication. The whole undertaking was to have for its object the "preservation and proper management of Spruce lands in the northeastern United States."

It was evident at that time, and it is still more evident now, that the original forests cannot long suffice to supply the increasing demands for Spruce which are made upon them. To provide for a second, and for succeeding crops of Spruce is the obvious and necessary way to prevent a scarcity of this valuable tree, and the consequent crippling, in the comparatively near future, of the industries which depend upon it. The purpose of the present study was to acquire such a knowledge of the laws which govern the growth of the Red Spruce that the main facts necessary for the conservative treatment of Spruce forests might be put within the reach of the men most likely to undertake it.

Under this plan instructions were prepared, and field-work was begun early in December, 1896, and was continued for nearly two months. It was the intention to confine it chiefly, but not altogether, to Ne-Ha-Sa-Ne Park, the property of Dr. Webb. To supply data which could not there be obtained, it consisted at the outset chiefly in tree-analyses on land belonging to the Santa Clara Lumber Company, near Santa Clara, Franklin County, N. Y., which was being cut over the second time for Spruce. Sincere thanks are due to the officers of this company for their constant courtesy and most valuable assistance. Mr. Henry S. Graves was charged with the execution of the work, and was assisted by two volunteers, Mr. U. F. Bender and Mr. Henry Farnham, and by two woodsmen hired for the purpose. The field work was interrupted for some months, when this part of it was completed, and was resumed about the middle of May at Ne-Ha-Sa-Ne, Hamilton County, N. Y. Mr. Graves was again in charge, and was assisted by Messrs. W. McClintock and W. S. Walcott, both volunteers. During the first week of July Mr. E. M. Griffith replaced Mr. Graves, who had been called away on important Government work in the West. Mr. Griffith was assisted by Messrs. W. McClintock, W. S. Walcott, T. H. Sherrard, F. E. Olmsted, F. Mosle, G. M. Leupp, and S. Woodruff, all volunteers. The work at Ne-Ha-Sa-Ne was completed early in September, 1897. The work of stating the results, and preparing them for publication, has occupied the intervening time. Acknowledgments are due to the men

who gave their services to the investigation, and special mention should be made in this place of the efficient and accurate work of Mr. Graves, to whom was entrusted the execution of plans in the making of which he shared, and of Mr. Griffith as his assistant.

The field work done comprised the counting and measurement, on 1046 acres, of all Spruces down to a diameter of two inches, and of all other trees ten inches or more in diameter. All Spruces below 2 inches were counted under the head of "tallies." On twelve of these acres the trees other than Spruce were also measured and counted down to two inches. Each of the twelve acres was a square, while the remainder (1034) were taken by the chain method described later on. In addition, fourteen sample plots, of rather more than an acre in average size, were carefully surveyed at Santa Clara, and their trees counted, and all the Spruces over 5 inches in diameter, to the number of 2,006, were analyzed. At Ne-Ha-Sa-Ne the number of tree-analyses reached two hundred and ninety-eight. These materials, together with the silvicultural and other notes collected by Mr. Graves and myself during several years, have furnished the data presented in this book. It is believed that they represent accurately the average conditions of the region with which they deal.

I

THE FOREST

THE forest of Ne-Ha-Sa-Ne Park, except for a small strip on the southern side, has never been lumbered. In places along the railroad the Spruce has been culled for ties, and near camp sites and rangers' cabins there has been some cutting for fuel and other local uses. But for the most part the Park is covered with a virgin forest.

A virgin forest is the product of centuries of struggle among the trees for the occupancy of the ground. This competition takes place between individuals of the same species, as well as between the different species, and its result determines the character of the forest. Nature does not provide for the survival of those trees alone which are of greatest use to man, or for the destruction of the valueless. The valueless species enter the contest with as much vigor as the more technically valuable, and often win in the race. A natural forest, then, contains alike valuable timber, unsound and worthless trees, and species which have at present no merchantable use. From a technical point of view the condition of the virgin forest is not good, because much of the land, which might be producing marketable timber, is occupied by scrubby and worthless trees.

The important species of Ne-Ha-Sa-Ne Park are all

TYPICAL VIRGIN FOREST. NE-HA-SA-NE PARK.

tolerant of shade to a considerable degree. As a consequence, the forest is composed of trees of all ages and sizes, for the younger trees are able to survive beneath the shade of the older ones. Such a forest is said to have the selection form.

A selection forest is usually composed of species tolerant of shade. This does not mean, however, that intolerant species are wanting, for these maintain their existence by prolific reproduction, rapid growth, and the ability to live on poor soil, rather than by overcoming their rivals in the struggle on the ground. Thus where openings are made by windfall or fire, such species often take possession of the land, coming up in fairly even-aged bodies, sometimes of very considerable size. On fire slashes in the Adirondacks, for example, the Poplar, a tree very intolerant of shade, but with very light seed easily carried by the wind, rapidly takes possession of the soil. White Pine comes up in openings after fire. Tamarack, the most intolerant of all, grows rapidly in height, and so maintains its place. It starts in openings, and, by growing faster than Spruce or Balsam, forms an upper story above them. In the long run, other things being equal, the tolerant species will win, and the intolerant will be forced to retire to the openings caused by fire, wind, insects or disease.

The species which occur in Ne-Ha-Sa-Ne Park are Spruce, Birch, Hard Maple, Soft Maple, Beech, Balsam, Hemlock, White Pine, Tamarack, Cherry, Black Ash, White Ash, two Poplars (distinguished as the Aspen and the Largetooth Aspen), and Bird Cherry. Of these,

Spruce, Hemlock, Balsam, the Maples, Beech, and Birch are tolerant. White Pine is intermediate, and the remainder of the trees are intolerant of shade. A provisional scale of tolerance is as follows, beginning with the species which demand most light: Tamarack, Poplar, Bird Cherry, White and Black Ash, Black Cherry, White Pine, Birch, Soft Maple, Balsam, Spruce, Hemlock, Beech, Hard Maple. These species occur in mixture of varying proportions, the preponderance of one tree or another depending primarily on the situation and soil.

In general, the forest may be divided into four distinct types, named from the situations where they grow; Swamp land, Spruce flat, Hardwood land, and Spruce slope. Further subdivision would be possible, but it is unnecessary for the purposes of this report.

From an examination of the land, from the topographical map, and from the 1046 valuation surveys, these four classes of situation are estimated to have approximately the following proportion in the Park:

Swamp lands, 22 per cent.
Spruce flats, 10 per cent.
Hardwood lands, 42 per cent.
Spruce slopes, 26 per cent.

An excellent mental picture of the forest may be obtained from the following table, which gives for each species the average number per acre of trees over ten inches in diameter breast high, and the percentage of each species in the mixture, as well as the average and maximum diameters. These figures represent the aver-

age of the 1046 valuation surveys taken in Ne-Ha-Sa-Ne Park. The proportionate number of acres of each of the four situation classes corresponds quite closely with the actual proportion of each kind of land in the Park.

TABLE I

Average number of trees per acre, percentage in mixture, and average and maximum diameters of all sound trees over ten inches in diameter breast-high.

Average of 1046 acres

Name of Species	Av. No. of Trees per Acre	Percent. of each Species	Av. Diam. breast-high. Inches	Max. Diam. breast-high. Inches
Spruce	31.40	42.77	13.0	30
Birch	14.00	19.06	17.1	38
Beech	10.00	13.62	13.2	26
Hard Maple	6.10	8.30	13.9	30
Hemlock	4.60	6.26	16.7	37
Balsam	4.20	5.72	11.4	20
Soft Maple	2.60	3.54	13.6	28
White Pine	.18	.24	18.4	39
Ash	.16	.22	12.9	19
Cedar	.12	.16	14.5	28
Cherry	.08	.11	15.3	24
Average of all species	73.44	100.00	14.5	29
Average of all species except Spruce	42.04	57.23	14.7	28.9

SWAMP LANDS

Under this head are included all the swamp and marsh lands of the Park. In certain places, on low, flat, wet ground, there is an almost pure growth of small, spindling, narrow-crowned Spruce, which apparently does not reach a merchantable size. The general aspect of this tree, in habit and color of foliage, is in marked contrast to those about it. On close examination, it is found to be Black Spruce (*Picea mariana* (Mill) B. S. P.), while the merchantable tree is Red Spruce (*Picea rubra* (Poir) Diet.)

The Red Spruce also occurs almost pure in low swampy ground, but it is more often found in mixture with Balsam. In such places it is usually short and scrubby. The following summary gives the average condition of the forest on swamp land in the Park.

SPRUCE SWAMP. THE DEAD TREES ARE TAMARACK.
NE-HA-SA-NE PARK.

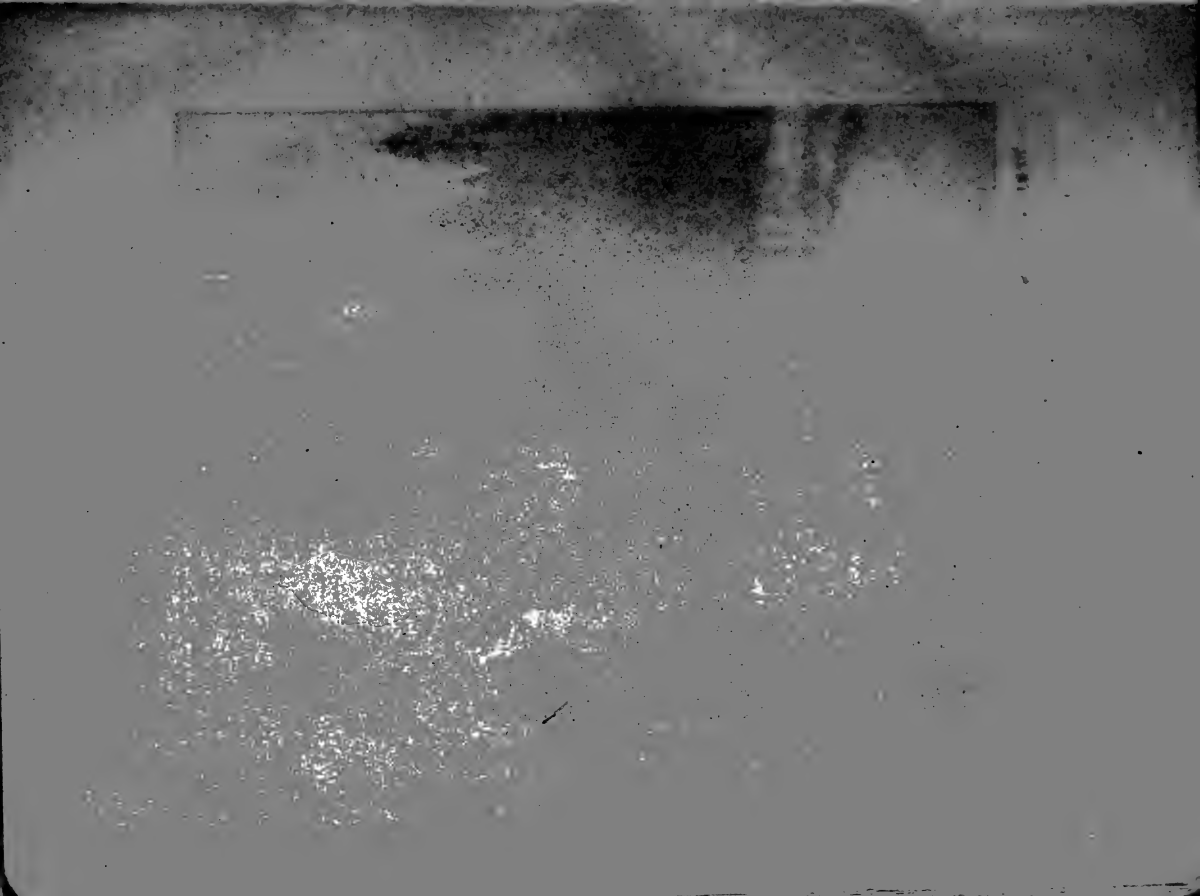


TABLE 2

SWAMP LANDS

Average number of trees per acre, percentage in mixture, and average and maximum diameters of all sound trees over ten inches in diameter breast-high.

Average of 225 acres

Name of Species	Av. No. of Trees per Acre	Percent. of each Species	Av. Diam. breast-high. Inches	Max. Diam breast-high. Inches
Spruce	34.00	47.94	12.8	27
Birch	13.00	18.33	15.4	36
Beech	2.40	3.38	12.8	25
Hard Maple	2.40	3.38	13.2	29
Hemlock	5.10	7.19	16.5	35
Balsam	9.40	13.25	11.4	24
Soft Maple	3.00	4.23	13.1	30
White Pine	.36	.51	17.1	37
Ash	.64	.90	13.4	21
Cedar	.60	.85	14.5	28
Cherry	.03	.04	19.4	33
Average of all species	70.93	100.00	14.5	29.5
Average of all species except Spruce	36.93	52.06	14.7	29.8

SPRUCE FLATS

These are level and rolling flats, usually near ponds and swamp lands. The soil as a rule is fresh and deep, although frequently the ground is covered with glacial boulders. The humus is fairly deep and the leaf-litter thick. The Spruce is of medium height and usually of medium diameter, with an occasional veteran of very large proportions.

On areas covered with rocks, and where the soil is moist, the danger from windfall is considerable. The second-growth after these windfalls is frequently Birch and Soft Maple.

The trees in mixture on Spruce Flats are Birch, the Maples, Beech, Hemlock, Balsam, White Pine, Cherry, and Ash.

Like the Spruce, the Birch is here of a quality and development intermediate between that of the higher ground and that found in swamps.

These flats form the lower limit of the Hard Maple. It is common on higher ground, but on the lower and moister flats it gives way to Soft Maple. The Hard Maple is here inferior in quality to that found on high lands. Here, as elsewhere in the Park, the Soft Maple is very unsound. On the higher flats Beech of excellent quality is common on good soil ; on the lower land it is unsound and of inferior development. Some of the best Hemlock in the Park occurs on Spruce flats, especially where the soil is fresh and not far above the level of streams and ponds. The Balsam for the most part is small, and other species have little importance.

SPRUCE FLAT. PURE EVEN-AGED STAND OF SPRUCE ABOUT 120 YEARS OLD. SANTA CLARA, N. Y.

TABLE 3

SPRUCE FLATS

Average number of trees per acre, percentage in mixture, and average and maximum diameters of all sound trees over ten inches in diameter breast-high.

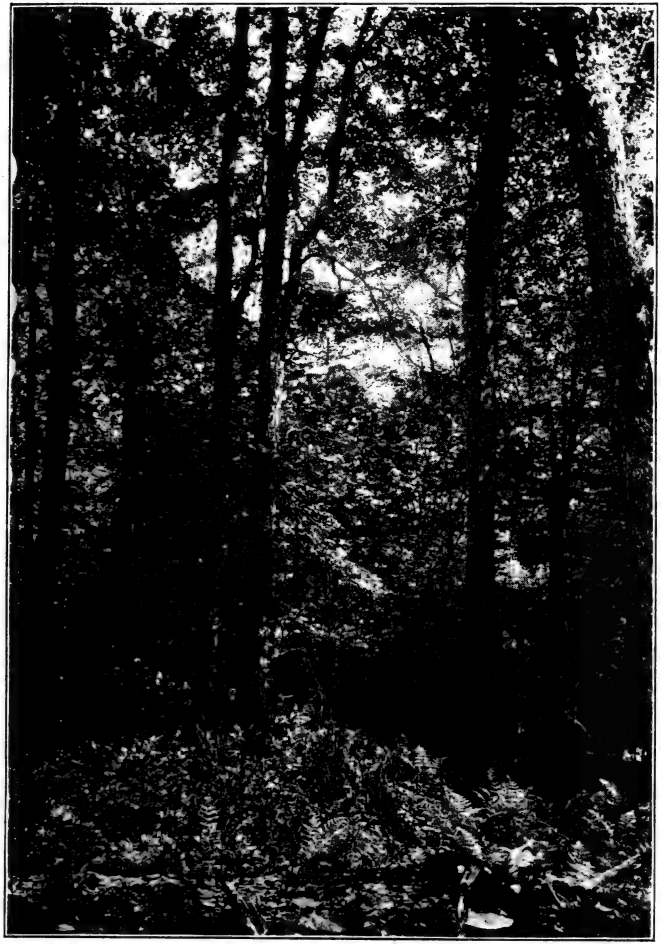
Average of 106 acres

Name of Species	Av. No. of Trees per Acre	Percent. of each Species	Av. Diam. breast-high. Inches	Max. Diam. breast-high. Inches
Spruce	29.00	45.00	13.5	27
Birch	12.70	19.71	16.4	34
Beech	5.60	8.69	13.4	22
Hard Maple	2.50	3.88	14.0	26
Hemlock	5.60	8.69	16.5	34
Balsam	5.80	9.00	11.3	18
Soft Maple	3.00	4.65	13.7	25
White Pine	.10	.15	21.0	45
Ash	.10	.15	13.0	16
Cherry	.05	.08	11.7	17
Average of all species	64.45	100.00	14.4	26.4
Average of all species except Spruce	35.45	55.00	14.6	26.3

HARDWOOD LANDS

Hardwood lands comprise the elevated flats and slopes where the hardwoods are the characteristic species, among which the Spruce grows in considerable quantity, both scattered and in groups. The soil is richest on high flats and moderate slopes, and here the largest Spruce and the best hardwoods grow. The humus is good and the fall of litter heavy. In general the Spruce is somewhat larger on the more level hardwood lands than on the slopes, but the crown is apt to be longer and the clear length shorter. The proportion of Spruce in mixture is nearly the same in each.

The characteristic trees in mixture are the Birch, Hard Maple, and Beech, with scattered Hemlock, Soft Maple, Pine, Cherry, and Balsam. The first three attain their best development on these lands, while the Hemlock is of inferior quality to that found on the moister soil of lower ground. While Soft Maple is not a characteristic tree of the hardwood forest, it is found scattered there in considerable numbers, and the largest specimens frequently grow on high ground. The other species are not important.



TYPICAL HARDWOOD FOREST. NE-HA-SA-NE PARK.

TABLE 4

HARDWOOD LANDS

Average number of trees per acre, percentage in mixture, and average and maximum diameters of all sound trees over ten inches in diameter breast-high.

Average of 442 acres

Name of Species	Av. No. of Trees per Acre	Percent. of each Species	Av. Diam. breast-high. Inches	Max. Diam. breast-high. Inches
Spruce	29.00	36.84	13.1	32
Birch	15.00	19.06	17.8	42
Beech	16.40	20.84	13.7	30
Hard Maple	10.10	12.83	14.3	33
Hemlock	4.00	5.08	17.4	36
Balsam	1.70	2.16	11.4	21
Soft Maple	2.30	2.92	14.0	30
White Pine	.05	.06	13.6	33
Ash	.03	.04	12.4	24
Cherry	.13	.17	15.8	27
Average of all species	78.71	100.00	14.3	30.8
Average of all species except Spruce	49.71	63.16	14.5	30.7

SPRUCE SLOPES

These are usually steep rocky slopes with meagre soil, bearing a forest chiefly of softwoods. In general the exposure is to the south. The Spruce is here of excellent quality, tall and clear boled, the largest specimens on benches and in hollows, where the soil is deeper and the growth of the trees more rapid. The danger from windfall on such rocky slopes is very great.

A fair amount of young growth and seedlings occurs on Spruce slopes, and in openings and windfalls the reproduction is very fine. Spruce seed finds an excellent germinating bed on the moss-covered soil.

Hemlock grows here in considerable quantities, and is often grouped at the brow of the ridge. Birch is the most abundant of the hardwoods in mixture, and is of excellent quality. Beech and Hard Maple are found, but less abundantly. There is frequently a small cluster of Pines on the brow of southern slopes.

SPRUCE SLOPE. NE-HA-SA-NE PARK

TABLE 5

SPRUCE SLOPES

Average number of trees per acre, percentage in mixture, and average and maximum diameters of all sound trees over ten inches in diameter breast-high.

Average of 274 acres

Name of Species	Av. No. of Trees per Acre	Percent. of each Species	Av. Diam. breast-high. Inches	Max. Diam. breast high. Inches
Spruce	34.co	48.45	12.90	34
Birch	13.7o	19.52	18.60	40
Beech	7.20	10.26	13.10	27
Hard Maple	4.00	5.70	14.00	31
Hemlock	5.20	7.42	16.30	42
Balsam	3.20	4.56	11.40	18
Soft Maple	2.50	3.56	13.70	25
White Pine	.30	.42	21.90	42
Ash	.01	.02	12.70	14
Cherry	.06	.09	14.20	20
Average of all species	70.17	100.00	14.88	29.3
Average of all species except Spruce	36.17	51.55	15.10	28.8

II

THE SPRUCE

HABIT

In favorable localities and in crowded forest, the Spruce forms a long, clear, full bole, and a rather compact, short, and blunted crown. It attains in Ne-Ha-Sa-Ne Park a height of one hundred feet and a diameter of thirty-four inches. These dimensions are, however, rare, and the average for large trees is not over ninety feet in height, and, for the diameter, from twenty-four to twenty-six inches. On low swampy ground Spruce has a long crown, and is comparatively short. The average length of crown for all situations and soils in the Park is about forty feet, and the average clear length from twenty-five to thirty feet. The average length of merchantable log was found to be forty-six feet. The root system is flat and superficial, and the tree, in consequence, is able to thrive on shallow soils.

SOIL AND SITUATION

The influence of situation and soil on the character and distribution of the Spruce is very marked. In general, the Spruce may be divided into three classes with fairly distinct lines, according as it is found on

GROUP OF YOUNG SPRUCE IN THE FOREST. NE-HA-SA-NE PARK.

hardwood lands or Spruce slopes, on swamp lands, or on the intermediate Spruce flats. Occasional groups of Spruce on the narrow tops of high ridges belong also to the latter class. While the character of the tree varies according to the situation, yet the Spruce is not fastidious, for it occupies all situations and soils; the tops of mountains and ridges, abrupt rocky slopes, and low wet swamps, as well as good soil. The best Spruce is found on rich flats or moderate slopes with rich fresh soil. Any aspect is good if the soil is suitable. It must not be wet or acid. Thus the largest Spruce is found on low moderate slopes, in sheltered coves, along the benches or hollows of steep slopes, and on rich flats. On low swampy land it is short and of slow growth. Spruce of intermediate growth occurs on Spruce flats, where the soil is fresh or even moist, but not wet.

Aside from these general considerations, the presence or absence of the Spruce in certain places is determined chiefly by accidental distribution and by the struggle with other species for possession of the ground. On steep southwestern slopes it is found in great abundance, and sometimes almost pure. This is not because the soil and aspect are here most favorable to the growth of Spruce, but because many of the hardwoods will not grow on such rocky, thin soil, and the Spruce is thus left almost without competitors. In the same way Spruce often predominates on poor, low, moist, or even wet, lands, because in such places also it is almost without competition. Spruce is then most

abundant not necessarily where situation and soil are best suited to its development, but in many cases where the soil is so poor that no other tree will grow. It is most abundant on the brows of ridges, on knolls, steep slopes, along the edges of lakes, and often on low moist ground. On high land it must contend with the numerous and persistent hardwoods, which, in capacity to bear shade, in height-growth, and in reproductive capacity, are fully equal to it.

REPRODUCTION

There are two qualities which enable the Spruce to maintain itself in fairly uniform proportion in the Adirondack forest. These are its ability to live under the heavy crowns of other trees, already referred to, and its remarkable power of reproduction. The latter depends first of all on the great quantities of seed which are produced year by year. The seeds of the Spruce are winged, and as they ripen and fall from the cones the winds catch and spread them widely throughout the forest. In this way the chance to take possession of suitable localities can be used whenever it arises. For the best reproduction of Spruce a good seed bed and a certain amount of light are required. Large quantities of seed fall annually which never germinate, and thousands of small seedlings perish through the lack of proper conditions of light and soil. Where there is light enough, Spruce seedlings germinate and grow easily on deep Spruce or Pine duff and on heavy beds of moss. Thus on Spruce slope seedlings are

REPRODUCTION OF SPRUCE IN A WINDFALL. NE-HA-SA-NE PARK.

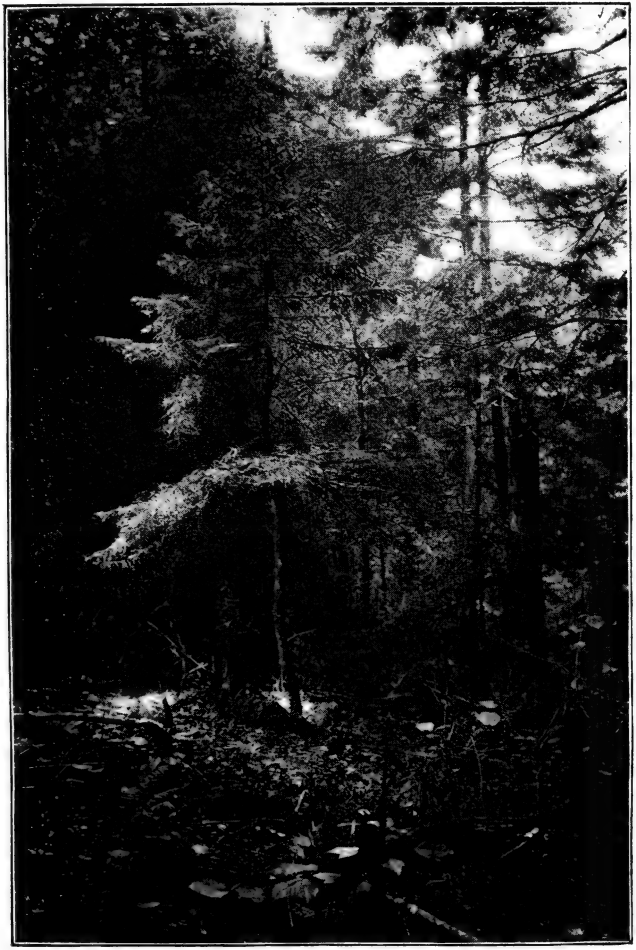
abundant on the moss-covered rocks and logs, and indeed wherever a break in the forest canopy admits sufficient light. A heavy matting of leaf litter, on the other hand, such as is found on hardwood land, seems less thoroughly adapted to their requirements, but they are found scattered in greater or less numbers almost throughout the forest. In small openings, especially those made by windfalls, they are most frequent, and here they occur in dense groups, growing rapidly under the influence of the light. In other still smaller openings in the forest such groups of greater or less extent are very common, and form one of the distinguishing features of the reproduction of this tree. In larger openings, caused by fire, the return of the Spruce to land from which it has been burned away is often slow. Commonly it is preceded by a growth of herbaceous plants, and vines, followed by Poplar and Bird Cherry, and then, when a suitable seed-bed has been prepared by the waste from these trees, the return of the Spruce itself takes place.

TOLERANCE

The fact that young seedlings and small trees are so widely distributed through the forest is due in part to the ability of this tree to grow under heavy shade. This does not mean that the Spruce will not flourish in the light, but merely that it is tolerant of the heavy cover which is a distinguishing characteristic of the hardwood forest in the Adirondacks and throughout New England. Specimens from 100 to 150 years old, and

less than six inches in diameter, are common. Such trees have survived on the little sunlight which could penetrate the heavy crowns above them, and, although not in vigorous health, are capable of continuing the struggle to an advanced age. This ability to tolerate heavy shade is common to large numbers of forest trees, among which both the Beech and the Hard Maple excel the Spruce in this regard. But few trees possess the wonderful capacity of the Spruce to recover from long years of suppression and grow almost or quite as vigorously and rapidly after it is ended as though all the conditions of life had been favorable from the beginning. It is to this capacity more than to any other that the Spruce owes its presence in the Adirondack forests. Slow of growth in youth, and germinating for the most part under heavy shade, the Spruce could not survive in the hardwood forest, where it reaches its best development, except by the combination of these two qualities, the ability to bear shade, and the power to flourish when the suppression is over as vigorously as though it had never been.

This power of tolerance is not restricted to early life, although very marked at that time, but continues into age as well. Thus, at Ne-Ha-Sa-Ne several trees but nine inches in diameter were found to have more than 200 annual rings on the stump, and of eighteen Spruces with diameters ranging from 8.5 to 9.4 inches, but seven were younger than 150 years, and none were younger than 100. One Spruce stump 4.5 inches in diameter had 121 annual rings. These trees had grown for years



SMALL SPRUCE WHICH WAS FOR MANY YEARS SUPPRESSED. THE LEADER WAS BROKEN OFF; A SIDE BRANCH TOOK ITS PLACE, BECAME THE MAIN SHOOT, AND NOW, WITH A FAIR DEGREE OF LIGHT, IS GROWING VIGOROUSLY. NE-HA-SA-NE PARK.

crowded and shaded by their more thrifty neighbors. Under such circumstances it is common to find small trees still alive, but with flattened and umbrella-shaped crowns. Even such trees are not beyond the possibility of usefulness. If the shade be removed they will usually begin to grow as vigorously as though they had never been suppressed. If the leading shoot has been killed, which is sometimes the case, a side branch will turn upward and take its place, and the growth, although somewhat retarded by the accident, will go rapidly on. A considerable proportion of all the large Red Spruce in the Adirondacks is found, on examination, to have passed through this umbrella stage. On old windfalls in certain sections, for example, and particularly on low flats, many of the old Spruces carry clusters of very numerous persistent branches growing close together at ten or fifteen feet above the ground. Such branches mark a period when the crown was flattened and umbrella-shaped. The present size of these Spruces shows plainly how when the old trees above them were blown down they shot up and grew thriftily in spite of the severe circumstances of their youth. It is true that when trees have attained such a size before being set free the injury to the lumber is serious, for the persistent branches entail the loss of a certain amount of clear stuff. If, however, the tree is small when freed, the knots from which these branches grew may be covered over in time, and lumber of good quality may be produced.

III

SPRUCE IN MIXTURE

THE forest on the Park has been described as a mixed selection forest composed of species which for the most part are extremely tolerant of shade. The distribution of different species in different places is determined primarily by the situation and soil. In localities suited to the growth of a number of species the factors which govern the preponderance of one tree over another are: First.—Accidental distribution, under which head are grouped such facts as may result from the wind blowing in a particular direction just as ripe seeds are ready to fall, from a windfall taking place just before an abundant seed-year, or from similar accidental happenings by which one species is given special opportunities or advantages for reproduction. Second.—The peculiar power of each species to contend with its neighbors for space and light. As different trees start together or in succession on any given tract, the struggle for existence begins and will be determined by the power of the different species for carrying it on. It is the outcome of this struggle which fixes the character of the forest, and in it without accidental aid the tolerant species must win in the long run. If the intolerant species can get the start, being often rapid of growth, they may hold their position by growing above

the other trees about them, as do Tamarack and Pine. Under average conditions on large areas, the proportionate numbers of different trees, equal in tolerance and other qualities, would be fairly evenly maintained. All species, however, are not equal in their tolerance of shade, their resistance to storm and disease, in tenacity of life and power of reproduction, so that an even mixture is seldom either achieved or maintained.

We have already seen that Spruce grows in all situations and soils. While in most portions of the Park it is mixed with other species, there are certain situations where Spruce occurs nearly pure. Thus, on southwestern slopes the soil is frequently so stony and the slope so abrupt that such trees as Hard Maple and Beech find difficulty in obtaining a footing. In such places Spruce reproduces itself abundantly; Birch and Hemlock come up to some extent; but, in comparison with the forest on northern slopes and high flats, Spruce has almost undisputed sway. The same is true on certain ridges and knolls where the growth is almost entirely softwood, and on certain lowlands where its competitors are reduced to a few species with which the Spruce is abundantly able to cope. In such situations, and wherever Spruce predominates, its future is assured. That is to say, under conservative treatment there is or there will be young growth enough to take the place of whatever merchantable timber may be cut, and hence the reproduction is sufficient to maintain the present proportion of Spruce. With proper care the latter could, on the whole, be increased.

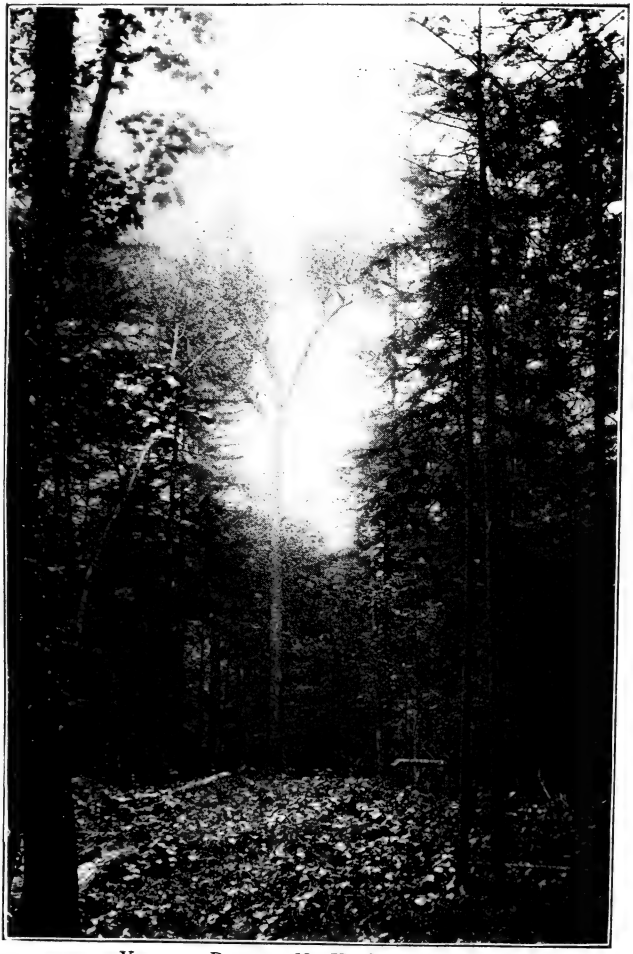
IV

ASSOCIATED TREES

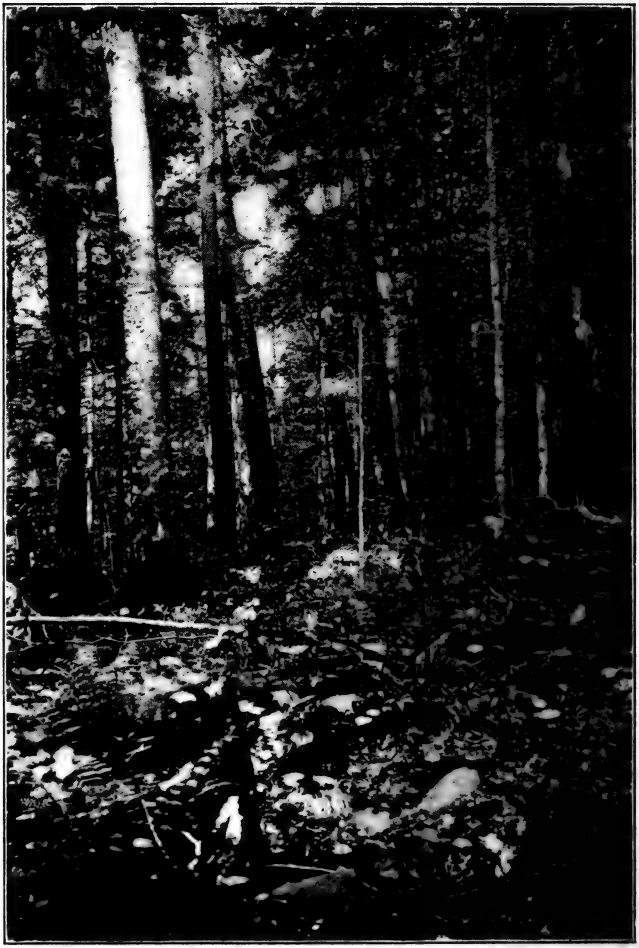
BIRCH

YELLOW BIRCH (*Betula lutea, Michx. f.*) is the characteristic hardwood tree of the Park. With an average diameter of fifteen inches when mature, in some cases it reaches a diameter of four feet and a height of 90 to 100 feet. When growing at its best in dense forest it forms a long, clear, full trunk and a narrow crown. It inhabits a great variety of soils and situations, but attains its best development on hardwood flats. Although it occurs on low marshy ground, Birch avoids wet swamps, where it is short, scrubby, and unsound. It has a shallow root system, well adapted to meagre, stony soil, and it frequently appears on bare rocks, spreading its roots over the edge into the soil below. Seedlings often come up on logs and stumps, so that when the latter rot away the tree is supported only by its prop-like roots. In general the Birch is more abundant on southerly than on northerly slopes.

Yellow Birch is decidedly tolerant of shade, but not to the same degree as Hard Maple, Beech, and Spruce. Under dense hardwoods its seedlings are less abundant than those of Beech or Maple. In open woods and in blanks in dense forest it springs up abundantly, with



YELLOW BIRCH. NE-HA-SA-NE PARK.



BEECH IN MIXTURE WITH SPRUCE. NE-HA-SA-NE PARK.

a marked tendency to associate in groups. Birch reproduces itself prolifically. The seed germinates better on moss-covered soil than where there is a thick layer of leaf litter. It is frequently abundant in windfalls. Thus, on Spruce flats, after windfalls, Birch with Soft Maple often forms the second-growth. It is common on Spruce slopes.

The average rate of growth was found to be, for the 78 trees measured, one inch in diameter in twenty years. Young trees are plentiful, and, as in the case of Spruce, there is a regular gradation in number of trees from the small to the large diameters.

BEECH

The Beech (*Fagus americana, Ait.*) reaches a diameter of nearly three feet, and in dense stands produces a long, clear, smooth trunk and a narrow compact crown. In its choice of soil and situation it is moderately fastidious. It reaches its best development on moderate northeastern slopes, where it often occurs in nearly pure patches. On high land it is abundant, and it is found also on Spruce flats, and even in some marshy situations. It is extremely unsound on low ground, and indeed throughout the forest the proportion of unsound Beech is large.

It reproduces itself abundantly. Young trees spring up in dense thickets where the hardwood forest is thinned, and are capable of living under heavy shade.

Compared to other hardwoods the growth in diameter is fairly rapid. The average current rate of growth for

sixteen trees, with an average diameter of 13 inches, was one inch in thirteen years.

HARD MAPLE

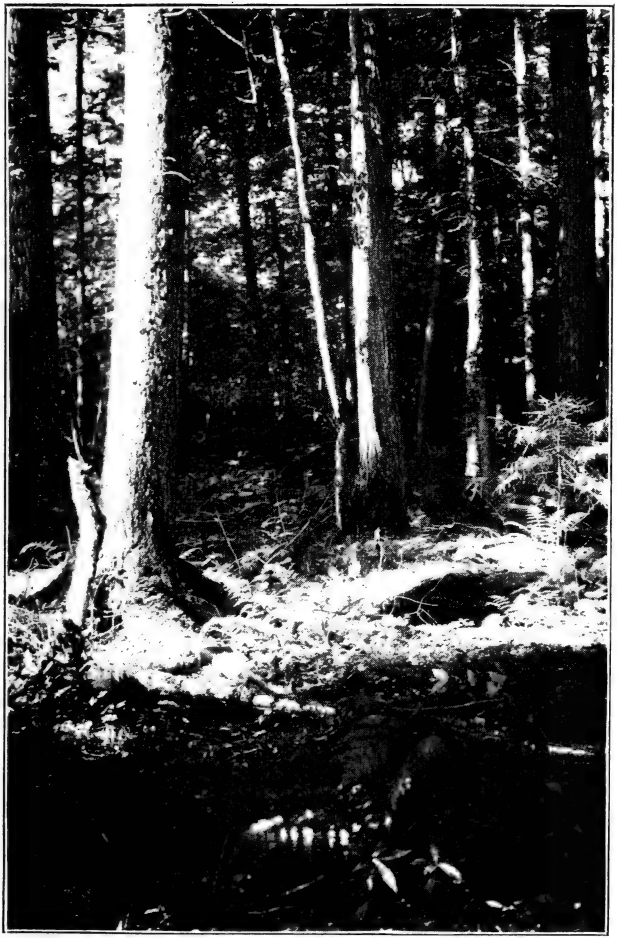
Hard Maple (*Acer barbatum, Michx.*) reaches a height of 90 to 100 and a diameter of nearly 3 feet. Of Hard Maples over 10 inches in diameter there are in the Park about six sound trees per acre, with an average diameter of 14 inches. In favorable situations these trees form long clear trunks and narrow compact crowns. They grow on high ground in fresh and rather deep soil, but not in swamps, and are most abundant on northerly slopes and high flats.

Hard Maple reproduces itself prolifically, and is tolerant of heavy shade both in youth and in later life. When the hardwood forest is thinned dense thickets of Hard Maple come up, often to the exclusion of all other species.

The growth in diameter under the present conditions is slow. Measurements were taken of sixteen trees which averaged 15 inches in diameter, and the average current rate of growth was found to be one inch in diameter in sixteen years.

HEMLOCK

The Hemlock (*Tsuga canadensis*, (*Linn.*) *Carr.*) is found in all parts of the Park, but reaches its best development on the borders of streams and on the low flats above the swamps. In such situations it is usually



HEMLOCK IN MIXTURE WITH SPRUCE. NE-HA-SA-NE PARK.

more sound than when growing on high slopes and ridges, although in general its timber is of inferior quality and suffers severely from windshake. On the 1046 acres measured there were four Hemlock trees over 10 inches in diameter per acre, with an average diameter of 17.5 inches.

Hemlock is very tolerant of shade both in youth and in later life, but in the Adirondacks it is inferior in this respect, as it is in reproductive capacity and quality of timber, to that found in Pennsylvania. The reproduction is poor, and the tree grows very slowly both in diameter and height. The current rate of growth in diameter of 141 trees averaging 16.6 inches in diameter was found to average one inch in twenty-five years.

BALSAM

Balsam (*Abies balsamea* (*Linn.*), *Mill.*) is for the most part a small tree in the Park. One specimen measured 2 feet in diameter, but the average of trees over ten inches in diameter is between 11 and 12 inches. A very large proportion of the whole stand is under 10 inches. Balsam is most plentiful in swamps, although the largest specimens are found on the knolls above them. On wet soil it is frequently almost pure, but in such cases the trees are small.

It reproduces itself well, and the young growth bears a considerable amount of shade. The rate of growth was determined, for 63 trees averaging 10.5 inches in diameter, to be one inch in diameter in thirteen years.

SOFT MAPLE

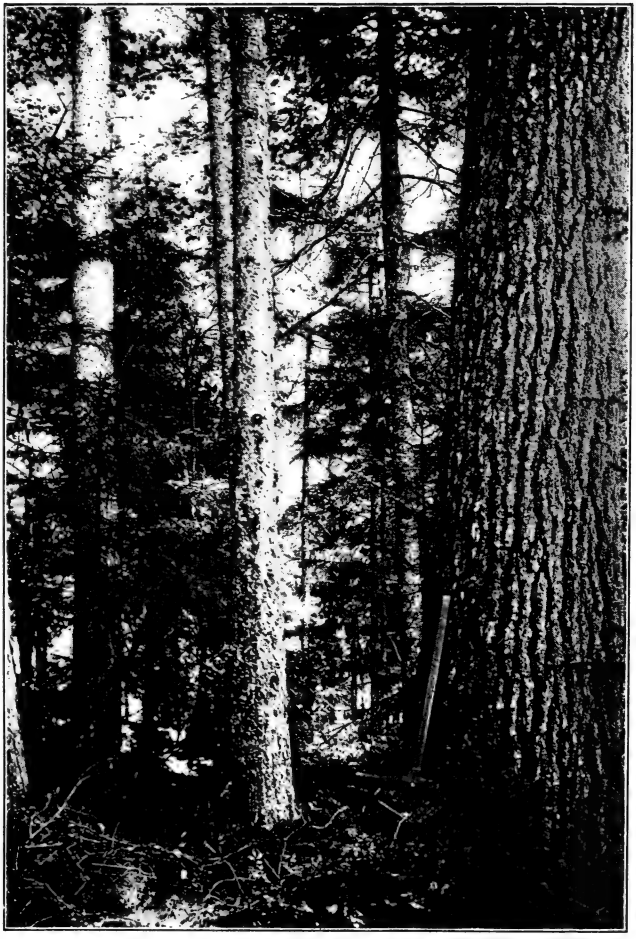
The Soft Maple (*Acer rubrum, Linn.*) reaches a diameter of nearly two feet, and, when growing at its best, has a fair clear length. A very large proportion of the trees are unsound. In the Adirondacks Soft Maple is most abundant in low moist situations, but avoids acid soil. It is found, however, on high ground, and the largest specimens observed were on hardwood land.

It reproduces itself well, as a rule, and in some places, notably on Spruce flats, young growth is very abundant after windfalls.

The rate of growth in diameter of twenty-one trees, averaging 11 inches in diameter, was one inch in seventeen years.

PINE

WHITE PINE (*Pinus strobus, Linn.*) is found in small groups scattered over the Park, but is nowhere abundant. It is most frequent on slight elevations in swamps, and is common on Spruce flats and southerly slopes. Nearly all the trees bend away from the prevailing wind. They form long clear trunks, and reach a height of about 120 feet, with a maximum diameter of sixty inches. On Spruce slopes the average diameter was found to be 21.9 inches, on swamp land 17.1 inches, and on Spruce flats 21.9 inches. The White Pine now standing in the Park is very old, and, as a rule, unsound at the butt. There are a few patches of second-



PINE IN MIXTURE WITH SPRUCE. NE-HA-SA-NE PARK.

growth near lakes and on ridges, where forest fires apparently have burned, but the small amount of young growth in the Park is chiefly confined to scattered individuals coming up in windfalls and on the edge of streams and lakes. Compared to the other trees with which it grows, White Pine is not tolerant of shade, and this is probably one of the important reasons why its reproduction is so poor.

ASH

Black Ash (*Fraxinus nigra, Marsh.*) occurs scattered in low moist situations, but nowhere forms an important element in the forest. It is apt to be rather crooked, and is often unsound. It has an average diameter of 12.9 inches. White Ash is very rare in the Park.

CEDAR

There is a small amount of Cedar (*Thuya occidentalis, Linn.*) in the Park, for the most part confined to swamps, although it occurs also to some extent on Spruce flats and on moist soil at the foot of Spruce slopes. Trees over ten inches in diameter were found to have an average diameter of 14.5 inches, and a height of 50 to 60 feet. Where the forest is open the Cedar has a long crown and short body. In crowded woods the crown is much shorter, and the timber is valuable for telegraph poles.

CHERRY

Black Cherry (*Prunus serotina, Ehrh.*) is not common in Ne-Ha-Sa-Ne Park, since measurements give an average of but one tree to twelve acres. It is most frequent along the line of the old military road between Lake Partlow and Gull Lake, where its presence is due to the light admitted by the cutting of the road.

Black Cherry stands about midway in the scale of tolerance among the trees in the Park, and reaches its best development in fresh, deep soil. Its reproductive power is rather poor, but the rate of growth is fairly rapid. The average diameter of all trees measured was 15.6 inches, and the average rate of increase one inch in thirteen years.

Black Cherry reaches a good height, and forms a long clear trunk and a well-developed crown. Its timber is more valuable than that of any other tree in the Park.

V

LUMBERING

LUMBERING, as at present practiced in the Adirondacks, affects the forest to its injury, because, in the first place, it decreases the number of valuable trees. The Spruce, which at best is only scattered here and there through the hardwoods, is removed, and no provision of any kind is made for its reproduction. The less valuable trees remain to perpetuate their kind, and the final effect on the forest is to leave it less valuable in composition and promise than when the lumbering was begun. The trees which, for the most part, are spared by lumbermen at present are the hardwoods, the less valuable conifers—chiefly Hemlock and Balsam—and the defective Spruce that cannot be used for pulp. Underneath these trees the young Spruces may live for many years, but in the end they find it exceedingly hard, or in many cases impossible, to penetrate the dense cover of foliage above them and reach the light. Until they do they must remain stunted and of little value. It often happens, by the removal of the sound Spruce, that not enough mature trees remain in any locality to provide seed for the future forest, and in this way the reproduction of Spruce is hampered or made impossible. Cutting for pulp does far more harm than cutting for lumber, because it takes a vastly greater number of trees. To re-

duce the diameter of the smallest tree cut from 10 to 6 inches is to double the number of individuals taken. In addition, the growth which would have taken place in the young thrifty Spruces in the next years is lost, and the ground produces hardwoods instead.

In felling under the present system the loss is very serious in broken-top trees (not to be confounded with trees which have merely lost their leading shoots), which have been found to gain very slowly in diameter and height as compared with sound specimens, in young trees smashed and destroyed, and in young trees whose soundness is injured by the loss of bark. Not only are small trees broken and smothered by the tops of felled trees, but in heavy cutting the tops are often a serious hindrance to the germination of new seedlings. Further, where the soil is exposed to the sun and wind the moss and humus dry up and disappear, the small seedlings whose roots have not yet become established in the mineral soil are killed, and the germination of new seed is seriously delayed. At present this injury to the capital value of the forest receives no attention. Practical work in the woods has demonstrated that the cost of the care required to prevent this loss is so small as to be altogether insignificant, and wholly out of proportion to the value of the result.

Many young trees, where skidding is going on, lose pieces of their bark by contact with the harness or the logs, and afterward become unsound. Young trees of merchantable species are commonly cut to build skidways when it would be almost as easy to take less

EFFECT OF LUMBERING FOR PULP. SANTA CLARA, N. Y.

valuable kinds. In road-building the destruction of useful young growth is particularly noticeable. Young Spruce is often cut where other species are at hand and would answer the purpose just as well.

In general, the amount of damage done under the present system of lumbering is in direct proportion to the number of trees cut per acre. Almost the whole of this damage is unnecessary, and could be easily prevented at very small expense.

The influence on water-supply of cutting for logs and pulp-wood—not for charcoal—as at present practiced in the Adirondacks is small, except as lumbering increases the spread of fires. So few trees are taken per acre in the Pine and Spruce forests that, as a rule, the forest cover is but little interrupted, and is capable of re-establishing itself within a few years. When, however, the forest is completely removed, as in places where Spruce occurs nearly pure or where the timber is cut for charcoal, the consequent drying up of the forest floor and washing of the soil has a decided and harmful influence on the flow of streams. The same result is brought about by the forest fires which have ravaged portions of the Adirondacks, and for the majority of which lumbering hitherto has been directly or indirectly responsible.

VI

THE BASIS FOR FOREST MANAGEMENT

IT would be unfair to condemn all lumbering because the present method is not wholly right. The qualities of the Spruce, and the general circumstances which surround its utilization in the Adirondacks, make it plain that better methods are possible from every point of view. It is the purpose of practical forestry so to modify the present systems of cutting that the harm now done may be avoided and the removal of the old crop be of permanent benefit to the forest which remains. At the same time the question of revenue is kept prominently in view.

Better methods of lumbering affect the forest chiefly through the kind and amount of the reproduction and growth which follow cutting, and through the conditions under which the trees develop to marketable size. They affect the owner through the sustained and increased value of his property and its yield.

YOUNG GROWTH IN THE FOREST

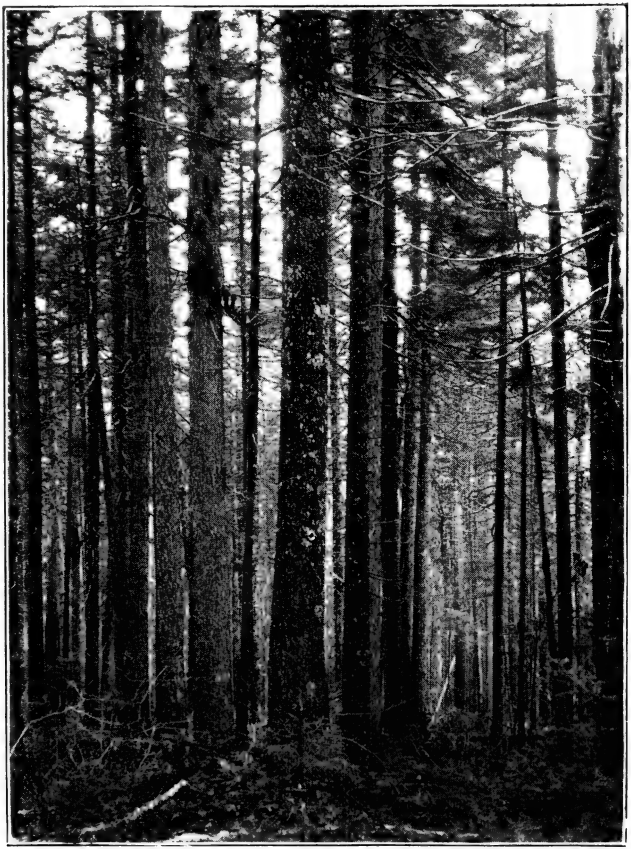
Attention has been called, in the chapters on Reproduction and Tolerance, to the large amount of small Spruce found throughout the forest. Not only in those portions where Spruce is the prevailing species, but also on hardwood lands, groups and single specimens

of young Spruce are very abundant. There are, it is shown later, on an average 75 Spruce trees per acre from 2 to 6 inches in diameter, and 143 trees under 2 inches which are large enough to be readily seen. Hitherto the young growth has been disregarded entirely or looked upon merely as a hindrance to lumbering operations. These young trees, with such seedlings as may spring up later, are the material which is to form the next generation of merchantable Spruce.

Much of the young growth, especially among the single specimens, has come up in deep shade and has been so suppressed that the crowns spread out like mushrooms, the leading shoot growing very slowly. But such suppressed Spruce trees possess the ability to recover when the shade is removed. If the plant is still small, the knots formed by the spreading branches will eventually be covered over, and timber of good quality will be produced. But if the tree has already reached some size, the branches may be so numerous and so well developed that it will never be of much value for lumber. The best advance growth is that which grows in groups, and the denser the group the more promising are the young trees.

There is enough small growth already in the forest to maintain the present proportion of Spruce, under right treatment, for at least one more generation, but the problem of increasing its proportion is a difficult one, especially where Spruce is the only species which can be marketed. In such a case the forester is expected to perform a difficult feat, namely, to remove

the old timber of one species from a mixed forest and yet increase the proportion of the same species in the next crop. If it were possible to cut the other species gradually, the unsound as well as the lumber trees, the reproduction of Spruce would be simple. Under the present conditions, however, only merchantable trees can be cut, and in some cases probably the Spruce alone, and the desired result must be accomplished by the judicious selection of the trees to fall, leaving certain specimens to distribute seed. On swamp land, on most Spruce flats, and on Spruce slopes, where the Spruce forms nearly 50 per cent. of the merchantable crop, this result is entirely within reach from both the silvicultural and the economic points of view. It will also be possible on a considerable portion of the hardwood lands. But in certain situations, especially moderate northerly slopes, where Beech, Hard Maple, and Birch far outnumber the Spruce, the openings made in the forest will probably be seeded up to hardwood species. This is abundantly evidenced at Ne-Ha-Sa-Ne Station and south of the Lodge, as well as along the old military road between Partlow and Gull Lakes. Under such conditions the young Spruce cannot compete with hardwoods of the same age. The latter come up in dense thickets, and grow in early youth more rapidly than the Spruce. In time, when the hardwoods are old and the forest cover high, doubtless the Spruce will gradually return, but in the first generation the hardwoods will have the best of it. But where the hardwoods also can be marketed not only will the repro-



HEAVY STAND OF NEARLY PURE SPRUCE. NEAR NORTH WOODSTOCK, N. H.

duction of the Spruce be simplified, but on lands where the hardwoods have possession the cuttings can be so directed that the inferior species will greatly decrease in the new crop.

THE EFFECT OF THINNING

The advantage of conservative lumbering is, however, not confined to the protection of young trees and the encouragement of new growth. The trees which remain after lumbering may be made to grow more rapidly than before.

When a piece of ground is fully covered with forest trees, the latter stand so close together that they crowd each other, and a struggle follows in which some trees are suppressed and checked in their development and others are so shaded that they die, and the rate of growth in diameter of every individual in the forest falls behind that of trees in like situations in the open.

But while the rapidity of growth of the individual tree is less, the total product is greater than it would be if the ground were covered with scattered trees only, and it is far better in quality, for in the deep shade of crowded woods the lower branches of the trees die and fall off, and long trunks clear of knots are produced.

It has been found that when a crowded stand is thinned the trees which remain grow more rapidly than before. This accelerated growth is caused: First, by the more rapid disintegration of the humus and the consequent liberation of an increased amount of availa-

ble food material; and, Second, by the increased spread and efficiency of the roots and crowns.

In the Adirondacks, where the forest is dense and the climate cool, a deep layer of humus accumulates. When the forest is thinned the humus disintegrates more rapidly on account of the admission of the sun's rays and the freer circulation of air, and an increased amount of food material is made available for the growth of the trees. The immediate increase in growth is probably due to this cause. How long it will last depends upon the length of time before the humus disappears. Professor Hartig, of Munich, estimates this period, under favorable conditions, at about ten years.

The effec of openings in the forest on vigorous and suppressed trees alike is to give them more room for development, a larger and better apparatus of roots and leaves for gathering and digesting food, and so to increase their rate of growth in diameter and height.

The practice of thinning is based on this capacity for increased growth on the part of trees which have been more or less vigorously set free, or, in other words, on the part of the members of a piece of forest which has been thinned. The removal of a certain number of trees from overcrowded woods increases the final product, instead of decreasing it, and an additional product is obtained from the wood cut in the thinning. In this way the total output of a piece of forest in final cuttings and thinnings together is greater than it would be without silvicultural attention.

INCREASED GROWTH AFTER LUMBERING

In the Adirondacks the forest to be dealt with does not consist of one species, but is a mixture of deciduous and coniferous trees of all ages. The cutting there has been governed by the distribution of merchantable timber, and such considerations as have just been described have been left entirely out of account. In this way it happens that a considerable amount of old Spruce may be removed with very little benefit to the young trees of that species. Old Birch and Maple and other hardwoods may remain, and the effect of the cutting may not be to free any considerable number of young Spruce trees from the heavy cover overhead. In other cases the merchantable Spruce may stand in groups of old trees without young growth, so that their removal will have little or no effect on the young trees which remain. The best results are attained only when the timber removed was well distributed above the young trees. Where but a single merchantable species is cut from the mixed forest this can not often be the case. Just what the effect of the cutting will be on the remaining trees depends then on the character of all the species in mixture as well as on the number and distribution of the old trees which were removed. It is therefore difficult to reach figures more than approximately exact.

The following method of study was employed as a means of attacking this question: On areas of definite size, usually of one acre each, on cut-over land, all trees which would make pulp-wood were cut and analyzed so that their exact contents were known.

The stumps and tops of trees taken at the first cut, and the distance between them, were then measured, and the number of logs and the amount of timber removed at that time were thus closely ascertained. All trees left by the second cut were then carefully measured with callipers. The date of the first cut was known, and it served, together with the measurements and counting of rings carried out in the second cut, to re-establish the history of the stand for about thirty years back. Fourteen such small plots were laid off, and over two thousand trees were carefully analyzed. The valuation surveys which were carried out upon them will be found in detail in the Appendix.

The object in taking these stem-analyses was to determine the present rate of growth in diameter of trees of all sizes and to obtain measurements of enough trees to make volume tables (or tables of solid contents). The stem-analyses were, therefore, not as complete as would have been the case had the intention been to make tables of growth according to the German methods.

The following measurements were taken of each tree :

Diameter at 4.5 feet from the ground.
Diameter on the stump inside and outside the bark.
Diameter at the top of each log inside and outside the bark.
Height of stump.
Length of each log and of the top.

The rings were counted on the stump and at the upper end of each log for thirty years in from the bark, and the distance to each ten-year point was measured. From these measurements it was easy to determine which trees had increased in rapidity of growth after the lumbering, and which had not.

Other measurements were taken, but, as they did not contribute directly to the results here presented, no further mention of them is required.

The great labor involved in collecting such data made it impossible to extend the present inquiry beyond the 2006 trees analyzed. This number, however, is great enough to establish a trustworthy basis, and the figures derived from it are used as such in the present study. The reasonableness of these figures, their number, and

the fact that the effect of the probable removal of hardwoods from Spruce lands during the next few years has been neglected, combined to give assurance that any error resulting from their use will be in favor of the forest owner, not against him.

The following table gives the per cent. of small trees whose growth was found to have been increased by the cutting of the old trees. It will be noticed that the causes of irregularity mentioned above have acted so powerfully as to prevent the statement of any exact ratio between the per cent. of trees affected and the amount of timber removed. In general the former may be taken at about twenty per cent.

TABLE 6

Amount of timber in standards removed at first cutting, and per cent. of small trees left standing whose growth was accelerated, on fourteen sample plots at Santa Clara, New York.

Area of Sample plot. Acres	0.8	1	0.9	1	1	1.5	1.5	1	1	0.2	1	1	1	1
Amount removed at first cutting. Standards	38.4	17	14.2	14	13	11.8	11.2	10	9.8	4.4	4.2	2.6	1.5	0.5
Per cent. of small trees whose growth was accelerated	42	31	6	40	13	0.2	20	36	11	21	11	0.5	0	0

EFFECT OF LUMBERING FOR PULP

THE STANDING TREES ARE SPRUCE (TOO SMALL OR TOO CROOKED AND UNSOUND TO CUT), BIRCH, BALSAM, MAPLE, AND DEAD TAMARACK. SANTA CLARA, N. Y.

The area chosen for the study just described was at Santa Clara, Franklin County, New York. Here the first lumbering operations took place in 1882, the next in 1888 and 1891, and the final crop was removed in 1896. In 1882 probably only the largest and best trees were taken, and in consequence the number cut was small. At least it was not possible to find any small trees showing an increased growth from that date. The cuttings of 1888 and 1891 were much closer, and the effect on the small trees was very marked.

In most cases the increased growth began with the first season after the cutting. On the areas cut over in 1888 there were but a few trees which showed an accelerated growth beginning after that year. In these cases it was not possible to determine whether the new start had been delayed, or whether it was due to windfalls following the cutting. On the area cut over in 1891 a considerable number of trees showed a small increase in growth the first year, and a much more rapid increase the following years. In general it may be said that the increased growth takes place, as a rule, the first year, and that it will in all probability continue until the next cutting, for if the first cause (the rapid decomposition of the humus) ceases after a few years, the roots and crowns will have begun to spread, and the second cause will thus have come into operation.

The average rate of growth of 1593 trees in diameter on the stump is found in the following table. It was determined for all the trees together for the periods just before and after the previous cutting, and sep-

arately for those whose growth was accelerated. These trees occurred on eleven of the sample plots which were studied at Santa Clara. The other three plots were omitted because only a very few trees were taken at the first cut, and almost none of the remaining small trees showed accelerated growth. These measurements exhibit the rate of growth under various conditions of situation and soil.

The figures of diameter growth given in the following table were derived from measurements of the last ten rings. For example, the third column gives the average rate of growth of all trees just before the last cutting, and was found in each case by subtracting the increment for the period since lumbering from the increment for the last ten years, and dividing by the nnmber of years during which the growth thus ascertained was made. The fifth column gives the average rate of growth of all trees since the lumbering, whether they show an increased growth or not. The column which gives the current annual growth in diameter after the values have been made regular by a curve also requires a word of explanation. When a series of averages are made out it often happens that the successive figures do not follow quite regularly. It will be noticed in the table that this is true of the lower part of the fourth column, and that it is probably explained by the lack of enough trees of 15 inches in diameter to get a fair average. In such cases the values are plotted on cross-section paper and a regular curve is drawn through or near the points which represent them. The points through which the curve actually passes are then taken as the true values. In this way accidental irregularities are avoided, and the results are brought much nearer the truth.

TABLE 7

Average rate of growth in diameter on the stump of 1593 trees on cut-over land at Santa Clara, New York.

Diam. Inches	No. of trees	Current annual growth in diameter just before first cutting Inches	Current annual growth in diameter since first cutting Inches	Current annual growth in diameter since first cutting. Values made regular by a curve. Inches	No. of years required to grow one inch in diameter	No. of trees showing increased growth	Current annual growth in diameter since first cutting Inches
5	8	.095	.095	.09	11	1	.100
6	158	.080	.100	.10	10	16	.180
7	329	.090	.110	.109	9	63	.185
8	350	.105	.125	.125	8	77	.205
9	277	.120	.140	.140	7	59	.205
10	226	.135	.150	.150	7	50	.215
11	135	.130	.145	.160	7	18	.210
12	64	.165	.175	.170	6	7	.240
13	30	.165	.170	.178	6	2	.170
14	11	.150	.150	.185	6	1	.200
15	1	.080	.080	.192	6		
16	4	.200	.200	.200	5		
Average		.112	.137				.20
No. years to grow one inch		9			7		5

Total No. trees—1593.
No. trees showing increased growth—294, or 18 per cent.

GROWTH IN THE ORIGINAL FOREST

It is interesting to compare the growth in diameter of trees growing in the original forest with the figures just given for cut-over land. Stem analyses were made on 298 trees in original forest near Ne-Ha-Sa-Ne, from which the table given below has been compiled. These measurements were taken at the lumber job of Patrick Moynehan, who was cutting on the southerly edge of the Park and on the Brandreth tract.

The results differ considerably from those given by the present writer in a report made for Dr. Webb, and published in the final report of the Special Committee of the Assembly whose chairman was Hon. Thomas H. Wagstaff and whose report was transmitted February 15, 1897. The rate of growth there given was derived from measurements printed in a State report, and was considerably more rapid than that which is now found to exist. This further study makes it evident that the estimate previously reached was too large.

TABLE 8

Rate of growth in diameter for the last ten years, from measurements of 298 trees at Ne-Ha-Sa-Ne Park.

No. of trees	18	39	48	28	29	39	19	12	12	17	11	5	4	5	5	5	2	Ave.
Diameter. Inches	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	27	
Mean annual growth in diameter. Inches	.10	.12	.14	.12	.13	.14	.11	.11	.11	.11	.12	.10	.11	.08	.10	.10	.14	.125
No. of years required to grow one inch	10	8	7	8	8	7	9	9	9	9	8	10	9	12	10	10	7	8

GROWTH IN DIFFERENT PARTS OF A TREE.

An exceedingly interesting question is the rate of growth in different parts of the same tree. It must be borne in mind that the material for growth is elaborated within the crown from material derived from the air and the roots, and that this elaborated sap comes down in the inside of the bark. It is not difficult to see that within the crown the rate of growth must be more rapid at the lower part than near the top, because each branch adds a certain amount of material for the growth below which the stem above did not have. In general, except close to the ground, the growth falls off below the crown. In the case of trees very much suppressed it may happen that not enough material for growth is formed in the crown to reach the lower part of the stem, and in some cases the number of annual rings on the stump will not represent accurately the age of the tree, because for some years there may have been no growth whatever in the lower part of the stem. This happens, however, usually only in the case of dying trees. The width of the annual rings is smaller at the lower part of the stem than above, even if the same amount of material is brought down, because it has to extend over a larger surface. The results of the measurements taken on about 2,000 Spruces show the largest growth in the crown, the smallest at the top of the first log, and a medium growth on the stump. Where the trees had an increased growth after thinning, the largest growth was at the stump. The fact that the increased growth at this part of the stem is out of proportion to that above has led some observers to believe that it is not necessary for all the food materials to be digested in the crown before they can be used in growth. This theory is the result of the phenomenon just mentioned, and of the fact that those roots of a tree which are in the richest soil grow to the largest size. In order to present more clearly the relation of the rate of growth at the different parts of the tree under the new influences of light and space after thinning, the following table has been made from fifty-nine trees, all of which showed accelerated growth on the stump:

TABLE 9

MEAN ANNUAL DIAMETER GROWTH

Diam. Inches	On the Stump		Top of 1st Log		Top of 2d Log		No. of trees
	1886–1888	1888–1896	1886–1888	1888–1896	1886–1888	1888–1896	
6	.140	.20	.12	.12			1
7	.105	.24	.12	.14	.15	.16	12
8	.125	.20	.12	.15	.16	.20	12
9	.110	.20	.11	.12	.14	.16	15
10	.130	.21	.11	.16	.15	.22	10
11	.105	.17	.10	.11	.12	.16	5
12	.170	.23	.08	.14	.20	.22	4
Average	.13	.21	.11	.13	.15	.18	59 Total

These results make it clear that measurements taken at the top of the first or second log cannot safely be used in reasoning about growth on the stump, or vice versa.

VII

VOLUME TABLES

VOLUME tables show the contents of standing timber. The primary object of the construction of such tables in this case was for use in working up the results of the 1046 acre measurements taken in Ne-Ha-Sa-Ne Park, but it will be seen that they supply in addition the means of estimating standing timber with accuracy and despatch whether the result is desired in standards, board feet, cubic feet of merchantable timber, or in cords. They are based on measurements of the product of trees of different sizes actually cut in the woods.

Mention has already been made of the 2006 stem analyses of small timber cut for pulp at Santa Clara, New York, and of the 298 analyses of trees cut into logs on the edge of the Park. The volume tables have been computed from the results of these stem analyses. Since this study is primarily for use in practical forestry, only tables of merchantable yield were made. For this purpose tables have been calculated which show the number of standards, board feet, merchantable cubic feet, and cords contained in trees of different heights and diameters.

MEASURING CREW, MAKING STEM ANALYSES AT SANTA CLARA, N. Y.

VOLUME TABLE OF STANDARDS

The number of standards in each tree was determined by Dimmick's Rule, which is the common scale used in the Adirondacks. The trees were worked up together by grouping them in diameter classes differing by one inch, and in height classes differing by five feet. It was found that the average results were so regular for the trees of different diameters and heights that it was possible to make a table by merely eliminating the irregularities by means of curves. (See p. 44.) At first the results of the trees cut for pulp at Santa Clara were kept separate from the results of the large trees cut in the Park, but the two series were found to correspond so exactly that they were thrown together into the single table of standards given below. The diameters in this table are taken breast-high, or four and one-half feet from the ground. Lumbermen usually refer to the diameter inside the bark on the stump, but that is an unsatisfactory measure, since the height of the stump varies greatly. In dealing with standing timber measurements must be taken outside the bark. A comparison of the diameter inside the bark on the stump with the diameter breast-high showed that, in the trees analyzed, the former was on the average three-quarters of an inch (exactly 0.79) larger than the diameter breast-high.

TABLE 10

VOLUME TABLE FOR SPRUCE—I

Diam. breast-high. Inches	HEIGHT OF THE TREE IN FEET															
	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
	Contents of the Stem in Standards by Dimmick's Rule															
6	.05	.06	.07	.07	.08	.09	.10	.12	.13							
7	.07	.09	.10	.11	.12	.14	.15	.17	.20	.22						
8	.10	.12	.13	.15	.17	.19	.21	.23	.26	.30	.34					
9	.13	.15	.17	.19	.21	.24	.27	.30	.34	.38	.42					
10		.17	.20	.23	.26	.30	.34	.38	.42	.46	.50	.54				
11			.22	.27	.31	.35	.40	.45	.50	.54	.58	.64				
12			.24	.30	.35	.40	.46	.52	.58	.63	.68	.74	.80			
13				.34	.40	.46	.53	.60	.66	.73	.80	.87	.94			
14				.38	.44	.51	.59	.67	.75	.83	.91	.99	1.07			
15					.48	.56	.66	.75	.84	.93	1.02	1.11	1.22			
16						.62	.72	.82	.92	1.03	1.13	1.24	1.38	1.52		
17							.79	.89	1.01	1.13	1.25	1.38	1.52	1.65		
18								.96	1.09	1.23	1.37	1.52	1.67	1.81	1.95	
19									1.17	1.34	1.50	1.66	1.82	1.98	2.14	
20										1.47	1.63	1.80	1.97	2.15	2.33	2.51
21											1.76	1.95	2.14	2.33	2.52	2.71
22											1.90	2.10	2.31	2.51	2.71	2.91
23												2.25	2.48	2.70	2.91	3.11
24													2.65	2.89	3.12	3.32

VOLUME TABLE OF BOARD FEET

To construct this table the contents in board feet was determined for each of the 298 trees analyzed near Ne-Ha-Sa-Ne by means of the well-known Scribner's Rule. The relation between the board feet and the standards was then found for each tree by dividing the number of board feet from Scribner's Rule by the number of standards from Dimmick's Rule. The average results for the different diameters, with the irregularities eliminated by means of curves, are given in the following table:

TABLE 10

Diameter Breast-high. Inches.	Number of Board feet in one Standard.
9	141
10	146
11	150
12	154
13	158
14	161
15	164
16	168
17	171
18	174
19	177
20	180
21	183
22	186
23	189
24	192

The table of standards was then converted into board feet by multiplying the number of standards of each diameter by the factor corresponding to that diameter in the small table. These factors do not correspond closely, except for the largest diameters, with those adopted by common practice in the Adirondacks. The latter range from 190 to to 200 board feet to the standard. The present figures, however, are taken directly from the logs by the use of the two rules, and therefore show the actual relation between Scribner and Dimmick. Since Scribner undervalues small logs, such logs scaled in standards would also overrun these figures, because they are made directly from the rules,

TABLE 12

VOLUME TABLE FOR SPRUCE—II

Diam. breast-high. Inches	HEIGHT OF THE TREE IN FEET															
	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
	Contents of the Stem in Board Feet by Scribner's Rule															
9	18	21	24	27	30	34	38	42	48	53	59					
10		25	29	34	38	44	50	55	61	67	73					
11			34	41	47	53	61	68	74	81	87	93				
12			39	48	56	63	72	81	88	97	105	114				
13					63	73	84	94	104	115	126	137	148			
14					71	82	96	108	121	134	147	160	172			
15					79	92	108	122	138	153	167	182	200			
16						102	121	137	155	173	190	208	232	255		
17							135	152	173	193	214	236	260	282		
18								167	190	214	238	264	290	315	339	
19									207	237	266	294	322	350	379	
20										265	294	324	355	387	419	452
21											322	357	392	426	461	496
22											353	390	430	467	504	541
23												425	469	510	550	588
24													509	555	600	637

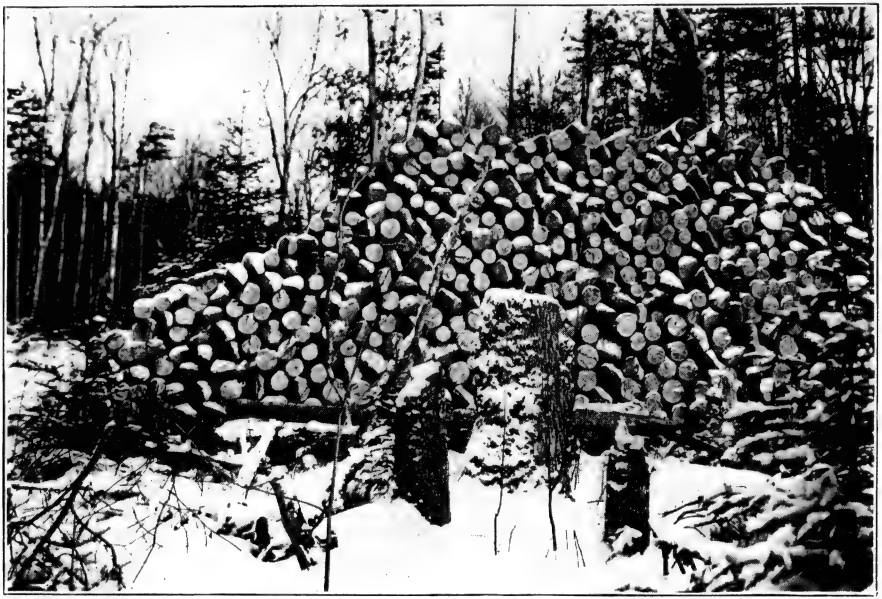
VOLUME TABLE OF MERCHANTABLE CUBIC FEET.

This table was constructed for the purpose of computing the number of cords of pulp-wood in trees of different diameters and heights. It was determined in the same manner as the table for standards, except that only trees which had been cut for pulp at Santa Clara were used. The merchantable cubic feet represent the amount of wood in each tree actually used for pulp.

TABLE 13

VOLUME TABLE FOR SPRUCE—III

Diam. breast-high Inches	HEIGHT OF THE TREE IN FEET.								
	25	30	35	40	45	50	55	60	65
	MERCHANTABLE CUBIC FEET OF PULP-WOOD.								
5	1.1	1.2	1.3	1.4	1.5	1.6	1.7		
6	1.6	1.8	2.1	2.4	2.8	3.2	3.6	4.0	
7	2.1	2.5	3.0	3.6	4.2	4.8	5.4	6.0	6.6
8		3.1	3.9	4.8	5.6	6.5	7.3	8.0	8.8
9		3.8	4.9	5.9	6.9	8.0	9.0	9.9	11.0
10			6.0	7.2	8.4	9.6	10.9	12.2	13.5
11			7.1	8.6	10.1	11.6	13.1	14.6	16.1
12				10.0	11.7	13.5	15.2	17.0	18.8
13					13.4	15.4	17.3	19.4	21.5
14					15.1	17.3	19.5	21.8	24.2



SKIDWAY OF SMALL SPRUCE CUT FOR PULP. SANTA CLARA, N. Y.

VOLUME TABLE OF MERCHANTABLE CORDS.

In order to convert solid cubic feet into cords it is necesssary first to divide by one hundred and twenty-eight, the number of cubic feet in one cord, and then to divide by a factor which shall represent the relation between solid and stacked wood. In Germany this factor has been found from a large number of experiments to be 0.65 for round billets stacked in the woods. In consequence of irregularities in shape due to roughness of the bark and to swellings where the branches entered the trunk, this figure seems to give results too large for rossed billets. For the case in hand, 0.7 is more accurate. When the results of dividing the number of cubic feet found in Table 13 by the factor 0.7 are compared with those obtained by dividing the values in the table of standards by 2.92, which is the number of standards in one cord, determined by the Santa Clara Lumber Company from several thousand cord measurements, they are found to correspond almost exactly. After this confirmation of the factor 0.7, it was adopted, and the table of cords was constructed by dividing the values in the table for cubic feet by one hundred and twenty-eight and the result by 0.7.

TABLE 14

VOLUME TABLE FOR SPRUCE—IV

Diam. breast-high. Inches.	HEIGHT OF THE TREE IN FEET.								
	25	30	35	40	45	50	55	60	65
	MERCHANTABLE CORDS OF PULP-WOOD								
5	.012	.013	.014	.015	.017	.018	.019		
6	.019	.020	.023	.026	.030	.035	.040	.044	
7	.023	.028	.033	.040	.047	.054	.060	.067	.074
8		.035	.043	.054	.062	.072	.081	.089	.098
9		.042	.055	.066	.078	.089	.100	.110	.123
10			.067	.080	.094	.107	.122	.136	.150
11			.079	.096	.112	.128	.145	.163	.180
12				.111	.131	.150	.168	.190	.210
13					.149	.171	.193	.215	.240
14					.168	.193	.217	.242	.270

VIII

VALUATION SURVEYS.

In making a working plan, the first step is to determine the amount and condition of the growing stock. In order to do this and to obtain data which would permit the prediction of future crops, the trees were counted and measured on 1046 acres on different parts of the Park. Since there are approximately 27,533 acres in Ne-Ha-Sa-Ne Park, not including the lakes and the fenced portion, these measurements cover about one in every twenty-eight acres, and supply the basis for a very thorough acquaintance with the standing timber.

Each acre was run out in a strip ten chains long and one chain wide. The length was actually chained off in every case and all the trees were measured for one-half chain on each side. The latter distance was either chained, paced off, or estimated. The measuring crew speedily became expert in estimating the distance at a glance. The sound Spruce was callipered down to two inches and the smaller trees were counted. Other species were callipered down to ten inches when apparently perfectly sound.

The strip method (or chain method, as this modification of it is called) has the advantage of giving a very fair representation of a large area, because it traverses so much ground. Square acres, where the lines and corners are carefully measured, are more accurate for single cases, and a number were taken for illustrative

purposes, but each acre is confined to a single situation and the possible number is so small, on account of the length of time required to take them, that the general average is not as good as by the chain method.

After the valuation surveys were completed in the field their results were worked out, with the object of finding the stand of Spruce on the area surveyed. To this end the average diameters and heights of the trees were first ascertained for each acre, then the general average was found for all the acres, first massed in groups and then all together, and finally the last result was used to get from the Volume Tables and the average number of trees per acre the amount of standing timber on all the acres taken together. From this sum it was easy to find the average stand per acre.

The average diameters and heights were calculated as follows:

The average diameters were computed for all trees on each acre six inches and over in diameter, ten inches and over, twelve inches and over, and fourteen inches and over. The heights corresponding to these diameters were determined from the large number of height measurements which were taken throughout the Park in connection with the valuation surveys. Eight hundred such measurements were made with a German instrument, Faustmann's Spiegelhypsometer, and recorded in connection with the acres on which they were made. The height measurements for each group of acres were entered on cross-section paper, the diameters being laid off on the horizontal and the heights on the vertical lines, and a regular curve was drawn through the points which represented the measurements. From these curves the heights corresponding to the various diameters were found.

For the purpose of working them up, the valuation surveys were grouped in two ways: First, according to the situation, under the heads of Swamp land, Spruce

MEASURING TIMBER WITH CALLIPERS.

flat, Hardwood land, and Spruce slope ; and second, according to the yield in thousands of board feet of all trees ten inches and over in diameter.

Within each class of these groups the average number of trees per acre of each inch in diameter was first calculated, and then the average diameter, height, and number of trees per acre were computed for trees six inches and over in diameter, ten inches and over, twelve inches and over, and fourteen inches and over, as well as the average number of trees per acre under two inches and from two to six inches in diameter.

The average diameters and heights and the average number of trees per acre being known, it was possible to determine the yield in board feet and standards from the Volume Tables already given. The yield was found first for trees fourteen inches and over in diameter by multiplying the number of trees by the value in the Volume Tables corresponding to the average diameter and height. In the same manner the contents of trees twelve and thirteen inches in diameter, ten and eleven inches, and six to nine inches were computed and added to that found for trees over fourteen inches, and the total contents of all trees six inches and over, ten inches and over, and twelve inches and over were found by addition.

The following tables (15 and 16) give the condensed results of the 1046 valuation surveys as to number of trees, dimensions, and yield, per acre, classified according to situation.

TABLE 15

Situation	No. of acres	Spruce under 6 inches			Spruce 6 inches and over				Spruce 10 inches and over					Situation
		Trees under 2 inches	Trees 2 inches and over	Trees 2 to 6 inches	No. of trees	Average diameter breast-high. Inches	Average height. Feet	Standards	No. of trees	Average diameter breast high. Inches	Average height. Feet	Standards	Board Feet	
Swamp Land	225	228	150	76	74	9.8	50.4	25.51	34	12.8	61.4	21.15	3439	Swamp Land
Spruce Flat	106	154	141	76	65	9.7	53.1	24.16	29	13.5	62.2	20.43	3309	Spruce Flat
Hardwood Land	441	100	132	71	61	10.2	58.8	27.22	29	13.1	71.9	23.38	3788	Hardwood Land
Spruce Slope	274	190	156	81	75	9.8	55.6	28.97	34	12.9	70.0	24.24	3934	Spruce Slope
Average		158	143	75	68	10.0	55.6	26.24	31	13.0	68.2	22.83	3703	Average

TABLE 16

Summary of valuation surveys in averages per acre according to situation.

Situation	No. of acres	Spruce 12 inches and over					Spruce 14 inches and over					Situation
		No. of trees	Average diameter breast-high. Inches	Average height. Feet	Standards	Board feet	No. of trees	Average diameter breast-high. Inches	Average height. Feet	Standards	Board feet	
Swamp Land	225	21	14.3	67.1	17.42	2838	11	15.8	71.9	12.39	2094	Swamp Land
Spruce Flat	106	19	14.7	69.5	16.58	2741	11	16.3	74.6	12.45	2107	Spruce Flat
Hardwood Land	441	19	14.7	75.6	19.59	3236	12	16.2	79.6	14.89	2505	Hardwood Land
Spruce Slope	274	22	14.5	71.5	20.09	3324	13	16.2	76.5	15.42	2596	Spruce Slope
Average		20	14.6	72.1	18.95	3045	12	16.1	76.6	14.25	2400	Average

It will be noticed, in the preceding tables, that the average diameters and heights have been determined only for trees six, ten, twelve, and fourteen inches and over, in each type of forest. In computing the number of board feet and standards by the method just described it was necessary to know the average heights and diameters of all trees from six to nine inches, ten and eleven, twelve and thirteen, and fourteen inches and over in diameter in order to get the totals by addition as before. The diameters were computed directly from the table giving the average number of trees for each inch in diameter, and the heights were determined in the following way: Having already the average heights for all trees six, ten, twelve, and fourteen inches and over, these values were entered on cross-section paper, laying off the diameters on the horizontal and the heights on the vertical lines. A curve was drawn through the points, and the heights corresponding to the diameters in the following table were obtained by interpolation.

Table 17 gives the average dimensions of all trees within certain specified limits of size in diameter, on four kinds of land.

Table 18 gives a complete summary of the Spruce over two inches in diameter measured on the 1046 acres. In this case the acres are grouped with reference to the total yield, cutting to ten inches, according as it rounds up to 1000 feet, 2000 feet, 3000 feet, etc. In each class the total number of acres involved is given, and the average number of trees per acre. For the sake of accuracy fractions of trees have been given. In the case of the large diameters there is less than one tree of each diameter per acre, and the result is often a very small fraction. The fractions have been rounded off.

TABLE 17

Average diameters and heights, rounded to inches and feet, of trees 6 to 9, 10 and 11, 12 and 13, and 14 inches and over in diameter, on Swamp Land, Spruce Flats, Hardwood Land, and Spruce Slopes.

Situation	Av. diam. of trees 6 to 9 inches breast-high. Inches	Av. height of trees 6 to 9 inches. Feet	Av. diam. of trees 10 and 11 inches breast-high. Inches	Av. height of trees 10 and 11 inches. Feet	Av. diam. of trees 12 and 13 inches breast-high. Inches	Av. height of trees 12 and 13 inches. Feet	Av. diam. of trees over 14 inches breast-high. Inches	Av. height of trees over 14 inches. Feet
Swamp Land	7	37	10	51	12	59	16	72
Spruce Flats	7	38	10	55	12	62	16	75
Hardwood Land	7	44	10	59	12	69	16	80
Spruce Slopes	7	44	10	55	12	60	16	75

Average number of trees per acre of different diam
ing to the yield in board feet of all trees ten inches and

YIELD OF ALL TREES TEN INCHES AND OVER						
Diam. breast-high.	1000 (139 acres)	2000 (213 acres)	3000 (223 acres)	4000 (204 acres)	5000 (106 acres)	6000 (71 acres)
Inches	AVERAGE NO.					
2	22.30	20.50	21.10	21.20	21.50	24.90
3	18.70	19.30	20.00	19.10	19.90	23.30
4	17.90	18.10	18.20	18.30	19.70	21.40
5	12.80	13.00	12.90	13.90	14.60	16.90
6	10.90	10.60	12.10	12.20	13.60	13.60
7	8.70	8.30	9.20	10.20	10.60	11.90
8	6.80	7.40	7.80	8.20	8.90	9.70
9	5.30	5.40	6.50	7.50	7.30	8.80
10	4.60	5.30	6.80	6.90	7.80	8.70
11	3.20	3.80	4.60	5.50	6.50	6.80
12	2.10	3.60	4.10	5.20	5.60	6.60
13	1.40	2.60	3.60	4.20	4.70	5.10
14	1.30	1.90	2.80	3.50	4.40	5.10
15	0.90	1.50	2.40	3.30	3.80	4.00
16	0.50	1.20	1.80	2.40	2.60	2.90
17	0.60	0 90	1.30	1.80	2.40	2 20
18	0.30	0 60	1.00	1.20	1.80	1.90
19	0.20	0.40	0.60	0.80	1.00	1.20
20	0.20	0.30	0.40	0.50	0.70	0,80
21	0.08	0.20	0.20	0.40	0,50	0.60
22	0.04	0.20	0.20	0.20	0.20	1.30
23	0.02	0.10	0.20	0.10	0.20	0.10
24		0.03	0.07	0.10	0.03	0.07
25	0.01	0.04	0.03	0.02	0.04	0.03
26		0.02	0.01	0.03	0.01	0.03
27			0.01	0.01		0.06
28	0.01		0.01			0.01
30			0.004			
31			0.004			
34						0.01

eters, and number of acres measured, classified accord-over in diameter breast-high.

IN DIAMETER BREAST-HIGH, IN BOARD FEET						
7000 (37 acres)	8000 (21 acres)	9000 (4 acres)	10,000 (5 acres)	11,000 (1 acre)	12,000 (2 acres)	Diam. breast-high.
OF TREES						Inches
26.30	24.20	23.50	23.00	16.0	49.0	2
24.30	24.10	18.20	24.40	9.0	41.0	3
23.10	21.80	14.50	18.40	20.0	34.0	4
18.40	18.50	13.00	17.80	15.0	23.5	5
14.50	13.20	13.00	16.00	25.0	17.5	6
12.80	12.90	12.70	12.60	17.0	19.5	7
10.60	9.80	11.00	8 40	20.0	13.5	8
10.30	9.40	7.20	8.60	10.0	13.0	9
9.80	9.60	11.00	8.20	8.0	14.0	10
9.60	7.40	8.50	8.60	12.0	15.0	11
7.80	6.40	7.20	8.60	18.0	17.0	12
6.40	7.10	7.50	6.60	13.0	14.0	13
6.30	5.80	7.00	6.40	12.0	8 0	14
4.00	4.90	6.20	7.00	4.0	7.5	15
3.30	4.10	7.00	4.20	5.0	5.0	16
3.00	2.30	4.00	5.60	2.0	6.0	17
2.00	2.20	3.20	3.20	1.0	2.5	18
1.10	1.30	1.70	2.40	1.0	2.0	19
0.90	1.10	1.50	2.00	2.0	1.0	20
0.60	1.00	1.70	1.20	1.0	1.5	21
1.30	1.00	1 20	0.50			22
0 20	0.30	1.20	0.40			23
0.10	0.10	0.70	0.40			24
0 03	0.10	0.20	0.20			25
0.03	0.10				0.5	26
0.03	0.05					27
						28
						30
						31
						34

Tables 15 and 16 give the results of the 1046 valuation surveys classified according to situation. The following tables (19–22) show the average diameters, heights, number of trees, and yield per acre of the 1046 valuation surveys classified according to the yield per acre of Spruce ten inches and over in diameter.

The average diameters and heights were determined, as is fully explained on page 60, by averaging the values found for the individual valuation surveys. The number of trees per acre was determined directly from Table 18, which gives the average number of trees per acre of each inch in diameter. The method described on page 60 was used to compute the yield per acre. It was first determined for trees fourteen inches and over in diameter by multiplying the number of trees by the value in the Volume Tables corresponding to the average diameter and height. The contents of trees twelve and thirteen inches in diameter, ten and eleven, and six to nine inches, were computed and added to that found for trees over fourteen inches, and the total contents of all trees six inches and over was found by addition.

TABLE 19

SPRUCE 6 INCHES AND OVER

Yield of all trees 10 inches and over in diameter breast-high, in thousand feet, board measure	No. of Acres	No. of Trees	Average diameter breast-high. Inches	Average height. Feet	Board feet	Standards
1	139	47.3	9.0	48.6	1860	12.04
2	213	54.6	9.6	53.2	2796	17.95
3	223	65.8	10.0	55.0	3943	25.42
4	204	73.2	10.2	57.3	5066	32.22
5	106	82.7	10.6	58.2	5738	36.42
6	71	91.6	10.4	61.2	7061	45.68
7	37	104.4	10.7	60.4	8466	56.35
8	21	98.6	10.0	63.3	8956	56.39
9	4	113.8	11.4	64.0	10019	62.43
10	5	110.6	11.0	64.0	11502	68.39
11	1	151.0	10.3	60.0	12679	76.81
12	2	157.5	11.0	62.5	12598	70.18

TABLE 20

SPRUCE 10 INCHES AND OVER

Yield of all trees 10 inches and over in diameter breast-high, in thousand feet, board measure	No. of acres	No. of trees	Average diameter breast-high. Inches	Average height. Feet	Board feet	Standards
1	139	15.6	12.3	61.7	1416	8.87
2	213	22.8	12.7	65.5	2382	14.45
3	223	30.2	13.0	67.0	3480	21.50
4	204	35.1	13.3	67.5	4228	25.74
5	106	42.3	13.5	68.5	5213	31.98
6	71	47.6	13.6	71.0	6005	37.32
7	37	56.2	13.6	70.6	7405	48.16
8	21	53.3	13.8	71.8	7868	47.78
9	4	69.9	13.7	75.0	9449	57.60
10	5	65.0	14.1	75.0	10498	60.92
11	1	79.0	13.3	72.0	11095	68.17
12	2	94.0	13.5	72.5	11772	73.19

TABLE 21

SPRUCE 12 INCHES AND OVER

No. of trees	Average diameter. Inches	Average height. Feet	Board feet	Standards	No. of acres	Yield of all trees 10 inches and over in diameter breast-high, in thousand feet, board measure
7.8	14.4	68.9	1073	6.53	139	1
13.7	14.6	70.7	1927	11.80	213	2
18.8	15.1	72.4	2910	17.62	223	3
22.7	15.0	72.6	3608	21.52	204	4
28.0	15.0	72.5	4341	26.22	106	5
32.1	15.3	75.2	5153	31.43	71	6
36.8	15.6	73.3	6086	39.43	37	7
36.3	15.6	78.6	6933	41.32	21	8
50.4	15.6	78.0	8474	50.97	4	9
48.2	14.8	79.0	9155	54.52	5	10
59.0	14.0	75.0	9615	58.17	1	11
65.0	14.5	75.0	9800	60.14	2	12

TABLE 22

SPRUCE 14 INCHES AND OVER

Yield of all trees 10 inches and over in diameter breast-high, in thousand feet, board measure	No. of acres	No. of trees	Average diameter. Inches	Average height. Feet	Board feet	Standards
1	139	4.3	15.9	72.4	744	4.43
2	213	7.5	15.9	75.9	1425	8.48
3	223	11.1	16.4	76.5	2109	12.54
4	204	13.3	16.7	76.4	2846	16.63
5	106	17.8	15.6	76.7	3382	20.10
6	71	19.4	16.4	78.5	4035	24.06
7	37	22.6	16.7	77.7	4836	31.19
8	21	22.8	17.0	81.4	5381	31.46
9	4	35.7	16.6	82.0	6783	40.24
10	5	33.2	16.6	82.0	7835	45.82
11	1	28.0	15.7	83.0	6608	38.64
12	2	34.0	16.0	82.5	7072	42.16

In Tables 19-22 the average diameters and heights are given for trees six, ten, twelve, and fourteen inches and over in diameter. As was the case in computing the yield in Tables 15 and 16, it was necessary to know the average diameters and heights of trees six to nine, ten and eleven, twelve and thirteen, and fourteen inches and over in diameter in order to obtain the totals by addition. The diameters were computed directly from Table 18, and the heights were determined in the following way: Having already the heights for all trees six, ten, twelve, and fourteen inches and over in diameter, these values were entered on cross-section paper, laying off the diameters on the horizontal and the heights on the vertical lines. A curve was drawn through the points and the heights corresponding to the diameters in the following table were obtained by interpolation.

TABLE 23

Average diameters and heights, rounded to inches and feet, of trees 6 to 9, 10 and 11, 12 and 13, and 14 inches and over in diameter, on acres yielding 1,000, 2,000, 3,000, etc., board feet.

Average of 1,046 acres

Yield of all trees 10 inches and over in diameter breast-high, in thousand feet, board measure	No. of Acres	Average diameter of trees 6 to 9 inches breast-high. Inches	Average height of trees 6 to 9 inches. Feet	Average diameter of trees 10 and 11 inches breast-high. Inches	Average height of trees 10 and 11 inches. Feet	Average diameter of trees 12 and 13 inches breast-high. Inches	Average height of trees 12 and 13 inches. Feet	Average diameter of trees over 14 inches breast-high. Inches	Average height of trees over 14 inches. Feet
1	139	7	35	10	50	13	60	16	70
2	213	7	40	10	55	12	60	16	75
3	223	7	40	10	55	13	65	16	75
4	204	8	45	10	55	12	60	17	75
5	106	7	40	11	55	13	60	16	75
6	71	8	50	10	60	12	65	16	80
7	37	8	45	11	60	12	65	17	80
8	21	8	50	10	60	13	70	16	75
9	4	7	40	10	55	13	70	17	80
10	5	7	45	11	65	12	65	17	80
11	1	7	45	11	65	12	70	17	80
12	2	7	40	11	60	12	65	16	80

IX

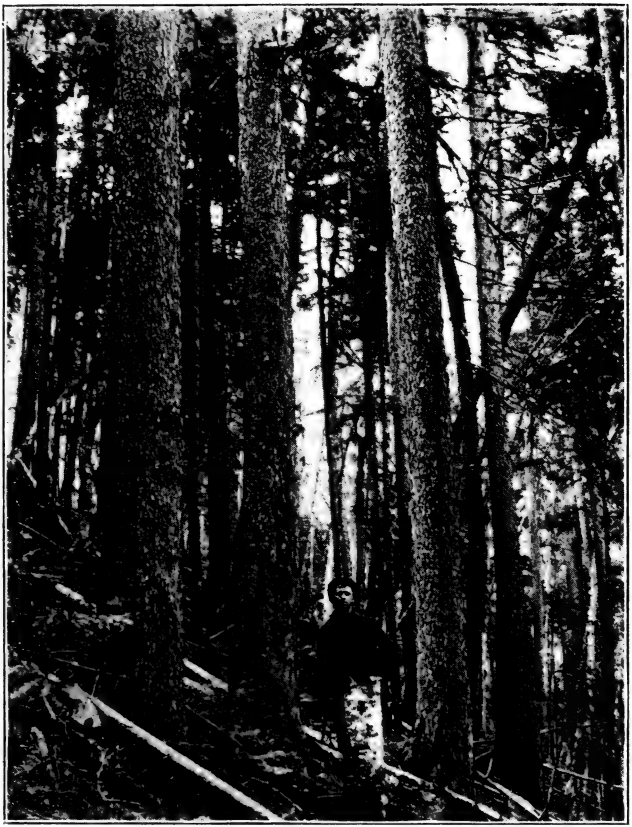
YIELD TABLES

THE material given in the tables in this and the preceding chapters has been prepared for the purpose of predicting future crops of timber after cutting to a given limit on lands yielding a known amount of Spruce. It is of great importance to the land owner to know how soon he can return to a certain tract of land after cutting and obtain the same yield as at first, and to what minimum diameter it will be most profitable in the long run to cut. There can be no doubt that the best immediate returns are obtained by cutting down to five inches. Forest management is out of the question for the lumberman who wishes to make all the money possible out of his property at once and without regard to its value in the future, for it rests on the premise that forest land is so much productive capital and that its productive capacity should not be impaired. It is easy to show that, if the Spruce is cut down to five inches, so long a time must elapse before there will be merchantable Spruce on the area again that it will not pay to hold the land for the next crop. In such a case there would be no timber worth cutting even for pulp in less than fifty to seventy-five years. Interest charges, taxes, and the cost of production cannot be

met for the sake of so meagre a crop as would result from the present system of cutting at the end of that period.

Many lumbermen are now cutting, from lands lumbered ten, fifteen, or twenty years ago, a yield as large as the first cut. As a rule, they are cutting to a smaller diameter than at first, as, for example, in some cases where the first cut was to about ten inches, the second cut is removing everything down to five inches. Even where the limit is said to have been the same at both cuts, and the product the same, it must be remembered that, while no trees may have been taken under ten inches at either cut, many trees over ten inches which would now be merchantable at the time of the first cut were considered unfit for market. Nor is it probable that the cutting to the limit at first was as close as it would be now.

The yield tables have been made in order to give definite information as to the production of cut-over Spruce lands. They embody the results of measurements on the 1046 test acres classified according as the yield was nearest 1000, 2000, 3000 board feet, etc., per acre. They give the number of acres in each class, the exact average yield of these acres, and the amount of timber which would be obtained in ten, twenty, and thirty years after cutting down to ten, twelve, and fourteen inches. The number of years which must pass before the land will yield exactly the same amount as at the first cut is also stated. These figures have not been evened off by curves in order to obtain regular



SPRUCE SLOPE. HEAVY TIMBER NEAR NORTH WOODSTOCK, N. H.

gradations, but represent the exact results from the 1046 acres.

The method used in determining the number of years which must elapse before the same yield can be obtained as at the first cut, and the amount of the cut in board feet per acre after ten, twenty, and thirty years was as follows: The table on page 45 gives the average rate of growth in thickness of trees of different diameters on cut-over land, and the tables on pages 66 and 67 give the average number of trees per acre of each diameter. Knowing the average number of trees of each diameter for the different classes of Spruce land, on acres scaling from 1000 to 12,000 board feet, and the rate of growth of trees of all diameters from five to fourteen inches, it is possible to predict the number of trees of merchantable size per acre, with their exact diameters, after any given number of years, and from these, by the use of the Volume Tables, the number of board feet per acre, cutting down to ten, twelve, or fourteen inches. Similarly, it was possible to predict the number of years which must elapse after the first cut (whether the limit was ten, twelve, or fourteen inches) before the land will produce again the same amount at the same limit.

It will be noticed that no allowance has been made for the death of trees spared by the first cut. All dead trees two inches in diameter and over were callipered on 563 acres, and were found to average a fraction over three trees per acre. Of these about one tree per acre was between six and ten inches in diameter. The number of trees over five inches which will die in the next twenty-five to thirty years under the new conditions is believed to be so small that it may be neglected altogether.

TABLE 24

Average number of dead Spruce trees on 563 acres at Ne-Ha-Sa-Ne Park.

Diameter. Inches.	3	4	5	6	7	8	9	10
No. of trees per acre.	0.76	0.69	0.58	0.37	0.26	0.17	0.14	0.08
Diameter. Inches.	11	12	13	14	15	16	17	18
No. of trees per acre.	0.03	0.011	0.005	0.002	0.002	0.002	0.002	0.004

General average per acre—3.12.

The yield tables on the next pages are followed by examples which explain their use.

YIELD TABLES

Present yield per acre of Spruce, amount which can be cut in ten, twenty, and thirty years after lumbering, and the number of years which must elapse before the same amount can be obtained again, cutting down to ten, twelve, and fourteen inches.

TABLE 25

YIELD TABLE I

SPRUCE PER ACRE 10 INCHES AND OVER IN DIAMETER BREAST-HIGH

Yield of all trees 10 inches and over in diameter breast-high, in thousand feet, board measure	No. of Acres	Amount of First Cut		Second Cut After Ten Years			Second Cut After Twenty Years			Second Cut After Thirty Years			Interval required between equal cuts. Years
		Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	
		a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*
1	139	1416	8.87	5.3	255	1.80	12.1	738	4.84	20.8	1685	10.82	27
2	213	2382	14.45	5.4	323	2.34	12.8	868	5.84	21.1	1991	12.94	34
3	223	3480	21.50	6.5	325	2.21	14.3	917	6.03	23.5	2183	14.18	37
4	204	4228	25.74	7.5	375	2.55	15.7	1070	7.14	25.9	2420	15.57	39
5	106	5213	31.98	7.3	365	2.48	16.2	1087	7.26	26.8	2483	15.99	43
6	71	6005	37.32	8.8	440	2.99	18.5	1581	8.40	30.4	2913	18.80	43
7	37	7405	48.16	10.3	515	3.50	20.9	1436	9.58	33.7	2988	19.43	45
8	21	7868	47.78	9.4	517	3.57	19.2	1366	9.18	32.1	2899	18.95	47
9	4	9449	57.60	7.2	396	2.74	18.2	1239	8.36	30.9	2670	18.65	52
10	5	10499	60.92	8.6	473	3.27	17.0	1043	7.18	29.6	2938	17.20	51
11	1	11095	68.17	10.0	550	3.80	30.0	1980	13.40	47.0	4488	29.20	46
12	2	11772	73.19	13.0	715	4.94	26.5	1887	13.67	46.0	4542	29.41	48

TABLE 26

YIELD TABLE II

SPRUCE PER ACRE 12 INCHES AND OVER IN DIAMETER BREAST-HIGH

Yield of all trees 10 inches and over in diameter breast-high, in thousand feet, board measure	Amount of First Cut		Second Cut After Ten Years			Second Cut After Twenty Years			Second Cut After Thirty Years			Interval required between equal cuts. Years
	Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*
1	1073	6.53	7.8	632	4.00	13.1	1336	8.46	19.9	2504	16.46	16
2	1927	11.80	9.1	845	5.68	14.5	1560	10.21	21.9	2935	18.20	23
3	2910	17.62	11.4	1029	6.57	17.9	1850	11.69	25.7	3471	21.44	25
4	3608	21.52	12.4	1131	7.22	19.9	2115	13.47	28.1	3924	24.23	29
5	4341	26.22	14.3	1208	8.35	21.6	2325	14.78	30.5	4109	26.52	32
6	5153	31.43	15.5	1412	9.01	24.3	2686	17.10	34.0	4778	29.49	32
7	6086	39.43	19.4	1792	11.43	29.7	3320	21.10	40.3	5636	34.66	32
8	6933	41.32	17.0	1696	10.97	26.4	3019	19.19	36.2	5264	32.44	37
9	8473	50.97	19.5	1946	12.59	26.9	3148	19.90	37.9	5538	34.12	37
10	9155	54.52	16.8	1711	11.03	25.4	2964	18.80	33.8	5283	33.73	40
11	9615	58.17	20.0	2084	13.40	30.0	3564	22.56	50.0	7182	46.14	39
12	9800	60.14	29.0	2957	19.07	42.0	4759	31.41	55.5	8767	53.80	32

TABLE 27

YIELD TABLE III

SPRUCE PER ACRE 14 INCHES AND OVER IN DIAMETER BREAST-HIGH

Yield of all trees 10 inches and over in diameter breast-high, in thousand feet, board measure	Amount of First Cut		Second Cut After Ten Years			Second Cut After Twenty Years			Second Cut After Thirty Years			Interval required between equal cuts. Years
	Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	No. of Merchantable Trees	Board feet	Standards	
	a	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*
1	744	4.43	3.5	441	2.70	6.7	1092	6.57	16.6	2919	17.30	15
2	1425	8.48	6.2	990	6.22	10.0	1864	11.36	20.7	4041	24.27	15
3	2109	12.54	7.7	1100	7.39	12.3	2166	12.95	25.6	4926	29.13	20
4	2846	16.53	9.4	1339	8.23	14.9	2624	15.69	29.3	5810	34.35	21
5	3382	20.10	10.3	1470	9.02	16.8	3044	18.21	40.8	6351	37.64	21
6	4035	24.06	11.7	1846	10.68	18.5	3369	20.14	36.0	7531	43.92	22
7	4836	31.19	14.2	2024	12.43	23.8	4279	25.61	43.9	8282	50.84	21
8	5380	31.46	13.5	2043	12.55	20.9	4095	24.47	39.9	8378	49.82	23
9	6783	40.24	14.7	2511	14.20	23.2	4598	28.06	41.4	9541	56.17	24
10	7835	45.82	15.2	2465	15.25	23.8	4769	28.52	40.6	9349	55.02	27
11	6608	38.64	31.0	2646	16.38	43.0	8851	53.00	61.0	15192	58.66	17
12	7072	42.16	31.0	5047	30.31	46.0	9381	56.01	73.0	17409	102.10	15

EXAMPLE NO. I.

A man owns 30,000 acres which yield on an average 3500 board feet per acre of Spruce ten inches and over in diameter. To what limit will it be most profitable in the long run for him to cut, how much can he cut annually if he wishes to obtain a sustained annual yield, and how soon can he return to the portion cut over the first year and cut the same amount of timber above the same diameter limit as at first?

Look in Yield Table I, column *a*, for the amount nearest 3500 board feet. 3480 in line 3 is the closest figure. All the desired information will be obtained on this line in the three tables.

If the diameter limit is ten inches, the total stand is $30{,}000 \times 3500 = 105{,}000{,}000$ board feet; the same yield can be obtained in thirty-seven years (Yield Table I, column *l*); the area lumbered annually will be $30{,}000 \div 37 = 811$ acres; the annual cut will be $105{,}000{,}000 \div 37 = 2{,}837{,}838$ board feet.

If the diameter limit is twelve inches, the average stand per acre is about 3000 feet (Yield Table II, column *a*), the total stand is $30{,}000 \times 3000 = 90{,}000{,}000$; the same yield can be obtained in twenty-five years (Yield Table II, column *l*); the area lumbered annually will be $30{,}000 \div 25 = 1200$ acres; the annual cut will be $90{,}000{,}000 \div 25 = 3{,}600{,}000$ board feet.

If the diameter limit is fourteen inches, the average stand per acre is about 2000 board feet (Yield Table III, column *a*); the total stand is $30{,}000 \times 2000 = 60{,}000{,}000$

board feet; the same yield can be obtained in twenty years (Yield Table III, column *l*); the area lumbered annually will be 30,000÷20=1500 acres; the annual cut will be 60,000,000÷20=3,000,000.

By comparing these results it appears that it will be most profitable to cut to twelve inches, since the annual cut is then largest. The area lumbered annually is about four hundred acres greater than if ten inches were the limit, but the annual cut is about 800,000 board feet larger. Lumbering under these conditions would nevertheless be profitable, inasmuch as the average stand per acre for trees twelve inches and over in diameter is about 3000 board feet.

EXAMPLE NO. 2

A man owns 1000 acres yielding 1000 board feet per acre of Spruce twelve inches and over in diameter. To what limit will it be most profitable in the long run to cut, if he lumbers the entire tract in one year, and how soon can he return for a second cut equal to the first?

Look in Yield Table II, column *a*, for the amount nearest 1000 board feet. The closest figure is 1073 feet, in line 1. All the desired information will be obtained on this line in the three tables.

If the diameter limit is ten inches, the average stand per acre is, in round numbers, 1500 board feet (Yield Table I, column *a*); the total stand is 1000×1500=1,500,000 board feet; the same cut can be obtained in twenty-seven years (Yield Table I, column *l*).

If the diameter limit is twelve inches, the average stand per acre is 1000 board feet. (See example.) The total stand is $1000 \times 1000 = 1{,}000{,}000$ board feet; the same cut can be obtained in sixteen years (Yield Table II, column *l*).

If the diameter limit is fourteen inches the average stand per acre is about 750 board feet (Yield Table III, column *a*); the total stand is $1000 \times 750 = 750{,}000$ board feet; the same cut can be obtained in fifteen years (Yield Table III, column *l*).

If ten inches is the limit, the tract will yield at present 1,500,000 board feet, and in twenty-seven years the same amount again, or together 3,000,000 board feet. If twelve inches is the limit, 1,000,000 board feet can be cut now, and the same amount every sixteen years, making a total in thirty-two years of 3,000,000 board feet. If fourteen inches is the limit, 750,000 board feet can be obtained now, and an equal amount in fifteen, and again in thirty years, or altogether 2,250,000 board feet.

It will therefore be most profitable to cut to ten inches. Aside from the question of profit, it would be better for the forest to cut to twelve rather than to ten inches.

EXAMPLE NO. 3

A man owns 20,000 acres of Spruce land from which he has cut 6000 board feet per acre twelve inches and over in diameter. How much can he obtain in twenty years if at that time he cuts to ten inches?

Look in Yield Table II, column *a*, for the amount nearest 6000 board feet. It is found in line 7. In twenty years there will be about 3320 feet per acre cutting down to twelve inches (Yield Table II, column *g*). What is wanted now is the corresponding cut down to ten inches. Look in Yield Table II, column *a*, for the amount nearest 3320. It is found to be about midway between the amounts given in lines 3 and 4. Now look for the corresponding point in the ten-inch table (Yield Table I, column *a*). Midway between lines 3 and 4 gives the final answer, or about 4000 feet.

EXAMPLE NO. 4

A man owns 10,000 acres of Spruce land from which he obtained 1500 board feet per acre ten inches and over in diameter ten years ago. How soon can he cut the same amount?

Look in Yield Table I, column *a*, for the amount nearest 1500 feet. It is found in line 1. In this table, column *l*, twenty-seven years is given as the time to obtain about 1500 feet at the second cut. The land having been lumbered ten years ago, it will require seventeen years more for the required amount to grow.

EXAMPLE NO. 5

A man cut his Spruce land twenty years ago, getting 2000 board feet per acre twelve inches and over in diameter. How much can he get now?

Look in Yield Table II, column *a*, for the amount nearest 2000. It is found in line 2. The same amount can be taken out in twenty-three years after the first cut (Yield Table II, column *l*). At the present time, therefore, the land owner can obtain nearly the amount of his original cut.

EXAMPLE NO. 6

A man cuts his Spruce land yielding 5000 board feet per acre ten inches and over in diameter, and wishes to return in ten years. How much can he get? Answer: About 365 board feet per acre (Yield Table I, column *d*, line 5).

X

YIELD OF ASSOCIATED SPECIES

In the discussion of the composition of the forest it was shown that, with the exception of some swamps and certain steep slopes and ridges, the hardwoods form an important element in the forest. Forty-two per cent. of the entire tract is classified as land on which hardwoods predominate. Until recently there has been comparatively little market for the Adirondack hardwoods, with the exception of Black Cherry. This has been largely due to the fact that hardwood lumber is difficult to handle, and because the demand has not been sufficiently great to make lumbering profitable. There is, however, an increasing demand for Birch and Maple, and many lumbermen are now cutting the hardwood timber where the haul to the railroad is not too long. In view of the fact that the Adirondack and St. Lawrence Railroad runs through the Park it is important to know the amount of available hardwood timber.

In the 1046 valuation surveys all species other than Spruce were callipered down to ten inches breast-high, great care being taken to measure only such trees as were *apparently perfectly sound.* The large hardwood timber is, however, very old, and there are probably many trees apparently sound which in the end

would be discarded by the lumbermen. The proportion of unsound hardwood trees varies considerably in different parts of the Adirondacks, and it is extremely difficult to determine what proportion of cull should be allowed in the Park, because no satisfactory figures could be obtained for hardwoods cut in this immediate section. The number of board feet of apparently sound hardwood timber was first computed without making any deduction for cull, suitable allowance being made later in the estimate of yield.

For the estimate of Birch the following table, recommended by Mr. James L. Jacobs, Superintendent of the Santa Clara Lumber Company, was used.

TABLE 28

STANDING BIRCH

Diameter in inches.	Contents in board feet.
16	157
18	222
20	302
22	400
24	499

The average number of trees per acre and the average diameter were determined from the valuation surveys, and the yield in board feet was found by multiplication from the table given above. Only trees over fifteen inches in diameter were used in the estimate for Birch and Maple, as this is the average limit of the

YELLOW BIRCH. SANTA CLARA, N. Y.

lumbermen, but in the case of the other species in mixture twelve inches was made the minimum diameter. Mr. Jacobs, from whom the table for Birch was obtained, estimated that although Hard Maple would contain more feet of wood than Birch, the amount of merchantable timber per tree would be from five to ten per cent. less, on account of the greater proportion of cull. The estimate for Hard Maple was accordingly made by deducting eight per cent. from the contents of the trees as given in the table for Birch. The yield of White Pine was determined by the use of the volume table for board feet contained in the study of that tree by Pinchot and Graves. The table given below, which was employed in determining the amount of Hemlock in the Park, is used by the lumber cruisers in northern Michigan.

TABLE 29

STANDING HEMLOCK

Diameter in inches.	No. of trees per 1000 board feet.
18	4
20	3
22	2 ¼
24	2
26	1 ½
28	1 ¼
30	1

In the absence of a scale for estimating Cherry and Ash, the following table, which is used by Michigan lumbermen for estimating basswood and elm, was used:

TABLE 30

STANDING BASSWOOD AND ELM

Diameter in inches.	No. of trees per 1000 board feet.
14	8
16	6
18	4
20	2⅔
22	2
24	1¾
26	1¼
28	1

In the case of Cedar no estimate was made, because it is used for so many purposes that it was impossible under the circumstances to obtain a satisfactory scale.

There is at present but little market for Beech, and therefore this tree, together with Soft Maple and Balsam, was left out of the estimate.

The average yield per acre is given in the table below, both for the entire 1046 acres, and for each of the four classes of situation. From this table it appears that there are 3004 board feet of Birch, 464 feet of Hard Maple, 982 feet of Hemlock, 74 feet of Pine, 15 feet of Cherry, and 16 feet of Black Ash per acre on the 1046

acres measured, if no reduction is made for unsound trees. The percentage which should be allowed for cull in hardwoods has been variously estimated by different lumbermen in the Adirondacks at from five to forty per cent. Probably about thirty per cent. of the Hemlock lumber will be found to be unfit for market. For the allowance actually made for cull in the various species see the estimates in the working plan on p. 114.

TABLE 31

Average Yield per Acre for Merchantable Species on 1046 Acres. Apparently Sound Trees without Deduction for Cull

Species	Minimum diam. Inches	All Situations Together Average of 1046 Acres			Swamp Land Average of 225 Acres			Spruce Flat Average of 106 Acres			Hardwood Land Average of 442 Acres			Spruce Slope Average of 274 Acres		
		Ave. No. of Trees	Per cent. of each species in merchantable crop	Board feet	Ave. No. of Trees	Per cent. of each species in merchantable crop	Board feet	Ave. No. of Trees	Per cent. of each species in merchantable crop	Board feet	Ave. No. of Trees	Per cent. of each species in merchantable crop	Board feet	Ave. No. of Trees	Per cent. of each species in merchantable crop	Board feet
Spruce	10	31.40	68.3	3639	34.00	75.1	3439	29.00	69.8	3309	29.00	62.70	3738	34.00	70.50	3934
Birch	15	8.70	18.9	3004	6.30	13.9	1752	7.30	17.6	2060	10.30	22.30	3375	8.60	17.80	3800
Maple	15	2.20	4.9	464	0.60	1.3	116	0.90	2.2	175	3.90	8.40	820	1.40	2.90	291
Hemlock	12	3.30	7.2	982	3.00	6.7	1150	4.10	9.9	1151	29.00	6.30	839	4.00	8.30	1008
Pine	12	0.10	0.2	74	0.30	0.7	99	0.10	0.2	83	0.03	0.06	5	0.20	0.40	160
Cherry	12	0.06	0.1	15	0.04	0.1	13	0.04	0.1	6	0.10	0.20	22	0.04	0.08	7
Ash	12	0.10	0.2	16	0.40	0.9	62	0.08	0.2	9	0.02	0.04	3	0.01	0.02	1
Cedar	12	0.10	0.2		0.60	1.3										

It has been said that the species mixed with Spruce were callipered down to ten inches. In order to determine the number of trees per acre of diameters smaller than ten inches, twelve square acres, selected as a fair average, were surveyed, and the trees of all species other than Spruce were measured down to two inches. The following table gives the average number of trees of the small diameters found on these acres.

TABLE 32

TREES OF SMALL DIAMETER, OTHER THAN SPRUCE, ON TWELVE SQUARE ACRES

	DIAMETER BREAST-HIGH. INCHES.									
	2	3	4	5	6	7	8	9	10	Total
	AVERAGE NUMBER OF TREES PER ACRE									
Birch	5.3	5.2	4.8	2.8	3.1	1.9	1.6	1.8	1.3	27.6
Beech	11.2	11.0	6.8	4.8	5.4	4.1	3.4	3.3	2.7	52.6
Hard Maple	1.1	1.9	1.3	2.0	2.4	2.5	2.3	2.0	2.0	17.6
Hemlock	.4	1.4	1.4	1.8	1.7	.4	.8	.3	.6	8.7
Balsam	11.6	14.2	12.3	8.1	6.5	4.3	3.3	1.8	1.6	63.6
Soft Maple	.5	.4	.5	.3	.3	.3	.1	.6	.6	3.4
Pine			.08	.08						.2
Ash	.08	.17	.9	.5	.8	1.7	.9	.5	.5	6.1
Cherry			.08		.08		.08			.2
Total	30.1	34.3	28.1	20.2	20.2	15.3	12.4	10.2	9.2	180.

On page 80 twenty-five years is shown to be the length of time which must elapse after cutting the first crop of Spruce down to twelve inches before the same amount can again be obtained. It is desirable to know what the condition of the hardwoods will be at the end of that time if the merchantable timber is cut now. It was not the purpose of this investigation to make an exhaustive study of the growth of the hardwoods, but in order to gain some slight knowledge of their development a number of measurements were taken by means of Pressler's Zuwachsborer. This is a short hollow auger, fitted with a fine wedge, by which a narrow cylinder about an inch long may be bored from the trunk of a tree, to show its present rate of growth in diameter. With the help of this instrument a number of measurements were taken of the growth of trees commonly found in mixture with the Spruce. The number of trees measured, their average diameters, and the number of years required to grow one inch in diameter are given in the table below. It was found that the growth for the different diameters varied so greatly that an average was taken of the trees of all diameters. It will be seen that the rate of growth of the hardwoods is very slow. Thus, the time required for Birch to grow one inch in diameter is twenty years, and for Hard Maple sixteen.

TABLE 33

THE RATE OF GROWTH IN DIAMETER OF ASSOCIATED SPECIES

Species	No. of trees measured	Average diameter of trees measured. Inches.	No. of years required to grow one inch in diameter
Birch	78	12.5	20
Beech	16	12.7	13
Hard Maple	16	15.0	16
Hemlock	141	16.6	25
Balsam	63	10.5	13
Soft Maple	21	10.5	17

Knowing the number of trees of the small diameters and their rate of growth, it is possible to make a fair forecast of the future crops. It seems, however, that, in view of the fact that a large number of the Birch measured were very old, twenty years is too slow a rate of growth for the small trees, which would enjoy after the cutting a considerably larger amount of space than at present. Fifteen years seems to be a conservative estimate for the rate of growth of young hardwoods from ten to fifteen inches in diameter, and this estimate is confirmed by observations made on the same species in northern Michigan.

If the Birch and Maple are cut down to fifteen inches they will yield 3468 board feet per acre. At the end of

twenty-five years, assuming that the trees left standing will grow one inch in diameter in fifteen years, the second cut would yield about 400 board feet per acre. If, however, eighteen inches were made the lower limit or the first cut, 2440 feet could be taken out now, and, in twenty-five years the land would yield 1057 board feet per acre if the second cut took all trees down to fifteen inches. From these figures it appears that the hardwoods, considered as producers of stumpage, are far less effective than the Spruce. It should be noted, however, that the estimate of yield (p. 116) is based on a first cut of but half the standing hardwoods. It is therefore certain that in actual practice the second cut would be far better than the estimate given above, and altogether probable that both in stumpage and in cash value it would exceed the first.

PART II

THE WORKING-PLAN

XI

TOPOGRAPHY AND CLIMATE

NE-HA-SA-NE PARK is a body of forest land, roughly triangular in outline, with the longest side to the north. It lies in the west central portion of the Adirondack Mountains of northern New York, and is traversed in a northeasterly direction by the Adirondack and St. Lawrence Railroad. About two-thirds of the area is in townships 37 and 38 of Hamilton County, while the western third lies in Herkimer County, townships 42 and 43 From east to west the Park stretches from Little Tupper Lake to Big Rock Lake, and includes the latter, together with Lake Lila, Lake Ne-Ha-Sa-Ne, and a portion of the headwaters of Beaver River. Other waters of the Park drain through Little Tupper Lake to the Raquette River, and through Cranberry Lake to the east branch of the Oswegatchie. Both these lakes are outside its boundaries. The general elevation is from 1700 to 2000 feet above sea level.

The whole Park includes an area of about 40,000 acres. Of this total about 10,000 acres are fenced and have been omitted from the investigation. The area covered by the working plan is then about 30,000 acres.

The general character of the country is hilly and

A Characteristic Group of Spruces and Pines on the Edge of Lake Lila, Ne-Ha-Sa-Ne Park.

somewhat broken, with low swampy tracts near the streams and lakes. Numerous knolls and ridges, from a few yards to over three hundred feet in height, rise from the lower ground. In general the ridges or series of ridges run northeast and southwest. Low rounded knolls rising above swampy ground are very frequent. More level areas, or flats, are of considerable extent; some of them low and rolling and covered with glacial boulders. There are numbers of broad flat ridges. The higher hills are for the most part conical, with small tops, or consist of long narrow ridges. A glance at the map will indicate that the southerly slopes are apt to be rocky, abrupt, or often even precipitous. The northerly slopes are more gradual. The country shows in many ways the effect of the ice with which it was once covered. The soil is a glacial drift, and the manner in which the rocks have been smoothed off and the rounded boulders deposited on the flats and on the south slopes affords similar evidence. The shape of the ridges is due to glaciation.

Granite, varying much in color and texture, is the principal rock.

The typical soil of the Park is glacial gravel or sand, replaced by loam in richer situations. On steep slopes it is thin, and what there is usually collects in hollows, on benches, on the uphill side of rocks and trees, or in rocky crevices. On moderate slopes and high flats the soil is deep, fresh, and porous; on low flats moist and often deep; on less level flats thin on account of the boulders; and in swamps a deep muck.

The conditions of heat, moisture, and ventilation are such in the dense and damp Adirondack forest that the waste materials which drop from the trees and other forest vegetation decay slowly after falling. The result is a mass of partially disintegrated vegetable matter which has been accumulating for years, and which may cover the ground to a depth of several feet. This layer, deeper on low than on high ground, often becomes acid humus in the swamps.

Rain is abundant. An indication of its amount is supplied by the rainfall of the upper Hudson, which is given by the State Engineer as follows, with the remark that in 1895 it was somewhat deficient:

1894	41.37 inches
1895	36.67 "
1896	45.21 "

The temperature, as shown by records kept at Ne-Ha-Sa-Ne Park in 1893, 1894, 1896, and 1897, has a considerable, but not an extreme, range. The highest temperature for the four years was ninety-three degrees above zero, in July, and the lowest thirty-six degrees below zero, in January. Frosts occur in October of each year, but in only one case of the four do they continue into May. The fall of snow is heavy, and it lies on the ground during six or seven of the twelve calendar months, beginning as a rule in November.

GULL LAKE. NE-HA-SA-NE PARK.

XII

TRANSPORTATION

THE conditions at Ne-Ha-Sa-Ne Park are very favorable for forest management, and in no way more so than in its accessibility to the market. The Park is crossed by the Adirondack and St. Lawrence Railroad, which affords an outlet for the timber to various sawmills located at no great distance, as at Tupper Lake on the north and Beaver River on the south, and the other mills scattered along the line.

There is a system of roads and trails throughout the Park which could be enlarged and adapted for logging without great expense, by which the timber could be hauled to the railroad. East of the railroad a large part of the Spruce can be floated directly to the jack works near Keepawa, and the hardwood can be hauled on the ice in winter to the same point. In general the timber is not difficult of access. A portion of the Park is swampy, and there it would be necessary to build corduroy roads. The hills are not very high and present no serious difficulty for the lumberman. On a portion of the Park north of the railroad the logs would have to be hauled a considerable distance and in places up grade. Work in the woods, as well as the guarding of the forest against fire, will be greatly facilitated by the existing telephone connections throughout the Park.

XIII

REASONS FOR FOREST MANAGEMENT

THE forest at Ne-Ha-Sa-Ne Park is in great need of silvicultural attention. Not only is there much unsound and worthless timber cumbering the ground, but the forest in its present state is virtually so much idle capital. On any considerable tract of virgin forest the growth is about equalled in the long run by the loss through windfall and decay. New trees spring up and take the place of those which decay or are blown down, but the total stand remains approximately the same. Considered as a piece of real property, the virgin forest yields no interest. The timber itself represents accumulated interest, it is true, but the producing power of the land is expended in maintaining the present total, without adding anything new. Under the present system the lumberman practically ignores the fact that forest land is productive capital. He speculates in the timber with little regard to the real productive capacity of the land. He cuts not only the mature timber, but the growing trees as well. In other words, he removes not only the accumulated interest of many years, but with it the most productive portion of the capital. If, however, the ripe timber alone is cut, and enough young trees are left to replace it, the growth of the small trees and of those which germinate under the new conditions will be actual added interest. That

YOUNG SPRUCE IN THE FOREST. SANTA CLARA, N. Y.

is to say, the unproductive portion of the capital has been converted into money to be invested elsewhere, and the forest has been put into such a condition that its power of growth is utilized.

The presence of a large amount of young growth and the prolific reproduction of the valuable trees makes it possible to manage the forest in such a way as to obtain a considerable profit now, and a very much greater profit in the long run. The latter is assured by the sustained and increased value of the forest capital, and by the opportunity to harvest successive crops at comparatively short intervals.

The present working-plan is based on the fact that the Spruce above an average diameter of twelve inches can be removed without injury to the forest, and that a satisfactory reproduction can be brought about by the cutting. As has been emphasized elsewhere, this limit is not a hard-drawn line, but, on the contrary, only an average figure to aid in the determination of the yield, and to serve as a guide to the forester in marking the trees to fall. It will be necessary, for silvicultural reasons, to leave many trees above this diameter, and to cut many which are smaller. But a careful silvicultural study of the Spruce has made it clear that an amount of timber equal to the yield above twelve inches can be removed safely and in such a way as to bring about the desired reproduction.

The working-plan is concerned chiefly with the yield, growth, and reproduction of the Spruce. Spruce is the most abundant species. Except Pine, Cherry, and per-

haps Cedar, it has been the most profitable tree to lumber, and, on account of its ability to grow more rapidly than the hardwoods, quicker returns can be obtained from it under forest management. The lumbering of hardwoods must, then, be subordinate in the general plan. All marketable hardwoods may be cut now, for their reproduction is abundant and secure, but in this case no provision is possible to assure a second equal yield in hardwoods at the time of the second cutting of Spruce. The present study was made primarily for the Spruce, and the hardwoods were worked up only in their relation to it. Their growth and behavior can only be described provisionally until some study is made on lumbered hardwood lands.

The objection will probably be made that if the merchantable Spruce and hardwoods are cut the remaining trees will be blown down. In certain places this is true, and in them it must be guarded against in the location of the cut. A large part of the hardwoods are on fairly deep soil, and are not easily uprooted, and in many cases the large number of trees which must be left because not perfectly sound or straight will prevent an undue thinning of the forest. In the statement of financial results ample provision and allowance have been made for leaving a large number of trees to furnish seed, for the protection of the soil, and to guard against damage by wind. In practice, the protection of the forest against windfall must be left to the man who marks the timber to be cut.

XIV

TREATMENT OF THE FOREST

FOREST management in the Adirondacks by owners other than the State must meet two conditions :

1st. The returns must be substantial enough to make it a profitable real property investment. Otherwise the lumbermen, most clubs, and nearly all private land owners will be unwilling to adopt it. The State may be satisfied with two per cent. interest on the capital invested, but the lumbermen could not consider such a proposition.

2d. The system of management must secure the establishment of a crop of trees to take the place of the timber cut, and it must improve the condition of the forest.

Ordinary lumbering pays a high interest now, but it leaves the forest in a very bad condition. Intensive forest management would secure most desirable results in the next crop, but it would pay too low a rate of interest now. A practicable system of management must then be a compromise, bringing sufficient returns to the owner to make it profitable for him to undertake it, and yet insuring an ample reproduction to establish new crops.

The cost of building and maintaining permanent roads is so great that the lumbermen could not afford to keep all parts of the forest always accessible for logging. It will not be possible to continue the cutting

on the same ground during a number of years, as is done in European regeneration cuttings and as would be necessary in the Adirondacks if the best possible reproduction were to be obtained without regard to expense, but each portion must be lumbered once for all, and the cutting must be so located that the reproduction will take care of itself.

It is essential to large companies with extensive milling plants that they should have a regular annual production of timber on which they can confidently rely. Such companies cannot afford to give up their business or to move their plants to new places as soon as the tributary land is exhausted. Forest management must secure for them a sustained annual yield by a suitable distribution of the cutting and by enabling them to cut the same land a second time in a reasonably short period. On the other hand a private individual or a club owning a small tract would in many, if not in most cases, prefer to cut the entire tract at once and then wait the required period before cutting a second time.

Technically it will do no harm to the forest to lumber it entirely in one year, provided due care is taken to spare the small trees and to secure reproduction. On the contrary, it will place the whole tract at once in a condition favorable for rapid growth, whereas if some portions were left uncut for 15, 20, or 25 years, they would remain for that time in the condition of the virgin forest, where the decay and growth are about equal, and would thus be producing nothing. Further,

the lumber operations would be much cheapened by cutting the entire tract in a short time, and the expense of extra rangers and expert superintendence would be saved from the time the lumbering was finished till the second cutting.

The working-plan for Ne-Ha-Sa-Ne Park has been made on two assumptions—one that it will be desirable to insure a sustained annual yield, and the other that it will not. The former would be accomplished by cutting an approximately equal portion of the forest each year. The area lumbered yearly would then be equal to the total area divided by the number of years which must elapse before any one portion can be lumbered a second time. If, however, for any reason the owner of the Park should desire to cut the entire area as quickly as the means at hand would permit, the plan would in no essential way be changed, except that the tract must be left for the allotted period before the second cutting without yielding any more return.

From the yield tables the period between equal cuts on the same area is determined to be twenty-five years, if, as is shown below, twelve inches is the minimum diameter to which Spruce should be cut in the Park.

The yield per acre for the trees ten inches and over is 3703 board feet; the total stand is 101,954,699 board feet; the same cut can be obtained again in thirty-seven years (Yield Table I, column *l*, line 3); the area lumbered annually would be $27,533 \div 37 = 744$ acres; the annual cut would be $101,954,699 \div 37 = 2,755,532$ board feet.

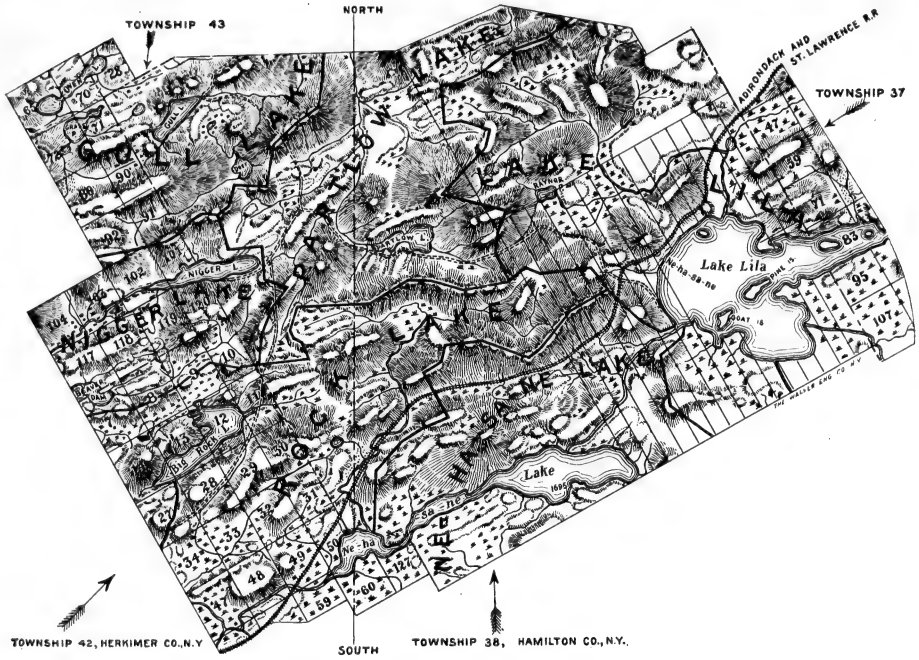
With twelve inches as the limit, the yield per acre is 3045 board feet; the total stand is 83,837,985 board feet; the same cut can be obtained in twenty-five years (Yield Table II, column *l*, line 3); the area lumbered annually would be 27,533 ÷ 25 1101 acres; the annual cut would be 83,837,985 ÷ 25 3,353,519 board feet.

With fourteen inches as the limit, the average yield per acre is 2400 board feet; the total stand is 66,079,200 board feet; the same cut can be obtained in twenty years (Yield Table III, column *l*, line 3); the area lumbered annually would be 27,533 ÷ 20 = 1377 acres; the annual cut would be 66,079,200 ÷ 20 = 3,303,960 board feet.

By cutting down to twelve inches the annual yield would be 597,987 board feet greater than if ten inches be made the limit. It would be necessary to lumber 357 acres more for this additional amount, but this would pay inasmuch as there are about 3000 board feet per acre over twelve inches. Technically it would be far better for the forest to cut to twelve rather than ten inches. It would be more profitable to cut to twelve rather than to fourteen inches, because slightly more timber could be cut annually and the area lumbered would be smaller.

In order to facilitate the location of the cuttings on the map the Park has been divided into six watersheds, as follows:

Lake Lila, 7470 acres, comprising the area draining into that lake, as well as a small section drained by Bog Lake.


TOWNSHIP 43
NORTH
ADIRONDACK AND ST. LAWRENCE R.R
TOWNSHIP 37
Lake Lila
Lake
TOWNSHIP 42, HERKIMER CO., N.Y
SOUTH
TOWNSHIP 38, HAMILTON CO., N.Y.

Lake Ne-Ha-Sa-Ne, 4160 acres, including the area drained by the main part of this lake and the river between it and Lake Lila.

Rock Lake, 6014 acres, comprising the watershed of the river emptying into the extreme lower part of Lake Ne-Ha-Sa-Ne from the North, and the portion of Beaver River below this lake, including the Rock Lake system.

Nigger Lake, 2221 acres, covering the area drained by that lake and Beaver Dam.

Gull Lake, 3206 acres, including the watershed of this and the other ponds in the northwest corner of the Park.

Partlow Lake, 4,461 acres, comprising the area about this pond and the river into which it empties.

If the Park is to be managed for a sustained annual yield, these watersheds may be subdivided, to suit the conditions of lumbering, so that about one twenty-fifth of the entire tract is cut each year. Otherwise they may be lumbered within whatever period is determined upon by the owner.

XV

CUTTING

THE object of forest management may be said to be the production of the largest amount of the most valuable timber in the shortest time on a given area. This is often best accomplished for a given species by forming dense even-aged pure forests. The largest amount is thus produced because there are no other species occupying the ground. The timber will be most valuable because in such a forest the natural pruning is very uniform and complete, and the trunks are long and clear. The timber is produced in the shortest time because there are no spreading trees overhead to suppress and hold back the young growth, which develops without hindrance except for the natural crowding within the stand.

At Ne-Ha-Sa-Ne Park it will not be possible to produce a pure forest of Spruce over any large area. The hardwoods, which are intimately mixed with the Spruce now, form a constant factor which cannot be eliminated; and without doubt in time their value will have increased to such an extent that their presence will be extremely desirable. In the original forest, however, the mixture is chiefly promiscuous, whereas if the trees were mixed in patches the advantages of both the mixed and pure forest would be attained. It should, therefore, be the ultimate aim in locating the cuttings to re-

produce the Spruce as well as the hardwoods in groups.

There is a very large amount of unsound and worthless timber in the forest at Ne-Ha-Sa-Ne, and one of the aims of the forester should be to increase the proportion of the valuable species and to bring the forest into sound condition. The land should be made to produce only sound individuals of valuable species. This condition is far in the future, it is true, but the forester should have it constantly in mind. With this ultimate aim in view, and with the knowledge gained of the capacity of the Spruce under present conditions and of its silvicultural character, we are in a position to discuss the immediate treatment of the forest and the principles that should govern the cutting. No detailed rules, but only general ones, can be laid down, because the conditions vary with each individual case.

The application of such general rules to specific cases is the province of the forester. The imperative need of this skillful adaptation is the fundamental reason why rules of thumb, such as a rigid limit of twelve inches, cannot safely be put in force, and why the marking of trees to fall must be done by some one well versed in the requirements of the forest.

There are certain localities where the cutting of Spruce should be very heavy and where everything merchantable should be removed. These places are on thin rocky ground and exposed situations, where the danger from windfall is very great, and where, in the event of a partial cut, the uprooting of the remaining trees by wind would be inevitable. Such areas should be chosen

with great care, and a sufficient number of seed trees should be left on the edge of each opening to seed the area to Spruce. Such conditions are found on certain Spruce slopes and on the tops of ridges and knolls. They are nowhere extensive.

There are other localities, particularly swamps, where trees twelve inches in diameter are not plentiful, and where many trees under that limit can be removed with decided advantage to the forest.

In general most large Spruce trees, say over fifteen inches, are ready to cut. The doubtful trees are those close to the limit, whether it be ten, twelve or fourteen inches. The trees which should be cut under the size limit are: First, those which show signs of decline and are more valuable at present than they ever will be again; Second, crooked or scrubby trees which can be utilized now for pulp, but which are crowding promising young growth. Trees which should be left above the limit are sound, thrifty, growing trees, which ought to remain in order to seed up an area in Spruce, or to protect the soil.

The general rules which should govern conservative lumber operations in Spruce timber are as follows:

1. Only trees marked by the forester must be cut, and each tree marked must be cut unless a reason satisfactory to the forester can be given for leaving it.

2. No timber outside the line of a road shall be used for corduroy, culverts, or other road purposes, until all timber cut for the clearing of the road has been utilized; and when more timber is necessary, all available trees

of other kinds within reach must be used before any Spruce is taken.

3. All lumber roads must be marked out by the contractor with the coöperation and assistance of the forester.

4. As a protection against fire all tops must be cut or lopped so that the thin branches will be brought in contact with the ground by the weight of the winter's snow.

5. Extreme care must be taken to prevent fire. No fire must ever be lighted where it can get into a rotten log or into the duff.

6. Great care must be taken not to injure young growth in felling timber, or to bark valuable young trees in skidding.

7. Felled trees must be cut into logs at once, to release young growth crushed by their fall, unless a reason satisfactory to the forester can be given for some other course.

8. Any young growth bent over by felled trees must be released and allowed to straighten without delay.

9. Provision for carrying out these regulations should be made in all contracts with lumbermen, and fines should be imposed by the contracts for failure to comply with them.

XVI

RETURNS

ALTHOUGH none but apparently sound trees were measured in the valuation surveys, in making the final estimate of stand the following percentages were allowed for unsoundness which did not appear on the surface:

Birch and Maple..... 40 per cent.
Hemlock..... 30 "

The low stumpage price given for Spruce and Pine is believed to equalize fully the loss through unsoundness.

Beech, Cherry, Ash, and Cedar are left out of account entirely. With this allowance for cull, the total stand of merchantable timber of the species named in the Park, taking 27,533 acres as the total wooded area, is as follows;

SKIDWAY OF HARDWOODS. SANTA CLARA, N. Y.

TABLE 34

MERCHANTABLE TIMBER IN NE-HA-SA-NE PARK

Species	Limit. Inches	Ave. merchantable stand per acre. Board feet.	Total merchantable stand. Board feet.
Spruce	10	3,703	101,954,699
Spruce	12	3,045	83,837,985
Spruce	14	2,400	66,079,200
Birch	15	1,802	49,614,466
Maple	15	278	7,654,174
Hemlock	12	687	18,914,171
Pine	12	74	2.037,442

According to conservative estimates the stumpage value of the various species is as follows:

	Per thousand board feet.
Spruce	$1 75
Birch	3 00
Maple	1 50
Pine	2 00
Hemlock (including bark)	1 50

If one-twenty-fifth of the standing timber, cutting the Spruce to twelve inches, were removed and sold as above, with allowance for cull, the receipts for the first year would be:

	Board feet.	
Spruce	3,353,515	$5,868 65
Birch	1,584,578	5,954 73
Maple	306,167	459 90
Pine	81,498	163 00
Hemlock	756,567	1,134 85
		$13,581 13

In order to be entirely safe, it may be assumed that on account of the necessity of leaving certain trees for silvicultural reasons, because of difficulties of transportation or a poor market, only fifty per cent. of the above receipts for the species other than Spruce and Pine would be obtained. The gross receipts for the first year would then be:

WHITE PINE ON LOW LAND. NE-HA-SA-NE PARK.

Spruce	$5,868 65
Pine	163 00
Other trees	3,774 74
Total	$9,806 39

The cost of administration for the first year is estimated to be:

Protection	$1,500 00
Taxes (at 4c. an acre)	1,101 32
Marking and inspection at 5 per cent. of gross receipts	487 28
Total	$3,088 60

Net receipts=$9,806.39 less $3,088.60 $6,717.79, or for the area cut (1101.3 acres), $6.09 per acre.

In order to determine what rate of interest on the capital value of the property the forest is producing annually, it is necessary to place a definite value on the land. The highest price paid for virgin forest by the New York Preserve Board in 1897 was $7.00 per acre.

It is, therefore, fair to use this figure for the sale lue of the property in the present case. On this sis the present value of the property is:

$$\$7.00 \times 27,533 = \$192,731.00,$$

on which sum the net receipts for the first year represent a return of 3.5 per cent. During the succeeding years the taxes as well as the value of the cut-over portions will be less than at first, until the timber shall have again attained merchantable size, and the price

of the timber will necessarily vary considerably; so that a statement of the financial results cannot safely be made. A return of at least 3.5 per cent. can, however, be obtained; for the decrease of the cut-over land in value as property will be followed by a decrease in the amount of taxes. This diminution in the cost of maintenance, and the probable increase in the price of timber, will both be to the advantage of the owner, and the rate of interest on the capital invested will in consequence be increased.

If the entire area were cut in one year, which for many reasons would be impossible, the gross receipts would be:

$9,806.39×25=$245,159.75, or $8.94 per acre.

The expenses of administration during the year in which the land is cut over are estimated to be:

Protection	$2,000 00
Taxes (at 4c. per acre)	1,101 32
Marking and inspection (at 2 per cent. of gross receipts)	4,872 84
	$7,974 16

Net receipts, $243,642.00, less $7,974.16=$235,667.84 or $8.56 per acre.

In this case the value of the land is not equal to the actual sale value of the timber, but this discrepancy is equalized by the cost of administration and the danger to the property through fire and windfall and other contingent risks which the owner must assume.

It would then be necessary to hold the land twenty-five years before an equal crop could be reaped. During this period there would be a necessary annual expenditure for taxes and protection, for which $2,000.00 per annum would be ample. This amount invested annually would amount in twenty-five years, at four per cent. compound interest, to $86,623.46. At the end of this period the land can be cut over a second time with the same yield of Spruce as at the first cut, and it is probable that on account of the rise in the value of Spruce much larger returns can then be secured than at present.

If the Park were cut over in five years the annual gross receipts for these years would be:

$9,806.39×5=$49,031.95, or $8.90 per acre.

It is estimated that the expenses for the first year would be:

Protection	$2,000 00
Taxes (at 4c. per acre)	1,101 32
Marking and inspection (at 3 per cent. of gross receipts)	1,461 85
	$4,563 17

Net receipts, $49,031.95, less $4,563.17=$44,468.78, or $8.07 per acre.

During the following four years a slightly better showing would be made on account of the decrease in taxes on the cut-over land.

There would then be twenty years in which an

annual expenditure of about $2,000.00 for taxes and protection would be necessary. In twenty years these payments, at four per cent. compound interest, would amount to $62,887.80.

APPENDIX

FOURTEEN valuation surveys, measured on cut-over land at Santa Clara, N. Y., in different situations and soils.

In each case the amount of timber removed at the first cut was estimated by measuring the old stumps and tops; and the Spruce suitable for pulp was cut and analyzed, the contents determined, and the rate of growth in diameter computed before and after the first lumbering.

PLOT NO. I

ONE ACRE MEASURED ON CUT-OVER SWAMP LAND AT SANTA CLARA, NEW YORK

MATERIAL CUT IN 1896.					Mean annual growth in diameter last 10 years. Inches.	MATERIAL LEFT AFTER CUTTING.				
Diameter. Inches.	Spruce cut in 1896	Average height. Feet.	Cubic feet	Standards		Spruce	Balsam	Birch	Maple	Cedar
1										
2						30	77			1
3						34	65			3
4						44	53			1
5	16	32.8	42.6	0.72	.08	23	27			2
6	36	36.7	140.0	2.38	.09	4	15	2		
7	38	40.6	232.6	4.52	.12	2	10			4
8	27	43.1	208.2	4.11	.12	1	10	2	1	1
9	21	43.7	221.6	4.65	.126	2	10			
10	12	43.8	174.9	3.56	.146		6			1
11	9	50.7	161.2	3.30	.138		2			
12	4	50.5	95.9	1.90	.18		1			
13	2	56.7	30.2	1.09	.13	1				
14	1	60.3	30.3	.63	.16					
15	1	56.0	28.1	.59	.08					
16	0									
17	0									
18	2	61.9	58.3	2.25	.09					
Total.	169		1423.7	29.70		141	276	4	1	13

This land was cut over in 1891, at which time one Spruce yielding .46 standard was removed. Situation: Spruce swamp. Soil: wet. Spruce short and long crowned. Balsam chiefly bunched on one side of the acre. No trees show increased growth after first cutting.

PLOT NO 2

ONE ACRE MEASURED ON CUT-OVER SWAMP LANDS AT SANTA CLARA, NEW YORK

MATERIAL CUT IN 1896					Mean annual growth in diameter last 10 years. Inches.	MATERIAL LEFT AFTER CUTTING.			
Diameter. Inches.	Spruce cut in 1896	Average height. Feet.	Cubic feet	Standards		Spruce	Balsam	Cedar	Birch
1									
2						66	187	1	
3						78	140	3	
4						46	98	5	
5	2	33.7	4.9	.06	.12	28	39	6	
6	30	37.8	120.1	1.95	.08	9	15		
7	41	37.8	230.6	4.58	.104		7	8	1
8	35	41.7	269.8	5.37	.11	1	3	2	1
9	26	43.6	272.5	5.92	.10		4		5
10	18	48.3	243.8	5.17	.116	1	2		
11	5	51.3	98.2	2.10	.132			1	
12	5	49.7	115.5	2.29	.132				
13	1	50.4	22.2	0.45	.13				
14	1	54.9	27.7	0 55	.08				
15	2	49.6	57.8	1.24	.16				
16	0								
17	1	45.7	41.6	0.86	.04				
Total.	167		1509.7	30.54		229	495	26	7

This land was cut over in 1891, at which time two Spruce trees with an estimated yield of 1.6 standards were removed. Situation: Spruce swamp. Soil: wet. Balsam bunched on one side of the acre. No trees show increased growth after cutting.

PLOT

ONE ACRE MEASURED ON A SPRUCE

MATERIAL CUT IN 1896								
Diam. Inches	Spruce cut in 1896	Ave. height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-91. Inches	Mean annual growth in diam. 92-96. Inches	Mean annual growth in diam. of 61 trees 92-96. Inches	No. of trees showing increased growth
1								
2								
3								
4								
5								
6	10	37.0	46.4	0.85	.11	.115	.20	1
7	27	39.9	156.9	2.75	.11	.165	.24	12
8	29	40.9	241.4	4.47	.115	.145	.20	12
9	32	43.2	328.6	6.92	.135	.18	.20	15
10	28	46.5	380.8	7.07	.15	.165	.21	10
11	12	48.0	182.9	4.24	.135	.175	.17	5
12	9	43.7	203.7	3.55	.16	.195	.23	4
13	1	48.1	22.0	0.42	.14	.20	.20	1
14	1	39.8	25.0	0.44	.18	.20	.20	1
Total	149		1587.7	30.71				61

This land was cut over in 1891, at which time 30 Spruce trees with were removed. Situation: intermediate between Spruce swamp and Spruce rather scrubby.

NO. 3

FLAT AT SANTA CLARA, NEW YORK

MATERIAL LEFT AFTER CUTTING							
Spruce	Dead Spruce	Balsam	Birch	Maple	Cedar	Cherry	Diam. Inches
							1
6	2	15	1	1	1		2
12	2	18					3
16	3	27				1	4
29	2	25		2	1		5
20		25					6
12		25			2		7
4		23			1		8
2		12					9
1		13					10
		3			1		11
1		4	1				12
		3				1	13
		1					14
103	9	194	2	3	6	2	Total

an estimated yield of 13.8 standards, and 8 Pine with 13.4 standards, Spruce flat. Soil: moist. Humus: deep. Seedlings: abundant.

PLOT

ONE ACRE MEASURED ON A SPRUCE FLAT AT

CUT OVER

MATERIAL CUT IN 1896								
Diam. Inches	Spruce cut in 1896	Aver. height Feet	Cubic feet	Stand-ards	Mean annual growth in diam. 87–88 Inches	Mean annual growth in diam. 89-96 Inches	Mean annual growth in diam. of 70 Trees 89-96 Inches	No. of Trees show-ing in-creased growth
1								
2								
3								
4								
5								
6	12	39.	41.3	0.74	.09	.10	.09	3
7	48	43.8	309.7	6.19	.09	.115	.18	14
8	61	49.5	524.5	11.81	.09	.13	.19	19
9	49	51.4	593.4	13.54	.115	.15	.205	14
10	30	52.0	456.7	10.12	.13	.18	.22	14
11	15	57.4	269.6	6.59	.14	.165	.17	4
12	2	57.1	42.0	.94	.13	.185	.26	1
13	1	56.2	25.7	.63	.05	.135	.135	1
14	1	57.8	26.7	.49	.10	.10		0
Total	219		2289.6	51.05				70

This land was cut over in 1888, at which time 37 Spruce with an were removed. Situation: Spruce flat. Soil: deep, fresh, rich. Humus: 0.8. Many young seedlings.

NO. 4

SANTA CLARA, NEW YORK, WHICH HAD BEEN IN 1888.

MATERIAL LEFT AFTER CUTTING						
Spruce	Dead Spruce	Balsam	Birch	Maple	Cedar	Diam. Inches
		4				1
7	2	13				2
20	5	9				3
22	3	11				4
24	3	5			1	5
16	1	6				6
1		2				7
		2		1		8
		2		2		9
			2	1		10
			2		1	11
			1			12
						13
						14
90	14	54	5	4	2	Total

estimated yield of 17 standards, and one Pine yielding 1.7 standards, deep. Character of Spruce excellent. Nearly even aged. Density

PLOT

0.2 ACRE MEASURED ON A SPRUCE FLAT AT

CUT OVER

MATERIAL CUT IN 1896.								
Diam. Inches	Spruce cut in 1896	Average height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-88 Inches	Mean annual growth in diam. 89-96 Inches	Mean annual growth in diam. of 13 trees 89-96 Inches	No. of trees showing increased growth
1								
2								
3								
4								
5								
6	4	47.0	19.5	0.32	.065	.065		
7	18	44.7	115.9	2.26	.085	.135	175	6
8	15	49.9	145.6	2.76	.105	.13	192	4
9	8	51.3	89.1	2.01	.115	.13	15	2
10	6	57.2	91.1	1.92	.135	.16	15	1
11	2	57.2	40.1	1.03	.15	.15		
12								
13	2	63.1	50.0	1.05	.17	.17		
14	1	64.7	31.8	0.72	.11	.11		
Total	56		583.1	12.07				13

This land was cut over in 1888, at which time 11 Spruce, with an as in Plot 4.

NO. 5

SANTA CLARA, NEW YORK, WHICH HAD BEEN IN 1888.

MATERIAL LEFT AFTER CUTTING.						
Spruce	Dead Spruce	Balsam	Birch	Maple	Cedar	Diam. Inches
4 8 4 3 5	1 1 1 1	5		1 1	1	1 2 3 4 5 6 7 8 9 10 11 12 13 14
24	4	5		2	1	Total

estimated yield of 4.4 standards, were removed. Situation and soil

PLOT

ONE ACRE MEASURED ON A SPRUCE FLAT

CUT OVER

MATERIAL CUT IN 1896.								
Diam. Inches	Spruce cut in 1896	Average height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-88 Inches	Mean annual growth in diam. 89-96 Inches	Mean annual growth in diam. of 20 trees 89-96 Inches	No. of trees showing increased growth
1								
2								
3								
4								
5								
6	20	38.2	38.2	1.47	.07	.075	.15	1
7	36	41.3	205.7	3.77	.095	.105	.235	3
8	25	43.0	197.2	3.71	.11	.125	.215	3
9	19	47.5	202.8	4.43	.11	.165	.235	7
10	17	49.3	236.4	4.94	.135	.165	.22	4
11	19	51.3	322.6	6.80	.145	.16	.27	2
12	8	56.1	191.7	3.99	.136	.136		
13	4	58.4	100.3	2.23	.164	.164		
14	2	55.7	56.3	1.42	.16	.16		
Total	150		1551.2	32.76				20

This land was cut over in 1888, at which time 13 Spruce with an removed. Situation: Spruce flat. Soil: deep, rich, moist. Humus: Old stumps chiefly bunched on western end.

NO. 6.

AT SANTA CLARA, NEW YORK, WHICH HAD BEEN IN 1888.

MATERIAL LEFT AFTER CUTTING.							
Spruce	Dead Spruce	Balsam	Birch	Maple	Cedar	Pine.	Diam. Inches
1				1			1
5		11	2				2
10	3	21	4				3
11	1	16	2				4
19		17	4				5
19	1	13					6
8		21					7
1	1	11		1	1		8
1		5	2	1			9
1		3		1	1		10
		2	1				11
			1	1		1	12
				1			13
							14
76	6	120	16	6	2	1	Total

estimated yield of 13 standards, and 6 Pine with 9 standards, were deep. Very gentle slope N. E. Spruce with moderately long crowns.

PLOT

ONE ACRE MEASURED ON A SPRUCE FLAT AT

CUT OVER

MATERIAL CUT IN 1896								
Diam. Inches	Spruce cut in 1896	Ave. height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-91 Inches	Mean annual growth in diam. 92-96 Inches	Mean annual growth in diam. of 45 trees 92-96 Inches	No. of trees showing increased growth
1								
2								
3								
4								
5								
6	11	40.4	49.	0.87	.085	.15	.205	6
7	24	42.9	150.5	2.69	.085	.13	.19	9
8	18	43.2	148.8	2.94	.115	.15	.18	7
9	21	48.9	248.8	5.25	.125	.185	.24	12
10	28	46.3	378.3	8.14	.145	.17	.215	9
11	11	50.2	176.4	3.53	.13	.14	.21	2
12	2	55.3	43.2	.88	.175	.255	.28	1
13								
14								
15								
16								
17								
18								
Total	115		1195.0	24.30				46

This land was cut over in 1891, at which time 34 Spruce with an removed. Situation: Spruce flat. Nearly level. Soil: deep, rich over the ground.

NO. 7

SANTA CLARA, NEW YORK, WHICH HAD BEEN IN 1891

MATERIAL LEFT AFTER CUTTING							
Spruce	Dead Spruce	Balsam	Birch	Maple	Cedar	Pine	Diam. Inches
							1
5	5	19					2
28	8	21					3
14	3	21	1				4
19	3	16					5
6	1	13					6
1	2	8	1		2		7
		10					8
		7	1		1		9
		2		1			10
		1		1			11
			1	1			12
			1				13
			2				14
							15
			1				16
							17
						1	18
73	22	118	8	3	3	1	Total

estimated yield of 10.4 standards, and 1 Pine with .5 standard, were moist. Spruce of excellent quality. Old trees evenly distributed

PLOT

ONE ACRE MEASURED ON A SPRUCE FLAT AT

CUT OVER

MATERIAL CUT IN 1896								
Diam. Inches	Spruce cut in 1896	Ave. height Feet	Cubic feet	Standards	Mean annual growth in diam. 87–91. Inches	Mean annual growth in diam. 92-96. Inches	Mean annual growth in diam. of 9 trees 92-96. Inches	No. of trees showing increased growth
1								
2								
3								
4								
5	3	37.4	9.3	.12	.08	.08		
6	19	37.7	78.3	1.30	.10	.10		
7	24	40.7	143.3	2.75	.085	.10	.18	3
8	39	44.6	331.4	6.76	.12	.13	.22	2
9	32	49.6	363.8	7.86	.12	.13	.20	3
10	24	48.0	307.2	7.32	.13	.13		
11	21	51.6	375.2	8.10	.12	.13	.26	1
12	21	56.2	453.6	9.97	.155	.16		
13	6	57.3	165.5	3.70	.172	.172		
14	4	60.4	112.4	2.28	.162	.16		
15	1	61.8	36.4	.84	.08	.08		
16	3	57.0	69.2	1.81	.226	.226		
Total	197		2445.6	52.81				9

This land was cut over in 1891, at which time 10 Spruce with an were removed. Situation: Spruce flat. Soil: fresh, rich. Spruce of

NO. 8

SANTA CLARA, NEW YORK, WHICH HAD BEEN IN 1891

MATERIAL LEFT AFTER CUTTING						
Spruce	Balsam	Birch	Ash	Cherry	Cedar	Diam. Inches
						1
37	90		1		2	2
36	89				2	3
47	69				2	4
37	51				1	5
13	50				8	6
1	24	1			2	7
1	20	1			6	8
	9		1		6	9
	10				1	10
	1	1			1	11
	2	1		1		12
	1					13
						14
	1					15
						16
172	417	4	2	1	31	Total

estimated yield of 2.6 standards, and 1 Pine with 1.5 standards, excellent quality.

PLOT

ONE ACRE MEASURED ON A SPRUCE FLAT

CUT OVER

MATERIAL CUT IN 1896								
Diam. Inches	Spruce cut in 1896	Ave. height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-90. Inches	Mean annual growth in diam. 92-96. Inches	Mean annual growth in diam. of 12 trees 92-96. Inches	No. of trees showing increased growth
1								
2								
3								
4								
5	1	29.4	3.2	.05	.08	.08		
6	27	39.0	125.7	2.22	.08	.09	.21	2
7	22	43.9	140.8	2.77	.10	.10		
8	28	44.3	253.9	5.59	.12	.145	.205	6
9	28	47.6	320.2	6.75	.12	.12		
10	20	51.0	302.5	6.66	.13	.14	.245	3
11	9	53.1	176.6	3.51	.11	.11		
12	8	54.6	177.1	3.96	.18	.18	.20	1
13	4	59.3	109.2	2.35	.184	.184		
14								
Total	147		1609.2	33.86				12

This land was cut over in 1891, at which time 11 Spruce with an were removed. Situation: Spruce flat. Level. Soil: moist, rich.

NO. 9

AT SANTA CLARA, NEW YORK, WHICH WAS IN 1891

MATERIAL LEFT AFTER CUTTING						
Spruce	Balsam	Birch	Maple	Cedar	Cherry	Diam. Inches
						1
28	33		5			2
26	21		2			3
25	15			1		4
13	21	1		1		5
6	20			1		6
	12			1		7
	11	1				8
	5	1		1		9
	4	2		1	1	10
	1	1				11
	1					12
	2					13
		1				14
98	146	9	7	6	1	Total

estimated yield of 2.6 standards, and 6 Pine yielding 11.3 standards Spruce of good quality.

PLOT

0.8 ACRE MEASURED ON A SPRUCE SLOPE

CUT OVER

MATERIAL CUT IN 1896								
Diam. Inches	Spruce cut in 1896	Average height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-88. Inches	Mean annual growth in diam. 89-96. Inches	Mean annual growth in diam. of 38 trees 89-96. Inches	No. of trees showing increased growth
1								
2								
3								
4								
5	3	34.6	9.57	0.15	.10	.10	.10	1
6	13	42.2	58.2	0.96	.11	.115	.09	1
7	25	46.2	162.0	3.50	.085	.12	.18	6
8	28	48.5	252.5	5.59	.09	.145	.185	16
9	15	52.5	180.0	3.99	.11	.12	.18	9
10	7	52.0	101.3	2.06	.12	.185	.17	5
11	2	54.6	32.6	0.63	.23	.23		
12								
13								
14								
15								
16								
17								
18								
20								
Total	93		796.17	16.88				38

This land was cut over in 1888, at which time 34 Spruce, with an slope. Soil: rather thin. Slope: S. W. about 10°–15°. Spruce of

NO. 10

AT SANTA CLARA, NEW YORK, WHICH HAD BEEN IN 1888.

MATERIAL LEFT AFTER CUTTING						
Spruce	Balsam	Birch	Maple	Cedar	Pine	Diam. Inches
						1
5	1					2
4	4					3
10	3	1				4
17		1				5
10		6	1	6		6
1	1	1		1		7
		9	2	4		8
		3	2	1		9
		6	1			10
		2	1			11
		2	1			12
		2				13
			1			14
						15
						16
						17
					1	18
		1				20
47	9	34	9	12	12	Total

estimated yield of 38.4 standards, were removed. Situation: Spruce excellent quality.

PLOT

ONE ACRE MEASURED ON CUT OVER

MATERIAL CUT IN 1896.								
Diam. Inches	Spruce cut in 1896	Average height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-88 Inches	Mean annual growth in diam. 89-96 Inches	Mean annual growth in diam. of 14 trees 89-96 Inches	No. of trees showing increased growth
1								
2								
3								
4								
5	1	35.0	3.4	0.06	.14	.14		
6	12	39.2	44.9	0.77	.09	.11	.22	2
7	36	42.9	213.0	3.72	.10	.115	.195	5
8	32	47.6	287.3	5.78	.10	.115	.23	3
9	15	47.9	177.8	3.66	.10	.10		
10	18	55.0	266.6	5.92	.11	.14	.255	3
11	11	53.6	201.5	4.27	.115	.125	.25	1
12	1	54.5	21.0	0.28	.20	.20		
13	3	62.2	83.0	1.61	.18	.18		
14								
15								
16								
17								
18								
Total	129		1298.5	26.07				14

This land was cut over in 1888, at which time 27 Spruce with an were removed. Situation: partly Spruce slope and partly Spruce flat.

NO. 11

LAND AT SANTA CLARA, NEW YORK

MATERIAL LEFT AFTER CUTTING.								
Spruce	Dead Spruce	Balsam	Birch	Maple	Cedar	Pine	Ash	Diam. Inches
	1							1
10	4	9	1					2
25	4	12			1			3
27	5	8	1		2			4
27	3	4	6	1	3			5
12	2	5	13	2	8		1	6
4	3	1	11	2	10			7
		5	20	3	3	1		8
1		1	7	2	4			9
		2	13	6	2			10
1			5	4	1			11
			4	2				12
			1	1				13
			2					14
			2					15
			1	1				16
			1					17
			1					18
107	22	47	89	24	34	1	1	Total

estimated yield of 9.8 standards, and 5 Pine with 7.9 standards, Spruce of good quality.

PLOT

0.9 ACRE MEASURED ON HARDWOOD LAND

CUT OVER

MATERIAL CUT IN 1896.

Diam. Inches	Spruce cut in 1896	Average height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-88 Inches	Mean annual growth in diam. 89-96 Inches	Mean annual growth in diam. of 4 trees 89-96 Inches	No. of trees showing increased growth
1								
2								
3								
4								
5								
6	9	42.8	41.2	0.61	.08	.08		
7	26	44.3	161.6	2.94	.07	.08	.205	2
8	12	49.0	107.5	2.23	.11	.12	.21	1
9	12	52.8	145.4	3.15	.13	.145	.21	1
10	11	53.4	166.4	3.52	.11	.11		
11	1	63.8	20.9	0.48	.10	.10		
12								
13	1	61.9	28.7	0.61	.18	.18		
14								
15								
16								
17								
18								
Total	72		671.7	13.54				4

This land was cut over in 1888, at which time 20 Spruce with an with 1.14 standards, 2 Cherry with 1.09 standards, were removed. good quality.

NO. 12.

AT SANTA CLARA, NEW YORK, WHICH HAD BEEN IN 1888.

MATERIAL LEFT AFTER CUTTING.								
Spruce	Dead Spruce	Balsam	Birch	Maple	Cedar	Hemlock	Cherry	Diam. Inches
								1
17		3						2
18	1	5	1					3
14		3			1			4
19	5	1	4	1	1	1		5
7	1		5	2	2		1	6
2		2	8	1	1	1		7
	1		6	4				8
			11	2	1			9
	1		7	3	1	1		10
			3	5				11
			5	3				12
			5					13
			5					14
		1	1					15
			4					16
			1					17
			3					18
77	9	15	69	21	7	3	1	Total

estimated yield of 12 standards, 2 Pine with 3.7 standards, 2 Balsam
Situation: hardwood land. One corner: Spruce flat. Spruce of

PLOT

1.5 ACRES MEASURED ON HARDWOOD LAND AT

OVER

MATERIAL CUT IN 1896								
Diam. Inches	Spruce cut in 1896	Aver. height Feet	Cubic feet	Stand-ards	Mean annual growth in diam. 87-88 Inches	Mean annual growth in diam. 89-96 Inches	Mean annual growth in diam. of 15 Trees 89-96 Inches	No. of Trees show-ing in-creased growth
1								
2								
3								
4								
5								
6	5	43.4	22.1	0.34	.056	.056		
7	10	44.4	101.0	1.80	.065	.085	.20	2
8	25	49.1	220.0	4.27	.07	.09	.30	10
9	14	50.0	246.6	4.91	.115	.125	.19	2
10	14	57.0	225.0	4.87	.115	.13	.30	1
11	5	59.1	90.5	2.09	.128	.128		
12	2	54.3	41.7	.89	.17	.17		
13	3	51.1	67.6	1.70	.14	.14		
14								
15								
16								
17								
18								
19								
Total	84		1014.5	20.87				15

Land cut over in 1888. 24 Spruce with an estimated yield of 11.4 removed. Situation: hardwood land. Soil: rather rocky and thin.

NO. 13

SANTA CLARA, NEW YORK, WHICH HAD BEEN CUT IN 1888

MATERIAL LEFT AFTER CUTTING								
Spruce	Dead Spruce	Balsam	Birch	Maple	Cedar	Hemlock	Cherry	Diam. Inches
								1
7		5						2
14		6	1	1				3
14	5	2			1	1		4
10	4	1	2			1		5
1	1	2	2			1		6
1		1	3	2	1			7
1	1	1	14	2				8
	4	2	6	5	1			9
		3	5	5				10
	1		11	3				11
			4	1				12
			7	1			1	13
			10	1			1	14
			6	1			1	15
			1					16
			2			1		17
			4	1				18
			1				1	19
48	16	23	81	23	3	4	4	Total

standards, 1 Pine with 1.4 standards, and 5 Cedar with 1.1 standards, Character of Spruce: good.

PLOT

1.5 ACRES MEASURED ON A SPRUCE

MATERIAL CUT IN 1896								
Diam. Inches	Spruce cut in 1896	Average height Feet	Cubic feet	Standards	Mean annual growth in diam. 87-88. Inches	Mean annual growth in diam. 89-96. Inches	Mean annual growth in diam. of 4 trees 89-96. Inches	No. of trees showing increased growth
1								
2								
3								
4								
5								
6	6	44.2	30.2	0.49	.094			
7	27	41.8	169.8	2.89	.12	.13	.18	1
8	38	46.8	357.2	7.49	.12	.12		
9	32	49.7	366.5	7.89	.116	.116		
10	23	53.7	357.6	8.45	.125	.125		
11	27	59.9	554.7	12.53	.14	.155	.265	3
12	16	57.5	362.0	8.00	.144	.144		
13	7	58.2	209.9	4.60	.182	.182		
14	2	60.5	65.7	1.45	.154	.154		
15								
16	1	65.0	45.0	1.07	.14	.14		
17								
18								
19								
20								
Total	179		2518.6	54.86				4

This land was cut over in 1888, at which time 13 Spruce trees, with ards; one Balsam with .6 standards, and 2 large Hemlocks cut for Old stumps chiefly bunched at one end of area.

NO. 14.

FLAT AT SANTA CLARA, NEW YORK.

MATERIAL LEFT AFTER CUTTING						
Spruce	Balsam	Birch	Maple	Cedar	Cherry	Diam. Inches
						1
16	23	1				2
28	39					3
20	27	2				4
33	20		1			5
12	26	2				6
7	25	4	4	1		7
2	13	2	2	3		8
	11	4	1	1	1	9
	3	8	10		1	10
	2	3	1			11
	2	2		2		12
			2	2		13
		2	4			14
		2				15
		1				16
		1				17
		1				18
			1			19
		1				20
118	191	36	26	9	2	Total

an estimated yield of 11.15 standards; 2 Tamaracks with 1.8 stand-bark, were removed. Situation: Spruce flat. Soil: fairly rich and moist.

INDEX