FORESTRY
IN
NEW ENGLAND

HAWLEY AND HAWES

The B. H. Hill Library

North Carolina State College

SD144

A12H3

Date Due

701/25			
23 Oct 35			
No'46E			
TLN2U			
3-22-78			

31144		Hawley, Ralph J.	
..1175		Forestry in New	
AUTHOR		5751	
TITLE		England.	
DATE DUE		BORROWER'S NAME	
Dec 17 '29	Crotches J.C.		
23 Oct 35	W. B. G. 3113		
F B '39	Page		
7 No'46E	R. E. Vail		

5751

FORESTRY IN NEW ENGLAND

A HANDBOOK OF
EASTERN FOREST MANAGEMENT

BY

RALPH CHIPMAN HAWLEY, M. F.

ASSISTANT PROFESSOR OF FORESTRY, YALE UNIVERSITY

AND

AUSTIN FOSTER HAWES, M. F.

STATE FORESTER OF VERMONT AND PROFESSOR OF FORESTRY,
UNIVERSITY OF VERMONT

FIRST EDITION

FIRST THOUSAND

NEW YORK

JOHN WILEY & SONS

LONDON: CHAPMAN & HALL, LIMITED

1912

.A13H3

COPYRIGHT, 1912,
BY
RALPH C. HAWLEY
AND
AUSTIN F. HAWES

5751

Stanhope Press
F. H. GILSON COMPANY
BOSTON, U.S.A.

To

HENRY SOLON GRAVES

FORESTER OF THE UNITED STATES.

WITH A DEEP SENSE OF OUR PERSONAL OBLIGATIONS TO HIM AS
OUR PRECEPTOR IN THE YALE FOREST SCHOOL WHICH HE
ORGANIZED AND BUILT UP TO RANK AS THE FORE-
MOST SCHOOL OF FORESTRY IN THIS COUNTRY,
AND IN RECOGNITION OF HIS SERVICES
TO AMERICAN FORESTRY AS AN
EDUCATOR, WRITER AND
ADMINISTRATOR.

PROPERTY OF
A. & M. COLLEGE LIBRARY.

5751

PREFACE.

THROUGHOUT America and especially New England there has been a rapid awakening of interest in forestry during the past few years. The disappearance of old forests, together with increased prices of lumber, has made ready converts to the forestry propaganda of the federal and state governments; but up to the present time nearly the only available literature on the subject is in the form of government bulletins. There are, to be sure, a number of good books on the trees written from a botanical standpoint, and several books dealing with forestry in a general way, besides a very few advanced textbooks. There is now such widespread interest in the subject, that a book dealing with the specific forestry problems of New England will not only be of interest to the nature lover but of real assistance to the land owner who wishes to adopt approved methods of forest culture, or to the student of forestry. Books are legend dealing with specific agricultural problems, and it is intended that this work shall be for the woodland owner what these are for the agriculturist. Every year more people are moving from the cities and acquiring country places. Many owners of this class cannot afford their personal time for farm supervision, and, without this supervision of the owner, farming is apt to be too expensive. Forestry particularly appeals to this class of owners because it requires less frequent attention than any other land culture.

It is gratifying to find that the farmers themselves are taking up forestry in the same practical way in which they are accustomed to handle other problems, and the authors frequently have been asked by farmers to recommend some good book on forestry. Practical problems, such as the planting of an old hill pasture to pine, or the advisability of pruning pine and

spruce; the proper treatment of a sugar orchard, — these and many similar questions are constantly being asked by the up-to-date farmer.

Lumbermen also are becoming interested in forestry, and, while they have not yet to any extent adopted modern methods of cutting, this is largely due to unfavorable conditions and ignorance of such methods.

In preparing this book the authors have been governed by a twofold purpose: first, by the desire to present a book which might be of practical assistance to all classes of land owners in the East; and second, to produce a textbook treating of forestry in New England. The latter is greatly needed, especially in the various agricultural colleges where courses in forestry are given, and where it is essential that thorough instruction in the forest problems of the northeastern United States be furnished. There is even a wider field for a book dealing with a definite section of the country, so arranged as to serve as a handbook for owners of woodland in the section treated. It has been the aim of the authors throughout to present the material in the simplest and least technical form possible, with the view of making everything clear to persons not familiar with forestry.

The book is arranged in two parts: one dealing with methods and principles of forestry in general, the second treating in detail with the forests of New England. While it is written with special reference to New England, the book has a much wider field of direct application. Forest conditions similar to those in portions of New England prevail over a large part of New York and New Jersey, in Pennsylvania, and also in southeastern Canada.

Part I is intended to furnish the woodland owner with a brief survey of the whole field of forestry, and to give him sufficient knowledge to rightly understand and be able to carry out the treatment recommended in Part II for his forest land. The subjects in Part I are too comprehensive to be fully covered in one volume. In many cases the presentation here will be

sufficient, but if a complete discussion is needed various more technical works restricted to a single subject should be consulted. For example, two books by Graves, "Forest Mensuration" and "Principles of Handling Woodlands," cover mainly the three subjects "Silvicultural Systems," "Timber Estimating" and "The Growth of Trees and Forests," which are here included in three chapters.

As a textbook, then, for the post-graduate forest schools giving the highest grade of instruction, this book will have a greater value for its detailed discussion of New England forests, than for the portion dealing with general forestry. But it is hoped that, for numerous undergraduate forest schools giving a slightly lower grade of instruction, all portions of the book will prove useful.

The publications of the United States Forest Service relating to New England topics, as well as those issued by the Forestry Departments of the different New England States, have been freely consulted, and much of the information which they contain has been incorporated in these pages.

Free use has also been made of various books dealing with the subjects treated in these chapters. Among them are the following: "History of the Lumber Industry in America" by Defebaugh; "Studies in Forestry" by Nisbet; "Principles of Handling Woodlands" and "Forest Mensuration" by Graves; "A Textbook of Botany" by Strasburger Schenck, Noll and Schimper; "Handbook of Trees of the Northern States and Canada" by Hough; and various articles in *Forestry Quarterly* too numerous to mention.

All the tables in the appendix, with the exception of certain log rules and several tables taken from a "Manual for Northern Woodsmen" by Prof. Austin Cary, have been secured from state or federal forest service publications. In connection with each table acknowledgment is made of the source from which it was obtained.

The sketches and a majority of the pictures are original with the authors, although a large number were secured from other

sources. Wherever a picture was not taken by the authors its origin is stated beneath the picture.

In conclusion, the authors wish to render acknowledgment to the many friends who have assisted with helpful suggestions in the preparation of this book.

CONTENTS.

	PAGE
PART I. GENERAL FORESTRY	I
CHAPTER I. SILVICS	I
Forest Types	8
Pure and Mixed Stands	10
Coppice and High Forests	12
Even and Uneven-aged Forests	14
High Forest Forms	15
Coppice Forms	16
Composite Forms	16
CHAPTER II. SILVICULTURAL SYSTEMS	17
I. Systems depending on Reproduction by Seed	17
Selection System	17
Clear Cutting Systems	20
Clear Cutting with Artificial Reproduction	21
Clear Cutting with Natural Reproduction	22
Clear Cutting the Whole Stand	22
Reserving Blocks of Trees	22
Reserving Scattered Seed Trees	24
Reserving Thrifty Standards	25
Clear Cutting in Strips	26
Clear Cutting in Patches	27
The Shelterwood System	27
II. Systems depending on Reproduction Wholly or Partly from	
Sprouts	31
Simple Coppice	32
Coppice with Standards	33
Pole-wood Coppice	35
CHAPTER III. SILVICULTURAL CHARACTERISTICS OF THE IMPORTANT	
NEW ENGLAND TREES	37
White Pine	37
Red Pine	41
Pitch Pine	42
Scotch Pine	43
Red Spruce	45
Norway Spruce	47

	PAGE
Balsam or Fir.....	48
Hemlock.....	49
Tamarack.....	50
European Larch.....	51
Arborvitæ.....	52
Juniper.....	52
Sugar Maple.....	53
Soft Maple.....	54
Yellow Birch.....	54
Paper Birch.....	55
Gray Birch.....	56
Beech.....	57
White Ash.....	58
Basswood.....	58
Poplar.....	59
Chestnut.....	60
White and Red Oaks.....	62
Tulip Tree.....	63
CHAPTER IV. FOREST PLANTING AND SEEDING.....	65
CHAPTER V. IMPROVEMENT CUTTINGS.....	74
Cleanings.....	74
Liberation Cuttings.....	76
Thinnings.....	79
Damage Cuttings.....	91
Schedule of Improvement Cuttings.....	92
Methods of Controlling Cuttings.....	93
Pruning.....	95
CHAPTER VI. INJURIES FROM ANIMALS.....	97
CHAPTER VII. FOREST INSECTS AND FUNGI.....	101
Insects.....	101
White Pine Weevil.....	101
Pine Bark Aphid.....	103
Spruce Destroying Beetle.....	105
Spruce Budworm.....	106
Gipsy Moth.....	108
Brown-tail Moth.....	110
Larch Sawfly.....	111
Elm Leaf Beetle.....	113
Forest Tent Caterpillar.....	114
June Bug.....	116
Fungi.....	118
Chestnut Bark Disease.....	118
Trametes pini.....	122

CONTENTS

xi

	PAGE
Polyporus schweinitzii	123
White Pine Blister Rust	124
White Heart Rot	126
White Pine Blight	129
CHAPTER VIII. FOREST FIRES	131
Kinds of Fires and Damage done	131
Causes of Fires	136
Fire Prevention	138
Fire Lines	142
Roads and Trails	146
Extinguishing Fires	146
Estimating the Damage done by Forest Fires	152
CHAPTER IX. TIMBER ESTIMATING AND VALUATION	156
Estimating Timber on Small Woodlots	157
Estimating Timber on Large Woodlots	161
Estimating Timber on Large Forest Tracts	161
The Money Value of Standing Timber	165
CHAPTER X. GROWTH OF TREES AND FORESTS	171
Growth of Trees	171
Age of Trees	172
Diameter Growth	174
Height Growth	175
Volume Growth	176
Growth of Stands	178
Age of Stands	178
Diameter Growth	179
Height Growth	179
Volume Growth	179
PART II. NEW ENGLAND FORESTS AND THEIR MANAGEMENT	183
CHAPTER XI. THE ORIGINAL FORESTS AND THEIR EARLY DEVELOPMENT	183
CHAPTER XII. PRESENT FOREST CONDITIONS	196
How to find Information Applicable to a Particular Tract	199
CHAPTER XIII. THE SPRUCE REGION	200
General Considerations	200
Forest Types	203
Swamp	205
Spruce Flat	206
Hardwood	208
Spruce Slope	209

	PAGE
Birch and Poplar	211
Old Field	215
Methods of Handling the Forest	216
Spruce Slope	217
Spruce Flat	220
Swamp	222
Hardwood	223
Old Field Spruce	226
Birch and Poplar	228
Planting	231
Avoiding Waste in the Woods	232
Logging Methods	235
Market Conditions	242
Industries	243
Pulpwood	243
Lumber Industry	245
Special Woodworking Industries	248
Summer Resort Business	249
Character of the Land and Timber Ownership	251
Forest Protection	253
Forest Fires	254
Methods of Fire Protection	257
Fighting Fires	261
Protection against Grazing Animals	262
Protection against Insects	262
Protection against Fungi	263
Watershed Protection	263
Summary	264
CHAPTER XIV. THE NORTHERN HARDWOODS REGION	265
General Considerations	265
Forest Types	269
Hardwood	269
Swamp	272
Birch and Poplar	272
Old Field Hardwoods	273
Old Field Conifers	274
Methods of Handling the Forest	276
Hardwood	277
Swamp	283
Birch and Poplar	283
Old Field Hardwoods	284
Old Field Conifers	285
Logging Methods	285
Market Conditions	287
Industries	288

CONTENTS

xiii

	PAGE
Lumber Industry.....	288
Maple Sugar Industry.....	289
Character of the Land and Timber Ownership.....	290
Forest Protection.....	291
Forest Fires.....	291
Methods of Fire Protection.....	292
Protection against Grazing Animals.....	293
Protection against Insects and Fungi.....	295
Watershed Protection.....	295
Summary.....	295
CHAPTER XV. THE WHITE PINE REGION.....	296
General Considerations.....	296
Forest Types.....	299
Hemlock.....	300
Pitch Pine.....	301
White Cedar Swamp.....	301
Pure White Pine.....	303
Pine and Inferior Hardwoods.....	308
Mixed Hardwoods.....	311
Soft Maple Swamp.....	312
Waste Land.....	312
Methods of Handling the Forest.....	313
Hemlock.....	314
White Cedar Swamp.....	316
Pitch Pine.....	316
Pure White Pine.....	318
Pine and Inferior Hardwoods.....	323
Mixed Hardwoods.....	324
Soft Maple Swamp.....	325
Waste Land.....	325
Logging Methods.....	327
Market Conditions.....	328
Industries.....	329
Ownership of Woodlands.....	332
Forest Protection.....	332
Forest Fires.....	332
Methods of Fire Protection.....	335
Methods of Fighting Fires.....	339
Protection against Grazing Animals.....	339
Protection against Insects and Fungi.....	340
Watershed Protection.....	341
Summary.....	341
CHAPTER XVI. THE SPROUT HARDWOODS REGION.....	342
General Considerations.....	342
Forest Types.....	346

	PAGE
Mixed Hardwoods.....	346
Hemlock.....	348
Hardwood Swamp.....	350
Cedar Swamp.....	351
White Pine.....	351
Old Field.....	351
Methods of Handling the Forest.....	354
Mixed Hardwoods.....	356
Hemlock.....	359
Hardwood Swamp.....	360
Cedar Swamp and White Pine.....	361
Old Field.....	361
Logging Methods.....	362
Market Conditions.....	364
Industries.....	364
Ownership of Woodlands.....	366
Forest Protection.....	367
Forest Fires.....	367
Methods of Fire Protection.....	369
Methods of Fighting Fires.....	371
Protection against Grazing Animals.....	371
Protection against Insects and Fungi.....	372
Watershed Protection.....	372
Summary.....	373
 CHAPTER XVII. THE PROGRESS OF FORESTRY IN NEW ENGLAND...	 374
Forest Administration.....	379
Connecticut.....	379
Administration.....	379
Fire Service.....	379
Educational Work.....	380
State Forests.....	381
State Nursery.....	383
Taxation.....	383
Massachusetts.....	384
Administration.....	384
Fire Service.....	384
Educational Work.....	385
State Forests.....	386
State Nursery.....	386
Forest Taxation.....	386
Control of Gipsy and Brown-tail Moths.....	388
Rhode Island.....	389
Administration.....	389
Fire Service.....	389
Educational Work.....	390

CONTENTS

XV

PAGE

State Forests	391
Taxation	391
Control of the Gipsy and Brown-tail Moths	391
Vermont	391
Administration	391
Fire Service	392
Educational Work	394
State Forests	394
State Nursery	395
Taxation	395
New Hampshire	396
Administration	396
Fire Service	396
Educational Work	398
State Forests	398
State Nursery	399
Taxation	399
Maine	399
Administration	399
Fire Service	400
Educational Work	402
State Forests	402
Insects	403
Forestry Practice	403
Lands under State Ownership	403
Lands under Corporate and Private Ownership	404
CHAPTER XVIII. THE YIELD TO BE EXPECTED FROM NEW ENGLAND FORESTS UNDER PROPER MANAGEMENT	408
APPENDIX	417
Forest Fire Statistics	417
Bibliography	420
Tables	426
Log Rules	427
Volume Tables	438
Growth of Individual Trees	464
Yield Tables	466
INDEX	475

FORESTRY IN NEW ENGLAND

PART I.

GENERAL FORESTRY.

CHAPTER I.

SILVICS.

IN any study of forests over a wide range of country, as a whole continent, it must be apparent that climate determines the character of the forest just as it affects the growth of agricultural crops in certain regions or belts. In a small region, such as New England, the climatic factors are less noticeable, but cannot be overlooked.

The average temperature of a region is of less importance in determining the range of different trees than the lowest and highest extremes of temperature. In these extremes we have an explanation of the inability of the eucalyptus of southern California to live in New England, and of the fact that the canoe birch, although growing from the Atlantic to the Pacific, does not extend as far south as Long Island Sound. In a less noticeable way it is probably the extreme cold of winter which limits the chestnut to southern New England and the region farther south. Aside from this matter of extremes it is not so much the winter's cold that is injurious to species, as the late frosts in spring when the young leaves and shoots are still tender, and the early frosts of the autumn before the summer's growth has sufficiently hardened to withstand the cold. The late frosts of the spring of 1910 killed back the new growth of pine and fir in northern Vermont.

Besides temperature there are other climatic factors influencing tree growth. It has been found, for example, that the southern limits of forest trees are mainly determined by the quantity and the regularity of the rainfall during summer. Taken as a whole, broadleaf trees consume on the average about ten times as much water as conifers, and, owing to the light foliage of pine, this species requires much less soil moisture than spruce or fir. The lack of rain for even two or three days may be fatal to young seedlings. White pine plantations established two years previously were badly killed out by the prolonged drought and hot weather of 1911. With age and development of the root system the ability of the tree to resist drought increases. A mature tree with the assistance of its reserve supplies of water can withstand a drought of several months' duration. Precipitation outside of the growing season is also valuable, in thoroughly wetting the soil, because during the growing season when the trees are in foliage the soil is seldom thoroughly wet.

Aside from these climatic factors, heat and rainfall, which influence the general distribution of forests, the factors most important to individual tree growth are light and soil moisture, and to a lesser extent the physical and chemical character of the soil. Each genus, and in some respects each species, reaches its best development under a certain set of conditions of soil, climate, etc., called its optimum, and varies whenever found under different conditions. Since topography, exposure, and altitude affect these factors, they must also be taken into account. Near their northern limits of distribution all trees ascend the mountains to a greater height on the southern than on the northern sides, because of warmth requirements.

Trees derive most of their nourishment from the carbonic acid of the atmosphere, but they depend upon the soil for water and mineral supplies; these can only be taken up when held in solution by the soil. Water is a chief essential of tree growth, part of it being retained in the wood. Greenwood often contains as much as 50 per cent by weight of water. Water in the plant serves as a carrier for the minerals (the salts, oxides, etc.), which,

being non-volatile, remain in the plant after the water is given off. The process of taking up minerals in solution through the roots, of depositing these minerals, and of giving off water from the leaves is called transpiration; this is one of the leading features of plant life. Trees of normal size lose by this process from 10 to 25 gallons of water daily, and it has been estimated that a large oak with 700,000 leaves gives off 244,000 pounds of water in the five months from June to November, or an average of 25 tons a month — nearly one ton a day. Transpiration is greater in the daytime than in the night, and leaves exposed to the sun transpire from three to ten times as much water as those that are shaded. There has not yet been developed any very satisfactory theory explaining the movement of water to the top of a high tree. It is known that the minute root hairs at the ends of the roots fasten themselves to the soil particles and withdraw water from them even when they appear dry; and it is probable that the transpiration current, which flows through the wood to the leaves, is forced up by a combination of atmospheric and root pressure aided by osmotic force¹ and capillarity. As has been said, the conifers are more moderate in their demands on water than the broad-leaved genera. This is the reason why sand plains, such as those of Cape Cod, can support the pine. The water table is always found to be farther removed from the surface of the ground under forest than outside it or under a cut-over forest; under old forests it is lower than under young stands. Seedlings spring up in a forest when the roots of the adjoining trees are cut through, thus allowing the water table to come nearer the surface. From the illustration of the oak mentioned above it will be readily realized, in dry seasons especially, that the amount of water available per tree might well be the controlling factor influencing growth or life itself. Forests transpire more moisture than other vegetation under the same conditions. Any deficit caused by excess of transpiration over precipitation is necessarily made up by water from the

¹ See "A Text Book of Botany," Part I, Sect. II, by Strasburger, Schenck, Noll, and Schimper.

open. Other things being equal and leaving the surface out of account, the soil under a mature forest is drier than in the open. Thus seedlings grown in the open get more moisture in a dry season than under large trees, but, on the other hand, the intense heat in the open may more than counterbalance the greater supply of water.

The chief element of dry wood is carbon, which forms about one-half the dry weight of plants. This element is entirely absorbed from the carbon dioxide of the atmosphere through the process called assimilation. As there are only two grams of carbon in 10,000 liters of air, one tree with a dry weight of 5000 kilograms requires about 12 million cubic yards of air to furnish the carbon. But for the fact that the air is being constantly resupplied with carbon exhaled by animals and poured forth from factories and chimneys these figures would seem startling. The process of assimilation, or the taking of carbon from the carbon dioxide, can only be carried on by the chlorophyll or green bodies in the leaves, by the action of sunlight, and a definite amount of heat. The first products of assimilation are carbohydrates, either in solution or as starch grains. The process ceases at night and the starch grains are dissolved and pass out of the cell. The surplus products that are not needed at once are stored. This surplus is greatest at the end of the growing season, and upon its amount depends all growth of the next year either of mother-plant or offspring in germinating seed. This material is stored in the form of starch or sugars in the embryo of the seed, in tubers, bulbs, roots, and medullary rays of the wood.

All trees require a certain amount of light in order to carry out this work of assimilation. With regard to their ability to bear shade, marked differences occur among the various species of trees, so that they may be classed as: light-demanding or intolerant trees, such as larch, red cedar, and gray birch; and shade-enduring or tolerant species, such as beech, spruce, hemlock. Between these is a class of intermediate trees, including white pine and chestnut. The demands of various species for

light may be gauged by the general density of the foliage of the crown and the capacity of overshadowed twigs to retain life.

Until very recently it was thought by foresters that the amount of light to which a tree has access determines its growth more than any other factor. Recent investigations of soil moisture indicate that this is an even more important factor, so that while it was customary formerly to attribute increased growth, after thinning a forest, to more light, it now appears that it is due as much to the increased supply of water available for the roots.

The physical qualities of soil, especially as related to ability to retain moisture, are more important than the chemical constituents, for almost all soils are chemically able to bear trees. The root systems of various species vary greatly with regard to shape and the depth to which they reach; but even shallow-rooting kinds derive advantage when the soil over which they grow is deep, owing to the greater fertility within easy reach of their roots. Some species, like the oak, have a strong tap root; others, such as beech and birch, develop strong side roots, but no tap root; and still others, like spruce, have a pronounced shallow-root system. Spruce and birch require least depth of soil, oak most. Whether the soil is loose or binding is a matter of great importance for tree growth. As a rule, the broadleaf trees do better than the conifers on the stiffer classes of land, although soils of average tenacity are on the whole most suitable for all kinds of trees. The chief constituents of soil are clay, lime, and sand; and as clay yields the most valuable materials for plants, the qualities of soil are often determinable to some extent by the quantity of clay in them. Clay soils are hard and interfere with the movement of moisture; sands are too porous; limes too easily heated; loamy soil, therefore, is usually best.

The chief chemical constituents of wood are carbon, hydrogen, oxygen, and nitrogen, but the ashes of wood also contain sulphur, phosphorus, chlorine, silicon, potassium, sodium, calcium, magnesium, and iron. The carbon is obtained solely from the car-

bonic acid of the air; the hydrogen and oxygen are derived chiefly from the water in the soil; and the nitrogen from the ammonia of the soil formed by nitrifying bacteria from organic decaying matter. These other chemicals taken from the soil in salts and oxides are contained in very small quantities. Thus iron, though very important for the formation of chlorophyll in the leaves, is present only in very small quantities, so the old remedy of driving nails into a dying tree was of no value.

The percentage of pure ash in the dry leaves of trees varies from 2.3 per cent in white pine to 7.6 per cent in the ash tree, and dry leaves have a higher percentage of minerals than wood. This indicates the well-known fact that conifers are less demanding as regards chemicals than broadleaves. For this reason the soil improves under coniferous crops if a good canopy is maintained, as the minerals accumulate. It also illustrates the way in which a forest soil is annually renewed by the return of the leaves rich in minerals.

Of all the elements taken from the soil nitrogen is the most important. The chief source of nitrogen is the raw humus composed of decayed leaves and wood. It has been found that dead leaves mixed with soil absorb nitrogen from the atmosphere in large quantities, probably through the assistance of bacteria, mosses, and lichens. This capacity of the bacteria is reduced by frost, so the supply of nitrogen is less in the open in places exposed to frost. Some plants take in nitrogen from the air through their leaves. About 10 pounds of nitrogen are carried to the ground per acre annually by rain, and the litter of leaves and twigs carries to the ground in a beech forest 40 pounds, in spruce 28 pounds, and in pine 26 pounds of nitrogen per acre. On the other hand, the annual consumption of nitrogen for wood production is 9 pounds for beech per acre; 12 pounds for spruce and fir; and $6\frac{1}{2}$ pounds for birch. An investigation in a plantation of maritime pine on a sand dune 56 years after planting produced, from a layer of soil 6 inches deep, 7 tons of organic matter per acre with nitrogen 1.5 per cent, or 248 pounds of nitrogen per acre. This is an annual accumulation of 4.5 pounds

per acre. In another plantation the average accumulation was 7.2 pounds per year.¹

As regards the chemical composition of soil, sour, marshy soils are unsuited to most species except Scotch and white pine and spruce. These are about the only species that will thrive on pure peat. Ash, maple, beech, and elm require a moderate amount of lime in the soil, and oak, locust, European larch, and Austrian pine thrive best on soils which contain some lime, while chestnut seems to do better in a soil containing very little lime. Some recent investigations in soil seem to show the commanding importance of lime as a controlling factor in tree growth. Most trees are lime-loving to a certain extent, but an overabundance of lime in all cases is unfavorable. The hardwoods — oak, ash, maple, chestnut, beech — seem to demand the presence of a considerable quantity of potash; spruce, fir, pine, and birch thrive on soils rich neither in lime nor potash. For the production of wood only, the demands vary as follows in high forests: from 4 to 20 pounds of lime; from 2 to 10 pounds of potash, and from $\frac{4}{5}$ to $4\frac{1}{3}$ pounds of phosphoric acid per acre per year. The combined influence of all these factors dependent on soil and situation is shown in the amount of timber produced per acre and in the quality of the timber.

When the trees of a wood are tall and straight, free from branches, and tapering but little, it is the best possible indication that the soil and situation are eminently suited to the woodland crops growing on them.

These factors of climate, soil, etc., have influenced the distribution of trees in such a way as to form forest "types." In crossing a mountain ridge we find one type of forest in the swamp at its base, which is quite distinct in its composition and appearance from that on the drier, rolling land just beyond. On the steeper slopes another forest type is substituted, just as the human type raised in the wild mountains differs from that of the fertile valleys below. Scientific forestry largely deals with the causes for these varied types, while applied

¹ See *Forestry Quarterly*, Vol. VI, p. 290, and Vol. VII, p. 192.

forestry, based on this knowledge, tries to develop in every locality the type which is best fitted to exist there.

The term "stand" is the unit of description applied to any definite portion of a forest having a definite distinguishing characteristic. Thus in a certain type we may have a stand of young growth; a stand of diseased and damaged trees; a stand of exceptionally tall specimens, etc. These stands may be extensive, covering many acres or they may be confined each to a small part of an acre.

Fig. 1. — Two stands of white pine of different age classes. The one at the right is 40 years, that on the left 70 years of age.

FOREST TYPES.

In every forest the ceaseless struggle going on gradually brings about many changes unseen by the casual observer. In the small openings of the forest, caused by windfall, snow breakage, or other causes, seeds of trees germinate and begin to grow. The kind of trees that come up here depends, as has already been shown, on many factors — the kinds of seed trees near, the covering of the soil and moisture content, the light available, etc. On the burned-over and freely-exposed

mineral soils, poplar, bird cherry, and birch spring up freely; on the abandoned fields, pine and spruce are especially apt to appear; and on the moss-covered decaying logs of the northern woods, little hemlocks, fir, and spruce seedlings start. In a few years the growth and very existence of these seedlings are influenced and other changes take place. The tops of the old trees may spread out and shade the openings, so that only the tolerant seedlings can endure; or the remaining old stand may be felled and an unlimited amount of light admitted. Under this impetus certain rapid-growing species may push up to the entire exclusion of the others, or these others if they are tolerant of shade may be relegated to an understory of secondary importance. On an acre of forest soil thousands of such seedlings may start, but in the course of their various struggles and under innumerable external influences their ranks are so thinned that only a few hundred grow into fair-sized trees. A stand of 1000 trees per acre 20 feet high by the time it is 80 feet high and correspondingly large will seldom contain over 400 trees to the acre. The trees that are killed in this constant strife fall to the ground after a few years, decay, and add to the humus of the soil. As the forest grows old gaps are caused by these deaths and reproduction again takes place. Whether the same kind of trees will come in depends upon the conditions at that time.

In every region certain combinations of forest trees and underbrush are characteristic of different sites. As already explained, this community of tree life is called a "type," and is influenced by soil, exposure, elevation, moisture, and other factors. As examples of types, we may mention the "spruce slope type," characteristic of the steep mountain slopes of northern New England, and "chestnut oak type," of the trap ridges of Connecticut. Under natural conditions such a forest type maintains itself century after century on the site to which it has become adapted. Accordingly it is known as the permanent type of that particular site. Circumstances not in the regular course of nature may entirely change the conditions and cause the

appearance of a different forest type. Such influences are wind-fall, extensive damage by heavy snows, by insects or fungi, by fires, and by lumbering or clearing for farming. The type following any change of this sort is a temporary type, as, for example, the "poplar type" on burns, or the "old-field type" on abandoned cleared lands. Gradually this temporary type, if left to itself, will change into the permanent type and after perhaps fifty or one hundred years the forest will have the form and composition that it had before the change. Such is nature's way of asserting her rights.

Every forest type will be found under a considerable variety of condition of soil, moisture, etc., and, of course, will make its best development where the sum total of conditions is most favorable. Foresters recognize this situation as Quality I for the type, and usually speak of Qualities II and III as designating respectively poorer sites.

PURE AND MIXED STANDS.

One of the first things to notice in the study of a forest is the kind of trees that are present and the proportion of the more important ones. In the virgin forests of northern New England, for example, we find spruce, hemlock, birch, maple, beech, probably basswood, and several other species. The hardwood forests of Connecticut and Rhode Island, on the other hand, consist of chestnut, oak, hickory, maple, birch, elm, hornbeam, etc. Both of these are termed "mixed forests." But in the former region, especially in Maine, there are extensive areas that have been burned over which are now covered with canoe birch. There are old pastures in northern Vermont now overgrown with impenetrable thickets of arborvitæ; and further south, with white pine. These are "pure forests," being composed of but one species. As used in this country a stand is called "pure" if 80 per cent of the main crop is composed of one species.

A study of the causes of these differences reveals the fact that pure forests are usually composed of trees whose seeds are light and are, therefore, borne long distances and in great numbers

by the winds. Anyone accustomed to tramp in winter must have seen the snow-covered fields, though far from trees, well sprinkled with birch seed. Although these light-seeded species often occur in mixed forests, the heavier-seeded varieties are characteristic of them and never form pure forests except under particularly unfavorable circumstances. Such exceptions are the summits of the trap ridges of Connecticut where the soil is too scant to support any tree life except a very open, pure forest of chestnut oak.

There are, of course, artificially pure forests, as those which are planted, or those from which all but one species have been removed. This brings us to the question which has been prolific of discussion among foresters, as to whether pure or mixed forests are more profitable.

Naturally there are advantages in a mixture of deep and shallow-rooted trees, since a greater store of soil moisture and fertility is thus made available. So also different trees having somewhat different requirements as to chemical or physical properties of soil can abstract more from a given area than could one species, and a mixture of trees having different degrees of shade endurance can dwell more closely and form a heavier stand per acre. But the chief advantage of a mixture is in case of some catastrophe which devastates one species but spares the others. The tamarack may suffer from insect ravages, as was the case twenty years or more ago. If other species are in mixture they remain to take up the area, to reproduce, and also, to some extent, to present a barrier to the invasion of insects. In case of a severe windstorm, the more shallow-rooted trees may be overturned in exposed situations, unless protected by a mixture of windfirm varieties. So against all forest enemies a mixture forms a safeguard. There is also a financial advantage in raising mixed forests. The length of time required to grow timber is so great that it is impossible to predict what species will be more valuable by the time of maturity. In Europe the first forestry measures were induced by a scarcity of fuel wood in the vicinity of the large cities. Hardwoods were, therefore, cultivated in

these early operations, but to-day when railroad transportation has brought coal to the cities from long distances and manufacture is given an impetus, the demand is for softwood lumber and the systems of management have been changed to produce it. A mixed forest provides against such changes of the market by furnishing different classes of timber. On the other hand, pure forests have now well-recognized advantages, the primary one being the simplicity of management. While the chances for injury are greater than with mixed forests, the profits are also greater if such injury is avoided, for a pure forest of trees adapted to a situation will produce more valuable timber than a mixed one.

Much can be said theoretically in favor of each kind. For practical purposes in New England, it may be said that good management of our existing mixed forests will gradually restrict the mixture to two or three of the most valuable species; while plantations will be made pure, at least over small areas. As certain soil-fertilizing qualities are furnished by the heavy shade and decaying foliage of less valuable species, such as beech and hemlock, they may be sometimes planted, but this planting should usually be in the form of under-planting.

Mixed forests undoubtedly have a greater æsthetic value than large pure forests, and for this reason will always be characteristic of estate forests.

COPPICE AND HIGH FORESTS.

Nearly all the deciduous trees of New England have the ability to resprout when cut, a power common to only one or two conifers. In some cases these sprouts spring from the top of the stump, but with most trees from its base. In the New England forest, chestnut is the most prolific sprouter as regards the number of sprouts, their thriftiness, and the advanced age to which it is able to produce them. While the white oak sprouts but little after the age of sixty years, there are numerous cases of chestnuts which have grown from stumps one hundred and ten years or more old. Besides the chestnut and various

species of oak, the red maple and white ash and basswood are prolific sprouters. Next to these in this regard are some species of birch and hickory; but the species characteristic of the northern forest, such as sugar maple, yellow birch, and beech, sprout comparatively little, and the trees resulting from them rarely amount to anything.

A forest produced by sprouts is a coppice or low forest, so called because the trees seldom attain the height of those raised from seed, and are grown mostly for the production of small-dimension materials, especially fuel.

As distinct from this is the high forest composed of trees that have grown from seed. Practically all our virgin forests were of this character, and wherever a second growth of conifers has come up on an old pasture it is a high forest, even if not over ten feet in height, the distinction being that trees sprung from seed will in time produce tall timber.

A combination of the coppice and high-forest forms is known as the "composite form," in which seedling trees and sprouts are grown together.

The effect of these different methods of reproduction are nowhere better exemplified than in the forests of northern and southern New England. The slopes of the White and the Green Mountains when once denuded of their spruce become reclothed with conifers only after a series of years. In the lower and warmer regions of Massachusetts and Connecticut, on the other hand, the hills are immediately reclothed with forest of the same species that were cut. Such are the advantages of the unkept woods of this region over those of the north. But as a practical system the simple coppice can be advised only in regions where there is a profitable market for fuel wood, as small-dimension material is its chief product. In America the sale of such products is slight compared with the demand for lumber, ties, poles, etc., so the land owner should gradually transform the coppice forest to a high forest, either of the same or more valuable species.

EVEN AND UNEVEN-AGED FORESTS.

If several specimens of the paper or canoe birch in a stand grown on an old burn are cut, it will be found that the ages vary but little, as, for example, from twenty to twenty-five years. In Connecticut it has been the practice of farmers for over a

Fig. 2. — A virgin forest of a mixed uneven-aged character. Spruce, yellow birch, paper birch, maple and beech are the chief species.

century to cut their wood lot "clean" whenever the trees were of a sufficient size to furnish the material desired. This was formerly cordwood, but during the past generation the use of coal has become so general that other products are now taken from the wood lot. In either case it has been the custom to cut all the trees on a certain area. These are of species that sprout

naturally from the stump, and the result is that another forest all of whose trees are of the same age comes up to take the place of its predecessor. These are called "even-aged forests."

Of a very different character is the virgin forest of the Adirondacks or the White Mountains. Here one will find stunted spruces that have not attained a height of three feet in fifty years along with one-year-old seedlings overshadowed by larger spruce and immense yellow birch that have been growing for over three centuries. This is an uneven-aged, or as it is often termed, a selection forest. Patches of seedlings spring up here and there in small openings where a few grow into saplings and finally into large trees. With such a variety of sizes and species these forests are often most beautiful, but on account of their unevenness are usually least profitable to manage.

We have now described the chief distinguishing characteristics of all our forests. Whatever the composition, the forest must fall into each of these groups: it must be pure or mixed; even- or uneven-aged; coppice or high forest.

The business of forestry is chiefly concerned with the harvesting of a crop in such a way as to leave a young growth of the desired species. To bring this about various methods have been developed to suit the requirements of different classes of forest.

For purposes of uniformity the classification of forest forms set forth by Graves¹ is here given in tabulated form.

A. HIGH FOREST FORMS.

1. *Selection Form.* — Seedling trees of all ages, from seedlings to veterans, are represented mixed together individually or in groups.

2. *Regular or Even-aged Form.* — The trees are approximately even-aged.

3. *Irregular Form.* — A stand which is not even-aged, nor yet of all ages, but has for some reason, either artificial or accidental, two or more ages well represented.

¹ See "The Principles of Handling Woodlands," by Henry S. Graves: Wiley & Sons.

4. *Two-storied Form*. — Two distinct stands on the same area, one growing underneath the other. They may be the same age, but composed of trees of different rates of growth.

5. *The Reserve Form*. — A regular stand in which scattered older trees are retained over a second rotation or longer.

B. COPPICE FORMS.

1. *Regular Coppice Form*. — Here the sprouts are approximately of the same age.

2. *Irregular Coppice Form*. — Various ages are represented owing to bad treatment.

C. COMPOSITE FORMS.

1. *Regular Composite Form*. — Here sprouts and seedling trees of approximately the same age are growing together.

2. *Irregular Composite Form*. — This corresponds to the irregular coppice with the addition of seedling trees of various ages.

3. *Coppice with Standards*. — In addition to the regular coppice stand there are scattered trees grown from seed on the same area; these are allowed to grow over several sprout rotations.

CHAPTER II.

SILVICULTURAL SYSTEMS.

IN order to harvest different kinds of forests and to insure an equally good growth after cutting, various systems of cutting have been developed. Often they differ very little from ordinary methods of lumbering, but in other cases may demand a considerable money investment and a high degree of forestry knowledge. The forester, or the layman who handles his own forests, should have these systems definitely in mind, as only in this way can he secure satisfactory results in the reproduction of the desired species. Thus far these systems have been little used in America, but as our market conditions approach those of Europe they will be adapted to our conditions. And even under our present rough conditions it is as well to have some ideal to work for, some definite method to follow, as in other agricultural lines.

The classification of these systems is the same as that used by Graves,¹ with the exception that some of the least important systems described by him (generally modifications of the chief systems) are here omitted in order to avoid confusion.

I. Systems Depending on Reproduction by Seed.

A. THE SELECTION SYSTEM.

This system, as its name implies, is adapted to selection stands.

Since the virgin forest of all countries is an uneven-aged or irregular high forest, the first and crudest system deals with this and is called the "selection system," because the trees to be harvested are selected here and there as they become mature.

¹ "Principles of Handling Woodlands," by Henry S. Graves: Wiley & Sons.

As the old trees are removed seedlings gradually take their place. By this method no area is ever cut clean, and for that reason it appeals to those interested in the woods mainly for æsthetic reasons. It is so well known that with many it stands, unfortunately, for the whole of forestry, with ill-advised legislation in some localities imposing a minimum diameter limit for cuttings. As forestry develops in this country the selection forest will gradually be supplanted by even-aged stands managed

Fig. 3. — The selection system in a stand of spruce and hardwoods.

- I. First cutting.¹
- II. Ten years later. Reproduction has started in the openings, and the stand is marked for a second cutting.

¹ In this and succeeding diagrams, trees to be cut are indicated by dashes.

under one of the other systems. In the application of this system the whole stand may be cut through every year, or the stand is divided into blocks each of which is cut over periodically. In this case the interval between cuts is called the cutting cycle. Under ideal conditions this would be about ten years. Care must be taken always that trees of all ages be maintained, other-

wise a time will come when the cut must be reduced and the revenue correspondingly diminished. If the whole stand is cut over annually the amount removed should correspond with the annual growth of the whole stand. If it requires ten years to get through the forest the equivalent of the growth of ten years would be removed at each cutting. Thus, in the application of the system in one of our white pine forests having an area of 100 acres and with an annual growth of 500 board feet per acre and

Fig. 4. — The hardwood type. A stand containing mature timber marked for selection cutting. (The marked trees are blazed.) Note overmature and unhealthy condition of many trees.

a cutting cycle of ten years, 5000 board feet per acre, or 500,000 board feet on the whole area, can be removed each decade. If the rotation in this forest, or the length of time required to mature the crop, is one hundred years, the area cut over annually, with a cutting cycle of ten years, would be 10 acres, and the annual cut from this area would amount to 50,000 board feet. In our virgin forests where there is a great range of age classes, all mature trees are grouped in the oldest-age class and the first cuttings will tend to eliminate them, so that in the forests of twenty years hence we shall have comparatively few trees over one hundred years old.

B. THE CLEAR-CUTTING SYSTEMS.

Where such a large proportion of the trees is cut that the remainder does not influence the growth of reproduction, it is called a "clear cutting." The clearing may be done in one or a series of operations but is usually accomplished in twenty years at most. While the selection system is best adapted for many of our virgin forests under present conditions, there are certain exigencies which make clear cutting, especially of even-aged forests, more profitable as well as preferable from a silvicultural standpoint. For example, in the pure spruce forests of the steep slopes of the White Mountains there is such great danger of windfall if scattered trees are left that some form of clear cutting is a necessity. This is also the case where logging is so difficult and expensive that only infrequent operations can be profitable; and where trees are so large that later removal would injure valuable reproduction. In many of our culled forests so little of value is left that it is practically necessary to cut clean the inferior growth and replant. Of course there are certain disadvantages in the use of these systems, among the most important being the exposure of the soil, especially on steep slopes, to erosion. Berry bushes and other weeds are apt to spring up on such areas and seriously interfere with reproduction. Young trees are more apt to be injured by sun, wind, frost, and insects than when started under shade. Good forestry principles demand that the areas cut clean shall not be very large.

Young growth may be secured after clear cutting either by natural seeding or artificially by sowing or planting. The detailed methods of accomplishing artificial reproduction will be discussed later under the chapter on Planting, so only its theory need be considered here. It will be readily seen that natural reproduction is a rather slow process, while restocking by planting can be accomplished at once, and is more certain to be successful. Then, again, the varieties obtainable by natural means are limited to those already present; but in planting, the species best adapted to the soil or most remunerative may be

substituted. On the other hand, natural reproduction is apparently, though not always actually, cheaper. Natural reproduction follows nature's methods closely and for that reason will be the method largely used for the present in this country, and, in fact, has preference in certain kinds of forests in Europe.

Fig. 5. — A stand of European silver fir in the Vosges Mountains, France, 100 to 150 years, managed on the selection system.

1. *Clear Cutting with Artificial Reproduction.*

By this method the area in question is cut clean and the planting or seeding is done afterwards. It is desirable that the slash or limbs be disposed of in some way before planting. This method was the chief one used by the Cornell Forest School some ten years ago in the management of its extensive tracts in the Adirondacks and for which the school became so unpopular that it was given up. It was not realized at that time that any form of clear cutting could be good forestry. It is a system admirably adapted for small tracts well protected from fire, in stands which

are either overmature or have been so damaged that desirable natural reproduction is impossible, and wherever intensive management is possible.

Graves recognizes three systems of clear cutting with artificial reproduction, but as they are practically identical except for the area cut over, these various modifications need not be considered in this book.

2. Clear Cutting with Natural Reproduction.

The success of this method depends on the thoroughness with which the area is seeded from trees standing on the border of, or scattered over, the cut area. Naturally, it can be used with light-seeded trees only. The completeness of the seeding is proportional to the area cut and the ability of the seed to be carried long distances. For example, the method on a large cut-over area would be much more successful with poplar than with spruce.

a. Clear Cutting the Whole Stand.

If the cutting is made just after a seed year, there may be enough seed on the ground to warrant cutting off the whole stand. Occasionally one finds a place where a pine or a spruce stand happened to be cut at such a time, and a dense growth of seedlings has resulted.

Very often a mature stand of timber may be surrounded by younger stands which would naturally be left for a number of years. If such a mature stand is cut clean the area will be seeded in for a considerable distance on all sides from the surrounding younger stands; and if this cut-over area is not too large it will be completely reseeded in this way.

b. Reserving Blocks of Trees.

When the clear-cutting system is to be used on extensive areas some provision must be made for reproduction by leaving a sufficient number of seed trees. In many localities, and especially with shallow-rooted trees, there is great danger of windfall

in leaving scattered trees or small groups, and to overcome this difficulty large blocks of trees are reserved. The ideal way to overcome this danger of windfall would be to use the strip system described a little farther on, which leaves 40 to 50 per cent of the timber for a second cutting. Oftentimes poor market conditions and expensive logging prevent two cuttings and require that at least 75 per cent of the timber be cut in one cutting. Under these circumstances the best which can be done is

Fig. 6. — The scattered seed-tree method.

- I. A mature stand marked for a reproduction cutting. The entire stand is to be cut except for occasional seed trees.
- II. Ten years later, showing the reproduction fully established and the old seed trees marked for removal.

to leave 15 to 25 per cent of the timber in the form of large blocks. These blocks are carefully located with reference to seeding the cut-over area, usually on ridges or the upper portions of slopes. A young stand should be selected for this purpose if practicable, since it is not expected to return to remove it for a number of years, possibly not for an entire rotation. Occasionally there are blocks of inferior trees of little value for lumber which, nevertheless, are perfectly good for seed purposes. At best the method

is only an expedient to be used during the present pioneer stage of forestry until our markets have improved enough to make a more intensive system possible. It is very doubtful even now whether it is better to invest money in reserve blocks of over-mature timber or in replanting after cutting clean.

By permission of the Massachusetts State Forester.

Fig. 7.—The scattered seed-tree method. Pine seed trees are seen together with some hardwoods. These latter will be cut clear for cordwood, only pine remaining.

c. Reserving Scattered Seed Trees (Scattered Seed-tree Method).

In some localities where there is little danger of windfall and with well-rooted species, this system of clean cutting with re-

serves of scattered trees is advisable. Neither this nor the preceding system can be used with any other than light-seeded trees. The best number of seed trees to be left varies considerably, but they should not be farther apart than their heights, three to eight per acre. Often very limby or partially decayed trees, so long as they are windfirm, may be left for this purpose. They should have large crowns occupying at least half the tree's height, since these bear the largest crops of seed, while suppressed and spindling trees have very little seed. The investment consequent on this method is less than that entailed by the previous method, since less timber in the aggregate is left. Wherever many or valuable trees are required as seed trees some other system should be substituted.

After reproduction has been established the seed trees are usually removed. In some cases small groups of three to ten or more seed trees are left standing together. This is done to better prevent windfall.

d. Reserving Thrifty Standards (Reserve Seed-tree Method).

Under the two systems just described trees are left for seed alone, hence inferior trees may be left. Under the reserve seed-tree system trees are left for greater growth as well as for seed, and only straight, thrifty specimens are reserved. The system is well adapted to stands of moderate age where there are many trees capable of continuing a thrifty growth for years, probably for another rotation. If, for example, the rotation used in white pine were seventy-five years, these reserves or standards might be left over one rotation, until they were one hundred and fifty years old, when they would be very valuable for special purposes, as for derrick sticks, besides having served as seed trees. While under the previous system less than a dozen trees per acre are required for seeding, under this system from 15 to 25 reserves per acre may be left. Naturally the reproduction is better on this account.

e. Clear Cutting in Strips.

As market conditions improve it will become feasible to cut a stand clean in two or more operations instead of taking out the bulk of the timber at once, as described in the clear-cutting systems already considered. When this is practicable one of the forms of the strip system will be of value in New England. The strip system may be applied in either of two ways: 1, with alternate strips; 2, with progressive strips.

Fig. 8. — The progressive strip system.

- I. A mature stand marked for reproduction cutting.
 II. Ten years later. The first strip is reproduced and a second is ready to be cut.

1. The strips are here cut at fairly regular distances removing about half the timber and leaving alternate strips uncut to seed up the cleared areas. The best results are obtained where the cut strips are not much wider than the height of the bordering trees, although they may be three times as wide with some light-seeded species. It is customary to allow several seed years to pass between cuttings so that the area may be well reproduced. The remaining stand can, of course, be cut clean and replanted; or one of the previously described seed-tree methods may be

applied on these alternate strips. If the period between cuttings were long enough to allow the new generation to produce seed this would be unnecessary, but it is not the practice to wait so long.

2. Under this method the stand is removed by a series of strips, beginning on one side and progressing in the direction of the prevailing wind across the area. The last strips must be reproduced by some other method. An interval of several seed years is allowed to elapse between the cuttings. It would, therefore, take a very long time to cut over a whole forest in this way. To overcome this delay the stand is divided into several nearly equal areas and a series of strips is established in each.

f. Clear Cutting in Patches (Group Method).

Irregular patches of unequal size are cut usually where a group of reproduction is already started. These first openings are not over 200 feet across and do not aggregate over one-third the entire area. When these patches are entirely reproduced from the surrounding stand, the cuttings are enlarged gradually until all is cleared. The last strips will, of course, have to be reproduced by some other method.

C. THE SHELTERWOOD SYSTEM (STAND SYSTEM).

There are certain disadvantages connected with all of the clear-cutting systems which are overcome by the shelterwood system. Under the former methods the soil is exposed and reproduction is retarded by drought and frost. It is also impossible to use them with heavy-seeded trees, such as oak, chestnut, and beech.

The principle of the shelterwood system is to open and remove the stand gradually by a series of thinnings. This results in reproduction under the shelter of the mother trees which are not all cut until complete reproduction has been accomplished. A more even distribution of seed results from this system because there are large numbers of seed trees well distributed over the area, and the young seedlings are protected by the shade of the

remaining trees. The mother trees also benefit from the thinnings and make a more rapid growth during the remainder of their lives.

Fig. 9. — The shelterwood system.

- I. An even-aged stand sixty years old marked for the preparatory cutting.
- II. Five years after the preparatory cutting has been made. The seedbed has been made more favorable for germination and a little reproduction may be seen in the more open places. The stand is marked for the seed cutting.
- III. Ten years after the seed cutting. Complete reproduction has been secured and the stand is marked for the final cutting.

The system can be applied only with windfirm species or where there is no danger from windfall, as the system of cutting leaves many trees isolated. On account of the gradual removal of the stand, by means of several cuttings, the shelterwood system is

best suited for well-settled regions where intensive management can be practiced.

The simplest form of this system, and the only one that can be applied with crude market conditions, is to remove the stand in two cuttings about twenty years apart. The first, intended to give opportunity for reproduction to start, is called the "seed

By permission of the U. S. Forest Service.

Fig. 10. — Reproduction of white pine under the shelter of a mature stand.

or reproduction cutting," and removes about 75 per cent of the merchantable timber. Ten to twenty years later the second or "final cutting" removes the remainder of the old stand.

The maturest and least thrifty timber is selected for the first cutting, while thrifty trees and good seed producers are the kind retained for the final cutting. These trees should be left distributed over the areas as uniformly as possible.

With the better market conditions which prevail in portions of New England, one of the more intensive forms, such as have

been developed in Europe, can be used. The cuttings fall into three classes:

1. Preparatory cuttings.
2. Seed cuttings.
3. Removal cuttings including the final cutting.

The purpose of the preparatory cutting is to prepare the soil for the reception and germination of the seed. Often in a dense stand, such as many of our spruce stands, there is a heavy layer of "duff" or decaying needles, and the seed cannot come in contact with the mineral soil, and hence may either fail to germinate or die soon after it germinates.

The increased circulation of air following a thinning disintegrates the humus and makes a favorable seed bed, and the remaining trees cast enough shade to prevent the rank growth of injurious weeds. The preparatory cutting also gradually accustoms the mother trees to isolation, and tends to make them more windfirm. This cutting removes the inferior trees — those which are diseased, suppressed, defective, or particularly liable to windfall, and weed species not desired in the next crop. From 20 to 30 per cent of the volume of the stand is removed in the preparatory cuttings, leaving a space of not over three to five feet between the crowns of the remainder. After an interval of from five to ten years the humus should be sufficiently decomposed to leave the mineral soil exposed in spots, when it is time for the seed cutting. This is a heavy thinning made during a seed year by taking out from one-quarter to one-half of the original stand, and with the purpose of establishing proper conditions for the start of reproduction. The best results are obtained with heavy-seeded trees, if this cutting can be made after the seed has fallen. The largest and most spreading-topped trees are removed at this time, as felling them later might damage the reproduction. If unfavorable conditions exist, the reproduction after the seed cutting may be assisted artificially by planting or simply by stirring up the soil with mattocks, or by pasturing hogs with the purpose of rooting up the litter and exposing the mineral soil.

The shelter trees which are left under this system to shade the ground and the little seedlings (thus distinguishing the system particularly from the clear-cutting systems) are taken out in the removal cuttings as soon as the reproduction is well established. The first of these cuttings is made within three or four years of the seed cutting. Under the most intensive system, as developed in Europe, there are three or four of these removal cuttings, including the final cutting, occurring at intervals of about three years. The inevitable breakage in the reproduction caused by these cuttings, if severe enough to leave gaps, is repaired by planting.

The following table shows the occurrence of the various cuttings used in this system, covering a period of twenty-five years. The number of preparatory and removal cuttings will undoubtedly be decreased and the total length of the period from the first to the last cutting will be shortened in the use of the system in New England.

TABLE SHOWING DISTRIBUTION OF CUTTINGS UNDER SHELTERWOOD SYSTEM AS MOST INTENSIVELY APPLIED.

Kind of cutting.	Date of beginning.	Approximate number of cuttings.	Percentage of original stand removed.
Preparatory cuttings.....	1900	3	25 to 40
Seed cutting.....	1910	1	25 to 50
Removal cuttings.....	1915 }	4	10 to 50
Including final cutting.....	1925 }		

II. Systems Depending on Reproduction Wholly or Partly from Sprouts (Coppice).

The systems already described depend for their success upon the production and growth of young trees from seed. The following systems depend largely on the ability of trees to sprout when cut back. Naturally these systems can only be applied in forests composed of trees which sprout readily. In this country the most prolific sprouters are chestnut, oak, basswood,

birch, maple, especially soft maple, ash, hickory, and other hardwoods.

There are three systems depending wholly or partly on sprout reproduction:

A. SIMPLE COPPICE.

B. COPPICE WITH STANDARDS.

C. POLE-WOOD COPPICE.

A. SIMPLE COPPICE.

Under this system which is so simple that it has long been practiced in southern New England, the stand is cut clear and allowed to sprout up again from the stumps. Usually several sprouts start from a single stump although only a few live to attain tree size. In the western part of Connecticut where the forests have been repeatedly cut under this system at intervals of about twenty years for the production of charcoal for the iron mines, it is possible to distinguish three or four generations of stumps in many wood lots, each younger generation of stumps surrounding the older ones. The system is so easy of application that neglect is common and a forest is very apt to deteriorate. Some species continue to sprout freely much longer than others, but nearly all after a certain age fail to sprout vigorously. Chestnut, for example, generally sprouts well if cut at 100 years or even at 120 years, while white oak sprouts poorly after sixty years. To maintain thrifty, fully-stocked coppice stands short rotations are necessary. Ordinarily the rotation must be less than forty years except for a species like chestnut, which sprouts well to a considerable age. Therefore the simple coppice system is chiefly applicable for the production of fuel, and for this purpose is generally applied in Europe on a rotation of about twenty years. In this country where fuel wood is as yet such a drug on the market, the system has little to recommend it. To secure the best results in sprouting the trees should be cut between September 15 and April 1. The stumps should be left with a clean slanting surface so that water will not settle in them and cause decay.

B. COPPICE WITH STANDARDS.

There already exists a form of forest which may be considered as a transition stage between coppice and high forest and which when fashioned by the science of the forester is called a coppice with standards forest. This is a forest composed largely of sprouts, but with an admixture of larger trees grown from seed. In the Rhine Valley of Baden this system has, perhaps, reached its highest perfection. Here the forest is laid off in regular subdivisions, one of which is cut each year of the rotation of the coppice, which is usually twenty years. In most cases an area is cut every twenty years and allowed to resprout. But instead of cutting quite clear a few selected trees or standards are left to grow on for several more rotations. The standards are trees from the seed and not sprouts. These standards are obtained either by planting or by natural seeding, a little of which is apt to take place even in simple coppice stands. At the end of the next twenty-year period the poorer trees are cut along with the stand of coppice, but the best, perhaps thirty to the acre, are left to grow for another coppice rotation. Again, part are removed and a few allowed to grow on to sixty, eighty, or one hundred years, thus producing timber of various dimensions at each cutting. When the system is once under way a stand of coppice together with standards of several different ages and sizes will be found on the same acre.

The reason that trees grown from seed are selected for standards is that such trees live to a greater age and attain larger proportions than those grown from sprouts. When a cutting among the standards is made the spaces formerly occupied by the old standards are filled with seedlings by planting. Trees are selected as standards which are of valuable species and will have a high value when mature. Since these standards are crowded only during the first part of their lives, they form short, thick-set bodies and usually produce one or two large logs of fast growth.

Fig. 11. — Coppice with standards.

- I. A sprout stand 25 years of age, which it is desired to manage on the coppice with standards' system; the rotation for coppice to be 25 years and that for standards any multiple of 25 years. The stand is marked for the reproduction cutting, everything being taken except a few selected standards (trees nos. 2, 7, 16, 21, and 25), which are either of seedling origin or are thrifty sprouts.
- II. Same stand immediately after the cutting, showing standards left.
- III. Same stand 25 years later. A second crop of coppice is ready to cut and the standards are 50 years old. The cutting will take all the coppice except selected standards. All the standards of the older age class which are unhealthy, like no. 21, or where standing too thickly, are removed.
- IV. Same stand immediately after the cutting. Two age classes of standards are left: trees nos. 7, 16, and 25 of the 50-year class and nos. 36, 38, 43, and 50 of the younger class.

Fig. 12. — Coppice with standards as used in Europe. The coppice has just been cut leaving the standards.

C. POLE-WOOD COPPICE.

This system combines reproduction by sprouts and reproduction by seed in varying proportions. The seedling reproduction is secured under shelter, as in the shelterwood system; and the pole-wood coppice system stands in a position midway between the simple coppice system and the shelterwood system. Its advantages are that sprout reproduction which requires so little skill to secure, is utilized, and yet long enough rotations can be used to grow saw timber, owing to the fact that seedling reproduction can be relied on to fill the gaps where sprouting has failed. The rotation instead of being limited to forty years or less, as in the simple coppice system, may be as high as eighty years.

In New England its field of usefulness is in the southern and central portions where the hardwoods reproduce extensively by sprouts. The system is applied by making two cuttings. The

first resembles the seed cutting in the shelterwood system and is intended to get seedling reproduction started. About 30 to 40 per cent of the volume is taken out, the poorest specimens being cut. Where the stand is composed of species like chestnut, which will sprout well even on an eighty-year rotation, there is less need to secure seedling reproduction and the seed cutting can be very light.¹ Where trees like white oak, which sprouts poorly at sixty to eighty years, occur the seed cutting must be made heavy enough to encourage complete seedling reproduction. Five to ten years after the seed cutting, or as soon as good seedling reproduction is established and has secured a few years' start, the remainder of the stand is removed in the final cutting. Sprouts at once start and with the seedlings on the ground develop a mixed stand of seedlings and sprouts.

¹ Even in stands where at eighty years every stump will sprout, the stumps are relatively so far apart that the young sprouts do not form a close stand, and a mixture of seedlings is needed to grow clear-bodied trees.

CHAPTER III.

SILVICULTURAL CHARACTERISTICS OF THE IMPORTANT NEW ENGLAND TREES.

IN the first chapter the relation of climatic influences, such as soil, light, etc., to tree growth has been traced and the kinds of forests to be dealt with have been described. The differences existing between forests are due to the trees composing them, and the presence of these in turn is due to the natural conditions previously mentioned. Through the centuries of its evolution each tree species, as each animal species, has acquired certain definite characteristics which the forester calls silvicultural to distinguish them from the botanical characteristics by which a species is identified. Scientific forest management must be based on an accurate knowledge of these characteristics of the different tree species.

The most important silvicultural characteristics of trees, which it is the purpose of this chapter to describe, are the following:

- (a) Range and distribution.
- (b) Requirements as to soil, light, and moisture.
- (c) Rate of growth and longevity.
- (d) Seed production and ability to reproduce by seed and sprouts.
- (e) Liability to damage by fire, insects, fungi, etc.
- (f) Purposes for which used.

WHITE PINE (*Pinus strobus*).

The white pine extends from Newfoundland and southern Labrador to western Minnesota and Manitoba. It reaches its southern limit in central Illinois, Indiana, and the southern Appalachians, where it is found as far south as northern Georgia

and Alabama. It originally grew in all sections of New England except on the higher mountains and in the region comprising southeastern Rhode Island and Cape Cod.

Few forest trees bear seed every year and the white pine is rather more irregular in this respect than are most trees. There is a common saying that the pine bears a seed crop only once in seven years. This notion, however, is incorrect. There was a good seed crop in Vermont in 1907, in parts of the State in 1910, and in other parts in 1911. It takes two years for the pine cones to mature. At the end of the first season the cones are about one inch long and of a purplish color. The mature cones begin to open early in September when the seed blows out and is carried by the wind for considerable distances. As there are two seeds on each scale, there may be eighty or more seeds in a cone. Usually about one pound of seed is secured from a bushel of cones. Some large-topped pines will yield from two to three bushels of cones, which carry anywhere from 50,000 to 100,000 seeds. A few such trees scattered over a tract are important factors toward its restocking. Much of the seed is carried twice the length of the tree and some of it considerably farther. It germinates best where there is plenty of light, as in a pasture at the edge of the woods, or in an opening caused by windfall. The little seedlings require a great deal of light and will soon die if deprived of it.

These facts are important reasons for making cuttings in a pine forest the season following a seeding. On account of the length of time required to mature the cones, it is always possible to know a year ahead when there is to be a good crop, and the harvest should be planned accordingly. If the cutting is made in the fall or winter following seeding, when the ground is covered with seed, germination goes on well in the soil which is stirred up by lumbering, and the seedlings grow well under the increased light. If made the year before, the seed from these trees will be lost; if made the year after, the seed would largely have germinated and died for lack of light and moisture. This explains why it is that occasionally one finds a splendid second

growth of pine following the cutting of pine, and at other times there is no growth at all.

Cones are often formed on very young pine trees, but until the trees become thirty years old there is either no seed in these cones, or the seed is liable to be sterile.

By permission of the U. S. Forest Service.

Fig. 13. — Windfalls as the result of planting white pine on low, wet ground where the drainage is insufficient.

The white pine is very indifferent in its demands upon soil and moisture and thrives on all but the driest of New England's sandy plains; it will grow also on hummocks, in swamps, even with clay substratum. However, it makes its best development on a fairly moist loam soil. In regard to light, it is more exacting. Under a light shade the seedlings will exist for several years, but they will make little growth and in a heavy wood are sure to succumb. The rate of growth, as with all species, depends upon conditions. On the whole, it is the most rapid growing native tree of New England, and usually averages over a foot a year in height. The annual height growth is sometimes over three feet, and the diameter growth is proportionately large.

A cross section of white pine, which attained a diameter of thirty-two inches in seventy-seven years, is on exhibition in the State Forester's office in Burlington, Vermont. Unlike some rapid growers, the white pine lives to an advanced age, occasionally three hundred years or more, though trees of that age are

Fig. 14. — A white pine of the best type for lumber; with straight trunk, without dead branches.

now rare. In youth it is very susceptible to damage by fire, but as it gradually substitutes a thick, rigid bark for the thin, green, smooth bark of youth, it becomes more resistant. Its chief natural enemy is the white pine weevil, which is described later (see Chapter VII).

On account of its smooth grain and the softness of its wood the white pine is a most valuable wood for many purposes.

Until it became scarce it was the chief building lumber. Now the better grades are used largely for interior finishing and other special purposes. The cheaper grades are used for match stock and the very poorest grades for box boards. Its high value and rapid growth, combined with its ability to thrive on the sandiest and poorest sites, make the white pine the most important tree to raise in New England; it should be encouraged wherever it occurs.

RED OR NORWAY PINE (*Pinus resinosa*).

The red pine has about the same natural range east and west as the white pine, but does not extend so far south. In New England it is a comparatively rare tree, and is scattered inexplicably in small clumps from the Canadian line to northern Connecticut. It derives its name from the fact that it was first noticed near Norway, Maine.

The demands of the red pine on soil, light, and moisture are about the same as those of white pine. It will grow, however, on an even drier sand, but is more exacting of light.

Measurements made in several New England plantations show an average height of thirty-five feet and a diameter of six inches, in thirty years. In mixture with white pine its height growth is fully equal to that of the latter, and its diameter growth only a little smaller. It does not attain as large a size in New England as does white pine, specimens one hundred feet high and three feet in diameter being rare.

The seed years of the red pine are more infrequent than those of the white pine, and in off years there is no crop; with white pine there are often some cones between regular crops. The seed germinates well in hot, dry situations, as on a litter of needles, on exposed mineral soil, or in thin grass growth, so that in spite of the comparative scarcity of seed reproduction is fairly prolific wherever seed trees occur.

This tree is free from insects and diseases, and suffers less from fire than the white pine. Its wood is harder than white pine, but is often classed in with it and for many purposes is nearly as good.

On account of its rapidity of growth and freedom from insects and disease, the red pine is a species that should be planted extensively.

By permission of the Connecticut State Forester.

Fig. 15. — Experimental plantations of the Connecticut Agricultural Station. Reading from left to right the species are:— red pine, Scotch pine, Austrian pine, white pine. The pines are 10 years of age.

PITCH PINE (*Pinus rigida*).

This is emphatically an eastern pine, being confined to a belt along the Atlantic from southern Maine to Georgia, and extending westward only to the edge of the Mississippi valley. It occurs throughout New England in the extreme northern part, and in the mountains.

It is the outcast of the pines and occurs pure only on the sandiest plains where other trees thrive with difficulty. On better soils it is sometimes mixed with other pines and with hardwoods. It is characteristic of sand plains in the Champlain valley, on Cape Cod, and in the lower Connecticut valley. In

early colonial times in the last-named region it was important as the source of tar and turpentine which were produced in large quantities to supply our early ship-building industry. To-day there are few stands of any size or age, as it has suffered from fire more than any other species, owing to the hot, dry localities which it inhabits.

Its habits are those of the red pine accentuated, in its ability to withstand drought, heat, poor soil, and in its greater demands for light. Its tendency is to grow rather short and crooked, but on the better soils it attains a height of sixty or seventy feet. Pitch pine seedlings grow more rapidly at first than those of our other native pines, but their growth is slower after three or four years. The pitch pine is a prolific annual seeder and reproduction on land not burned over is usually good, since the seed germinates well on the driest of mineral or needle-covered soils. This species also has the ability (uncommon in conifers) to sprout from the stump. After fires, especially, it is common to find numerous sprouts growing from the stump. As a rule, however, these do not mature.

This tree has no serious enemies, and as the bark is often an inch thick it is very fire-resistant. It is this ability to withstand fire that accounts for its frequent occurrence pure where other trees once in mixture, such as the white pine, have been killed by fire.

The shade cast by the pitch pine is not very dense, and the conditions for reproduction of white pine and other species are often best under its mild protection, so that it is a valuable agent in the natural reproduction of worn-out, sandy plains.

On account of the poor quality of the timber and its smaller yield per acre, the pitch pine is not an especially desirable species.

SCOTCH PINE (*Pinus sylvestris*).

This is a foreign tree and resembles the Norway pine in appearance, but its foliage is somewhat bluer and its bark redder. A native throughout Europe, it attains there a height of one

hundred and twenty feet and a diameter of from three to five feet. In America it has been extensively planted, generally with success. The largest plantations in the East are those on the New York state lands near Saranac Lake.

Fig. 10. — A 7-year-old plantation of Scotch pine on sandy soil.

Having the ability to withstand intense drought and to thrive on the poorest of sandy soils, it makes a remarkable height growth under the most trying circumstances. In Europe it is also extensively planted on peaty soils. Its demands for light are greater than those of white and red pines.

The seed crop is abundant every two or three years, but as yet seed used in America is imported. Experience has shown that the seed which comes from northern Europe produces better timber trees than that from the southern part of its range. The presence of old Scotch pine is so limited in this country that very little reproduction occurs and it is impossible to judge of its ability in this direction.

In this country it has escaped all enemies except a blister rust which occasionally attacks young trees.

The lumber of Scotch pine is similar to that of pitch pine, but of better, though not of first-class quality. This with its rapid growth makes the tree well worth planting.

RED SPRUCE (*Picea rubens*).

This is a distinctly eastern species of the cooler regions, extending west from New Brunswick and Nova Scotia, nearly through New York, and in the Appalachians as far south as northern Georgia. In New England it occurs throughout Maine, New Hampshire, and Vermont, and on the higher hills of central and western Massachusetts.

All spruces are tolerant of shade, and it is one of the well-known traits of this species that it can exist for half a century or more under heavy shade without making appreciable growth, and then shoot up with the vitality of youth if the shade is removed.

As might be expected from its preference for a cool climate it naturally selects moist situations. Together with balsam and tamarack it is one of the first trees to grow on the gradually forming lands of our northern swamps. However, a lack of water does not prevent its growth, for it inhabits high elevations in the Green and White Mountains where it often forms pure stands of excellent timber. Its root system is very shallow and where grown on hardpan or on ledges, trees are liable to be blown over if exposed to the wind by the removal of surrounding trees.

Under favorable circumstances, though the spruce can hardly be considered a rapid-growing species, it often grows from ten inches to a foot a year in height. More often in virgin forest it grows very slowly, and very old specimens are common. A growth of a tenth of an inch per year in diameter is a fair average for virgin spruce. Four hundred and seventeen annual rings have been counted on a tree less than a foot in diameter, which grew on the upper slope of a Maine mountain.

The seed years are more frequent than those of pine and it begins to seed at an early age.

Trees bear prolific crops of cones which open some two or three weeks later than those of white pine, owing to the cooler situations in which the spruce occurs. For a germinating bed it prefers decaying logs or moss, but does well on bare mineral soil or one covered with needles. In any small opening in a spruce forest numerous seedlings can generally be found, and on

Fig. 17.—A stand of spruce 60-70 years of age on an old field. Note the number and size of dead branches still on the trees.

abandoned fields in the spruce region reproduction invariably follows. The young roots cannot penetrate the leaf litter of a hardwood forest, and spruce reproduction in such places is, therefore, scarce.

Like most conifers it is severely damaged by fire, and, as mentioned above, is very susceptible to windfall. There are also several bark-boring insects which cause periodic damage. Though spruce is neither as rapid growing nor as valuable as white pine, its natural adaptability to the higher and northern portions of New England, its value for many uses as lumber and pulp, its fair growth and easy reproduction, all combine to make it the most important tree to encourage in the higher elevations.

NORWAY SPRUCE (*Picea excelsa*).

The Norway spruce, like the Scotch pine, is native throughout northern Europe, but is not peculiar to Norway any more than the pine is to Scotland. It was planted considerably in this country between 1850 and 1875, chiefly for ornamental purposes, and made such a rapid growth that in a few instances it has been planted in clumps and large groves, for commercial purposes. Individual specimens may be found throughout New England. It grows much faster than the red spruce, two feet a year in height being not uncommon. Its diameter and volume growth are equally rapid. One of the best known plantations of this spruce, a small patch on the Billings Estate in Woodstock, Vermont, is now thirty-four years old. Many of these trees have diameters from a foot to eighteen inches. Four of them when cut made a cord of pulpwood. Tests made by the International Paper Company proved that the wood of the Norway makes a whiter and stronger-fibered paper than that of the red spruce. For this reason, combined with its rapidity of growth, this company has commenced planting it extensively.

Its requirements as to moisture, soil, and light appear to be similar to those of red spruce, except that possibly it does not thrive so well on wet land. In liability to damage it is also similar to our native species.

There are, however, two serious objections to the Norway spruce. The first is that in this country it does not seem to live much over fifty years. This, perhaps, is not a serious objection from the standpoint of raising pulp since an excellent crop may be secured in thirty-five to fifty years. The other objection is that it is a very poor reproducer. Although this tree has been planted extensively in this country, it is difficult to find any number of small trees that have seeded from old ones. But this is not an acquired fault, for this spruce is notorious, even in the Black Forest of Germany, for its poor reproduction. Our native red spruce is much superior in this respect, and this difference will be of importance as years pass and forests now

starting approach the period when they should be reproduced. Artificial reproduction will always have to be the method of securing another stand of Norway spruce.

Even with these objections it cannot be denied that the Norway spruce, on account of its rapid growth, is a much more encouraging tree to plant than red spruce; it should have a large field in localities not adapted to pine, especially in the northern part of New England.

BALSAM OR FIR (*Abies balsamea*).

This tree is a northern species extending from Labrador to the Rockies, and southward in the Appalachians to West Virginia. It is not native to southern New England, though in the west it extends through the Berkshires into northern Connecticut.

The fir is less tolerant of shade than spruce, and it is a common thing in the woods to find small trees dead from lack of light. For the same reason the lower limbs die out more, making lumber freer from large knots. Balsam should be classed, however, as a tolerant tree. The fir is even more cosmopolitan as regards soil and moisture than the spruce, but, in general, prefers more moisture. It seldom occurs on dry, sandy soils, though it is common on high mountains where there is little soil, and that very dry; in swamps also it often occurs pure.

Both spruce and fir are subject to damage by wind but in different ways. A heavy wind that will uproot a spruce on account of its shallow-root system, will break down a balsam four or six feet above the ground. This breakage is possible because the balsam is seriously attacked by a fungus which weakens the stem.

The fir is distinctly a rapid-growing tree, a height growth of one and one-half feet and a diameter growth of one-half inch per year being not uncommon. This is nearly twice the growth made by the average red spruce.

The fir is short-lived. Trees over eighteen inches in diameter are rare. On the lower lands fir begins to deteriorate between

fifty and sixty years; higher up on the slopes it usually remains sound until seventy years.

The fir is an exceptionally prolific reproducer. Wherever in a mixed spruce and fir stand a cutting is made the reproduction is sure to be largely of fir. It prefers as a seed bed the bare mineral soil or a soil covered with needles, and seldom grows on hardwood litter, although it does better in such situations than spruce.

Fir lumber is of an inferior quality, but on account of the rapid growth and splendid ability to reproduce, it is possibly as profitable to raise as the red spruce. In the future when the profit from growing is given as much consideration as the profit from cutting, the balsam will be more appreciated.

HEMLOCK (*Tsuga canadensis*).

The range of hemlock is from Newfoundland west to Minnesota and south to Georgia. It is found scattered throughout New England except in the Cape Cod region.

The hemlock is only a little more particular than the pine in regard to soil, as it will grow in very dry situations. It is rather a tree of the hillside than of the plain, and especially prefers cool glens or ravines, probably on account of the atmospheric moisture, where it is usually mixed with other trees. Hemlock stands a great deal of shade, even surpassing the spruce in this ability. It is very slow growing and is apt to become shaky in old age.

Reproduction is good, as seeds are borne nearly every year. They germinate on practically all sites but prefer decaying logs and similar moist beds.

Hemlock is comparatively free from disease, and much less susceptible to windfall than spruce.

The lumber is of inferior quality, but the bark has a slight additional value for tanning purposes.

Altogether, when its slow growth and low value are taken into

consideration, the hemlock cannot be recommended in forestry operations, and is doomed to disappear from our forests except when maintained for æsthetic purposes.

TAMARACK (*Larix laricina*).

Tamarack is one of our most northerly trees, ranging from Labrador and Newfoundland northwest to Alaska, and south to Illinois and Pennsylvania. In New England it is not at all common but is found in many restricted localities, usually on the border of a swamp or the edge of a pond. It does not extend into southern New England, the northern part of Connecticut being its southern limit.

It requires more light than most trees, but will live in water and on sour soils. Tamarack is occasionally found on hillsides but very rarely. It is but seldom found on sand, preferring a loam soil. It has a tendency to form pure stands but is often mixed with balsam, birch, spruce, and cedar. The root system is shallow but very compact.

Tamarack grows rapidly on well-drained soils, but very slowly on the average swampy site. It seeds abundantly and is a good reproducer especially on abandoned fields. The seed germinates well in pasture grass or on the moss-covered soils of swamps.

The tamarack is our only deciduous conifer.

Many years ago the tamarack was practically destroyed by the worm of the larch sawfly which eats the foliage. For this reason it is seldom that one finds a large, live tamarack although dead specimens two feet in diameter are common. Of late years, however, the sawfly has not been abundant and the tamarack is again prospering; in many places it is encroaching on old pastures.

Its wood is durable and strong and is used for posts, poles, railroad ties, and in ship building. In early times it was transported in large quantities from Maine to England for the last purpose. Wherever it occurs it should be encouraged.

EUROPEAN LARCH (*Larix Europæa*).

This is a European tree very similar to its American relative, the tamarack. Unlike the tamarack, it thrives only on well-drained soils and requires a deep and moderately fertile soil. It has been planted somewhat widely throughout New England and prospers in all sections.

Fig. 18. — A pure plantation of European larch, planted in rows 12 by 12 feet.

It is fully as intolerant of shade as the tamarack and requires a sheltered, warm situation, so that it is well adapted for planting on south slopes. Here and there in the vicinity of cemeteries and other places where the larch has been planted a few seedlings can be found, but the examples of European larch reproduction in this country are few. Aside from the damage by the larch saw-fly, to which it is subject with the tamarack, the larch appears to be very free from enemies.

Larch is a rapid grower, exceeding white pine in height growth but not in diameter growth. This quality combined with the durability of the wood in the soil makes it an excellent tree to plant for the raising of posts, ties, poles, etc.

ARBORVITÆ OR NORTHERN WHITE CEDAR (*Thuja occidentalis*).

This is a northern species common throughout eastern Canada and as far west as Minnesota and extending south in the Appalachians to northern Georgia. It is confined to the northern portions and seldom is found in Connecticut. It usually grows in wet areas forming dense thickets known as cedar swamps, but also frequents hillside pastures in Vermont. It is intolerant of shade as is shown by the characteristic death of the lower limbs when grown close together.

Cedar produces an abundant crop of seed almost every year. It prefers for a germinating bed bare mineral soil or old pasture. As the tree advances in age it is apt to be affected by a fungus which causes the red rot of the heartwood, and renders it useless.

The cedar is very slow growing, although in swamps it grows as well or better than other conifers. As the wood is very durable in the soil it may be encouraged in wet situations for the production of posts and poles.

JUNIPER OR RED CEDAR (*Juniperus virginiana*).

This is one of the most widely distributed conifers being well scattered over the United States from New England to North Dakota and Texas. In New England its range is restricted to the southern portion. It is characteristic of abandoned pastures in Connecticut and parts of Massachusetts where it is easily recognized by its picturesque conical form similar to the cypress of the Mediterranean. It is very intolerant and slow growing, often being killed out by faster growing and more tolerant trees.

Red cedar is not fastidious as to soil for it is often found on ledges and sand plains. Although slow growing it is a long-lived tree, but seldom in New England does it attain a height of over sixty feet or a diameter of over twelve inches.

Its seed, which is in the form of a berry, is largely distributed by birds. It is supposed that some chemical action which takes place in the bird's stomach aids germination. In old pastures

reproduction is plentiful under old hardwood trees and along fence lines.

The wood is very durable and in great demand for posts and lumber for chests, but on account of its slow growth it is not a tree to be particularly favored.

SUGAR MAPLE (*Acer saccharum*).

The sugar maple extends throughout the eastern part of the country from the Atlantic to the great plains of Dakota and Oklahoma and south to the Gulf of Mexico. It occurs everywhere in New England, but is more abundant in the northern portion and is especially associated with spruce. However, the sugar maple is never mixed with the spruce in the swamps or the higher mountain slopes, but on the lower slopes and gently rolling land where the soil is neither very wet nor dry. It seldom occurs on sand, and is an unmistakably lime-loving species. The maple prefers a well-drained, deep loam soil. It is one of the most tolerant trees as regards shade, and young seedlings do well even where they receive no direct sunlight. Although large-topped and ornamental trees on well-fertilized lands often make a conspicuously good growth, it is on the whole a slow-growing species. In the sugar bushes of Vermont and the virgin forests of Maine it is not infrequent to find trees from three to four centuries old. Although like most deciduous trees it is able to reproduce by sprouts from the stump, as a matter of fact it seldom does so in New England except in the southern portion. It more than makes up for this, however, by being a very prolific seeder. The seed matures in the fall and is often thickly scattered over the ground near old trees. It germinates well in pasture grass or on bare mineral soil. The result is that our northern forests often have dense thickets of maple saplings. On account of the thickness of the bark it suffers comparatively little from fire. It sometimes suffers severely from defoliation by the forest tent caterpillar. An injury to the sap is caused and often ends in the death of the

tree. Another common insect enemy is the maple borer which makes great sores on the trunk.

SOFT MAPLE OR RED MAPLE (*Acer rubrum*).

The range of this species is slightly more restricted than that of hard maple, as it extends westward only as far as eastern Minnesota and Nebraska, but it reaches a little farther south in Florida. It is found throughout New England but is more common in the southern section. In the northern portion another species, *A. spicatum* or mountain maple, commonly takes its place and is similar in character.

The red maple is not in the least fastidious as to soils for it is the most common deciduous tree of swamp lands and is found as well on very dry sites, although seldom on sand plains. In the swamps its growth is only medium, but on the old fields of southern New England where it is a characteristic feature it grows rapidly. It does not, however, attain great age and specimens over fifteen inches in diameter and eighty feet high are rare.

It produces an abundant crop of seed every spring and reproduction both by seed and by sprouts is good. The seed germinates best on old fields and also on soil made bare by fire.

The bark of red maple is soft and the tree is easily damaged by fire. It has no serious insect or fungus enemies.

As the wood is of inferior quality it is used chiefly for fuel. Except in swamps and as a pioneer in the reëstablishment of forests on old fields, it is of little importance silviculturally, and it is bound to play a less and less important part as such worthless species gradually are eliminated.

YELLOW BIRCH (*Betula lutea*).

The yellow birch extends westward from Newfoundland and Nova Scotia into Minnesota and south in the Appalachians to northern Georgia. It occurs throughout New England from northern Maine to Long Island Sound.

It is less particular in regard to the character of the soil or moisture than the sugar maple, but is less tolerant of shade than that tree. In second growth stands it is a fairly rapid grower, but under virgin conditions the growth is similar to that of maple and it lives to equally advanced age. Like all birches this species is a very prolific seeder, and as the seed is very light it is blown long distances. Birch seed germinates particularly well on burned-over land where the mineral soil is exposed. Openings in spruce forests caused by windfall or fire or camp clearings frequently grow up to a dense stand of seedlings either of pure yellow birch or of this mixed with other species. This tree has no serious natural enemies and is little damaged by fire.

PAPER BIRCH (*Betula papyrifera*).

The range of the paper birch extends across the continent to the Rocky Mountains but not very far south. It occurs throughout New England but only occasional specimens are found in Connecticut and Rhode Island.

This tree thrives best on a fresh, well-drained soil, being fond of moisture but not of swampy land. Although frequently found on dry slopes it does not prosper there as well as the yellow birch. Paper birch is one of the most intolerant trees and is often killed out, for lack of light, by slow-growing but more tolerant species, which started under its protection but finally caught up with it in old age. Although rapid growing in youth, it is comparatively short lived, trees over one hundred years old being uncommon. Specimens over eighteen inches in diameter and seventy-five feet high are scarce.

It produces an abundant supply of seed, but on account of its intolerance of shade reproduction is only successful under favorable light conditions such as those obtained on burned areas. These also furnish the bed on which the seed germinates best because the bare mineral soil is exposed. When cut at an age of less than sixty years the stumps sprout prolifically and these sprouts grow even more rapidly for forty or fifty years than trees grown from seed.

The wood of the paper birch is used principally in the manufacture of spools, bobbins, dowels, shuttles, toys, pegs, etc.

Paper birch is very susceptible to injury by fires.

Grown in pure stands as it usually is, this birch is one of the most beautiful trees. In fact, it is difficult to imagine anything more beautiful than such a grove with the sunlight filtering through the foliage upon the pure white bark. In too many places this beauty is destroyed by the ruthless peeling of the bark for souvenir purposes. It should be realized that the white bark never grows again, and that once peeled the beauty of the tree is gone forever.

On account of its rapid growth, its value for special purposes, and its prolific reproduction on burns, this tree always will be one of considerable importance in northern New England.

GRAY BIRCH (*Betula populifolia*).

The tree is found from New Brunswick south through Delaware and Maryland and west through New York. It occurs in all parts of New England, but chiefly in the three southern states.

The gray birch is a poor imitation of the paper birch but is sometimes confused with it on account of the whitish color of its bark. This, however, does not peel so readily and is a dirty white compared with the clean white bark of its superior. Furthermore, this tree seldom attains a diameter over eight inches or a height over fifty feet, and is short lived.

The gray birch is as characteristic of the old fields of southern New England as is the red cedar. It grows rapidly in such situations where there is plenty of light, but under shade is soon killed out. It thrives on the driest of sand plains differing in that respect from the paper birch, but is also occasionally found in rather swampy places. The quality or texture of the soil seems to be of less importance than the amount of light available. It produces a large crop of seed every fall which is blown long distances. This germinates best on bare mineral soil, though

often starting well on a thin sod. For the first twenty years or so it grows very rapidly and when cut sprouts vigorously, so that in many cases it is an undesirable weed on account of the difficulty of keeping it out of the fields.

The gray birch is easily killed by ground fires, but has no serious enemies.

It seldom attains lumber size, and is an indifferent fuel, but is beginning to be used for spool and bobbin manufacture and other purposes for which its wood, which is similar to that of the paper birch, is fitted. However, it is not a tree that will ever be favored by the forester.

BEECH (*Fagus atropunicea*).

The range of the beech extends throughout the eastern United States from the Atlantic to Wisconsin and Texas and south to the Gulf of Mexico. In New England it is found principally in the forests of the three northern states. As found in New England, it occurs always in mixture with other trees, and prefers a loam soil. However, it frequently grows on very poor sandy soils or other dry situations. It is one of the most shade enduring trees, and on this account it is able to grow under a dense cover of other species. Like the yellow birch and maple it is slow growing and lives to an advanced age. Although it suckers from the roots, its chief means of reproduction is by seed, which being a heavy nut cannot be transported by the wind. Heavy seed crops occur only at long intervals, although some seed is borne every three or four years. The seed germinates best on a mineral soil well mixed with humus. In Connecticut, Rhode Island, and southeastern Massachusetts the beech reproduces very poorly from seed and is forced to depend on root suckers.

Its smooth, heavy bark is a good fire resister, and it has no serious enemies. The lumber is used for heavy planking, for tool handles, etc., but is of relatively low value, and the tree will never hold an important position in forestry operations.

WHITE ASH (*Fraxinus Americana*).

The white ash occurs throughout the eastern half of the country, west into Nebraska and Texas, and south into Georgia and Mississippi. In New England scattered specimens are found in all sections, but it is most common in the northern hardwood forests.

The white ash usually occurs as individuals mixed with other trees, seldom forming a large proportion of the stand. It prefers a moist loam soil and is almost never found on dry, sandy sites. It also requires considerable light, and, when favored with good light and soil, makes a fairly rapid growth.

The ash seeds nearly every fall, but some years more heavily than others. The seed has a long wing and is carried considerable distances by the wind. It germinates best on a mineral soil rich in humus, and where such conditions prevail near seed trees reproduction is usually good, although never so plentiful as with some species, as birch and maple.

The ash is frequently covered with the oyster-shell bark louse, but has no serious enemies and investigation indicates that it is not attacked by the gipsy moth. The bark is not very thick and consequently the trunk is seriously injured by ground fires.

Ash lumber has a high value for carriage manufacture, scythe snathes, tennis racquets, and other special uses requiring bending qualities.

On account of its high value and its rapid growth, the white ash is the best deciduous tree of New England to cultivate and should be especially favored by the forester.

BASSWOOD (*Tilia Americana*).

The national range of the basswood is practically the same as that of the white ash. In New England it is found chiefly in the northern hardwoods region. It is also similar to ash in its requirements as to a good moist loam soil and plenty of light, but will survive in comparatively dry situations. It grows rapidly but seldom reaches advanced age without becoming decayed in the center.

The seed has a wing which helps to carry it some distance. It germinates best on moist mineral soil rich in humus and seedling reproduction in the north woods is usually fair. The tree has the further advantage of being a prolific sprouter, by which it reproduces almost entirely in Connecticut and Massachusetts. Clumps of basswoods are common wherever the tree occurs.

It is little troubled by insects, but is easily damaged by fire. Its wood being light, straight-grained, and easily worked, gives it a demand for many purposes, as for lumber, clapboards, excelsior, etc.

The high value of the lumber, its rapid growth, and ability to reproduce by seed and sprouts, make the basswood second only to ash in the forester's estimation, especially in northern New England.

POPLAR (*Populus tremuloides*, *P. grandidentata*, *P. balsamea*).

The national range of these three species is somewhat different but they all occur well scattered throughout New England. *P. tremuloides* is more common in the northern, and *P. grandidentata* in the southern portions.

These true poplars should not be confused with the tulip tree which is called in some sections yellow poplar and is native in southern New England but has a different character from the real poplars, which are all similar to each other.

The poplars are not fastidious as to soils except that they rarely grow on heavy clay. They are common on sandy soils and prefer warm, well-drained situations. They are all very exacting of light and do not endure much shade at any time.

Poplar is noted for its rapid growth and attains a diameter of ten inches or a foot, and a height of sixty feet, in forty years. It is short lived, however, and usually infested by a fungus, *Fomes igniarius*, by the time it is forty and begins to die at the top. The bark is thin and the tree is damaged easily by fire.

The crop of seed which is borne every summer is always a prolific one and as the seed is very light it is blown long distances.

It germinates best on bare mineral soils, especially those which have been burned over and, therefore, along with the birches, the poplars are the first trees to reclothe burned areas.

Poplar is used for lumber, paper pulp, and many special uses, and on account of this, its rapid growth and its power to cover burns, it is a tree to command considerable respect in forestry.

CHESTNUT (*Castanea dentata*).

The chestnut is a southern tree and extends north only to the southern portions of Vermont, New Hampshire, and Maine. It extends west into the Mississippi valley and south into Alabama and Georgia.

Chestnut prefers a rather moist loam soil, although it sometimes grows on sand plains and on the dry, trap ridges of Connecticut where, however, it is unable to compete with the chestnut oak. Perhaps of all deciduous trees it is the most conspicuously independent of lime. As regards light, however, it is more exacting. The young seedlings cannot thrive long under shade any more than can the sprouts which spring in great numbers from the stumps. This sprouting capacity of the species is its strongest characteristic, and the one by which, with each successive cutting, it gains in the struggle for existence with the rival inmates of the wood lot. Trees sprout to a more advanced age than any other species, and vigorous sprouts are common on specimens 110 to 120 years old. Seed years are not infrequent, but the nuts are eaten so extensively by men and rodents, and are so injured by insects, that reproduction depends largely upon sprouts. The chestnut is one of the most rapid growing New England trees. The young sprouts are especially fast growing, often making a height of five or eight feet the first year. In the course of forty or fifty years, however, the seedlings overtake the sprouts and live to a greater age. Most of the chestnuts of southern New England are of second or third growth, and it is seldom that a tree over 150 years is found, though in the virgin forests of the south they attain an advanced age. The smooth bark of the young chestnut renders it particu-

larly liable to damage by fire, and even the older trees are so severely scorched that they become liable to fungus diseases.

By permission of the Connecticut State Forester.

Fig. 19. — A plantation of chestnut and black locust 68 years of age.

Chestnut killed back by fire often sprouts again, and it is common to see groups of fairly thrifty sprouts surrounding the old dead

stubs. There is a special bark fungus, *Diaporthe parasitica*, discussed in the chapter on Fungi, which is now a serious enemy of the chestnut.

Chestnut wood is particularly durable in the soil and has a wide range for poles, piles, ties, etc., as well as for lumber. On account of its wide use and consequent value, its ability to sprout and its rapid growth, the chestnut is the most valuable tree of southern New England, and should be much raised in the future, unless the bark disease renders it impracticable.

WHITE AND RED OAKS (*Quercus alba* AND *Quercus rubra*).

These two trees, which are the most important of the New England oaks, although somewhat different in character, may well be considered together. The oaks are essentially southern trees, extending up into New England from southern regions. The white oak has a range similar to that of chestnut; scattering specimens of the red oak extend to the Canadian line, and are found on Mount Kineo in Maine, and on an island in Lake Memphremagog, Vermont, although it is doubtful if it is native there. Neither species is especially fastidious as regards soil, for although they prefer a well-drained loam they frequently grow on dry sand or heavy clay. They do not thrive in swamps and are seldom found there. Both oaks can stand a fair amount of shade, more than the chestnut but less than maple. They differ widely as regards rapidity of growth. The red oak on good soil often grows nearly as fast as chestnut; with the other species the growth is slower. Both attain a very advanced age and the oaks are proverbially the longest lived trees. Both reproduce fairly well from seed. White oak seeds abundantly once in several years, but a seed crop of red oak is produced every other year. The nuts, of course, cannot be transported any considerable distance except by squirrels and similar means. The acorns germinate best on a mineral soil lightly covered with leaves. In southern New England the chief reproduction of oak is by sprouts. The sprouting capacity of the white oak de-

creases rapidly after sixty years. The red oak is a better sprouter, and here again is a close second to the chestnut.

Oak bark is so thick that it is little damaged by surface fires. The white oaks, however, are scorched severely by hot surface fires, after which they become infested with fungi.

In eastern Massachusetts and the adjacent territory the oaks are damaged and frequently killed by the gipsy and brown-tail moths.

Oak lumber is strong and the white oak particularly is durable in the soil. It has accordingly many uses and sells at a good price. The numerous uses make the oaks important trees to produce, but their rather slow growth is a factor against them from the forester's standpoint. Red oak will be planted much more than the white.

TULIP TREE, WHITEWOOD, YELLOW POPLAR (*Liriodendron tulipifera*).

This tree, known in different parts of its range by these various names, is a southern species extending from Massachusetts west into Illinois and Arkansas and south to the Gulf of Mexico. In New England it is most common in Connecticut.

In the region treated in this book, the whitewood, as it commonly is called here, is usually a tree of the rich, moist bottom lands, and rarely grows on dry upland sites. In its requirements as to light it is exacting, though the seedlings sometimes start under a light shade.

The tulip is a fairly rapid grower, although in this section its growth is probably less rapid than farther south. It is also a long-lived tree. It has a characteristically straight form, free from defects, and veterans two feet through and eighty or ninety feet high are sometimes found even in this northern extension of its range. In the south it grows much larger.

Seed is borne prolifically, and being light and equipped with a wing, like ash seed, it is carried considerable distances. The seed germinates easily on light leaf litter or bare mineral soil, but

as only a small percentage of the seed is fertile, reproduction in this region is somewhat scanty. It sprouts occasionally from the stump but cannot be considered a vigorous sprouter.

The tulip has a tender bark and is easily damaged by fire. Although the leaves are sometimes badly infested with a scale insect it has no serious insect or fungus diseases.

The lumber is smooth, clear-grained, soft, and usually free from defects, hence, easily workable. Known in the market as whitewood, although usually of a greenish-yellow color, the lumber has many uses, as in the manufacture of carriages and furniture, for cheap interior finish, etc. Near the seacoast it is used for piling.

On account of its rapid growth and its value the tulip is a tree to be encouraged in sites suited to its production.

CHAPTER IV.

FOREST PLANTING AND SEEDING.

THE essential difference between forestry and lumbering lies in the measures taken when harvesting timber to make provision for a second growth. We have described the various silvicultural methods by which this may be brought about. It often

Fig. 20. — One-year-old white pine seedlings grown for forest planting.

happens that these attempts are not wholly successful and large gaps occur in the young stand. These are as much to be deplored in good forest management as they would be in raising corn or tobacco, and in addition to the natural methods it is necessary to resort to artificial means of stocking. Among these methods clear cutting with artificial reproduction was described. Under this system planting or sowing is depended upon entirely for the new stand.

In all parts of the country there is land once used for agriculture, which was either unsuited for that purpose or has become

exhausted by a system of farming which did not maintain the fertility of the soil. Such lands are often better suited for the raising of forests than any agricultural crop, and must be stocked artificially. Much land forested to-day is not covered with fast growing trees or with timber that possesses high value. Such lands are not producing so much or so valuable wood as they might. Another opportunity for artificial reproduction is found in introducing better species into such woodlands. This can often be satisfactorily accomplished by setting out one to two hundred plants per acre. Although only partially stocking the land at the time of planting, if cared for they will finally develop and dominate the stand. The desired change in the forest is thus accomplished for a fraction of the expense necessary to plant the whole area. It will be apparent that there are numerous opportunities for the use of artificial reproduction, and it is necessary that the best methods of accomplishing this be thoroughly understood.

Artificial establishment of a forest may be effected by planting or by seeding. By "seeding" is meant the use of seed on the land to be restocked; "planting" implies that small trees raised in a nursery or taken from the woods are used, and it has been found that planting is almost always preferable, because for the same amount of money a more complete stand can be secured by planting and because two or three years of the rotation are saved thereby.

Several methods of seeding are practiced. Broadcast sowing of seed, the most common, is also least often productive of the best results. This may be modified by brushing in, or raking in the seed. Sometimes the ground is prepared in advance for the reception of the seed by stirring the soil with a harrow. Where the land is sufficiently free from rocks and brush very satisfactory results can often be secured by plowing and harrowing the land and then sowing the forest seed with some farm crop, such as buckwheat. This, however, is an expensive method and land which can be so treated is usually fitted for agriculture.

Partial seeding instead of broadcasting is sometimes tried.

Where plowing is possible furrows may be run across a tract at intervals of from six to ten feet and seed sown broadcast in these furrows. Another modification is the so-called "seed-spot method." In the application of this system, spots favorable for germination are prepared, every six or eight feet, by scraping away the sod for a foot square and loosening the soil. Seeds are then sown in each spot and are pressed in by the foot or buried at different depths according to the nature of the seed. Depressions made in this way or from plowing a furrow give the seedlings the benefit of more moisture than is available on level ground, and free them for a brief period from the encroachments of grass and weeds.

Several good methods of planting are recognized. In New England the tool most used is the mattock or old-fashioned grub hoe, as it is often called. With this the sod must first be scraped away for a space about a foot square, that the seedling may not be harmed by grass or weeds. With a strong stroke of the mattock the blade is driven well into the soil. Then by raising the handle and turning it slightly to the right the soil is broken on one side, while under the blade a cleft is made into which the rootlets of the plant may be placed before the blade is removed. The mattock is then taken out and the earth made firm with the foot. This is called the slit system of planting. Sometimes with a light sod the preliminary scraping away may be omitted, thus shortening the operation but decreasing the efficiency.

A more thorough way of planting and one surer of results is to scrape away the sod, and then to remove the earth from the center of the square. In this hole the tree is set by hand or with the aid of a trowel. Fine dirt should be packed tightly around the plant. This and the slit method are recommended for ordinary work. In either case the emphasis must be placed on the removal of the sod before the hole is made.

In wet places where planting is desirable it is customary to make mounds of earth and set the plants in the center of these. This is, of course, a more expensive method.

One precaution above all others must be taken in forest plant-

ing, especially with conifers, and that is, not to expose the fine rootlets to drying influences of sun or wind, even for a few minutes, because they are very tender and will be killed by such exposure. When the nursery stock arrives at the plantation it should be heeled in immediately near the place of final planting. To do this a slanting ditch is dug slightly deeper than the length

By permission of the Connecticut State Forester.

Fig. 21. — A small planting crew organized in units of two men.

of the roots. The bundles of trees are untied and loosened, and the roots carefully spread out and covered with soil. This is called "heeling in" the plants. It is well to wet the roots by pouring on water after the plants have been heeled in. The soil should be firmly pressed against the tree roots and if several days are to elapse before planting, some boughs should be spread over them for a shade. It is better yet to dig the ditch where there is shade.

Just before planting, the roots should be thoroughly puddled, that is, dipped in a thick mud. For this a mixture of clay and

loam is preferable, of such consistency that it will stick to the roots but will not harden on them, in case of a prolonged drought. The plants should be carried to their destination either in pails half filled with a mixture of mud and water or in baskets with plenty of wet sphagnum moss to cover their roots.

An important consideration is the size of the plants with which the plantation is established. A small, inexpensive plant is wanted, yet one hardy enough to withstand the severe conditions

Fig. 22. -- Nursery beds of 2-year-old pine seedlings.

to which it is often exposed. What are known as two-year-old seedlings and three-year-old transplants are the two grades ordinarily employed in establishing commercial plantations. The former has been grown for two years in a seed bed; the latter was transplanted after one or two years in a seed bed and has grown one or two years since transplanting. Three-year-old transplants cost approximately twice as much as two-year-old seedlings and are much stronger plants. The present tendency is to use seedlings only on the most favorable sites, and this is the wiser course.

The relative merits of pure and mixed forests have already been discussed. It is safe to say that most of the planting in this

country will be pure, that is, that there will be little mixture of species on the same area. This is because it is simpler and, on the whole, a pure plantation of a tree well adapted to the soil is more satisfactory than a mixture. It is well, however, for the reasons mentioned in discussing pure and mixed forests, to plant small areas with different species. Commercial planting,

By permission of the Connecticut State Forester.

Fig. 23. — A plantation of white pine about 8 years old spaced 6 by 12 feet.

This is too wide.

whether pure or mixed, should, however, be restricted to a few species of known value and adapted to the site. White, red, and Scotch pines, Norway spruce, European larch, white ash, and red oak are the standard trees for commercial plantations in New England. On the whole, conifers or softwood trees in contrast to the hardwoods recommend themselves especially for forest planting for the following reasons:

1. Softwood lumber is in greater demand for general purposes, and, therefore, commands the best prices.
2. The conifers, such as pine and spruce, are more rapid growing than the hardwoods.

3. The conifers yield more lumber to the acre in a given length of time than deciduous species, because the trees stand closer together and grow faster.

4. Much of the land to be planted is of very light soil and is, therefore, better adapted to such trees as the pine than to any other species.

The question of the proper spacing of trees is one which has led to endless discussion on the part of European foresters, and it must be decided in every case according to the owner's particular aims. In many of the early German plantations the trees were spaced not farther than one meter (three feet) apart. The general tendency to-day, even in Europe where nursery stock and labor are still comparatively cheap, is toward more open spacing, and the practice thus far in New England is to plant about five or six feet apart.

For most purposes a spacing of six by six feet is recommended.

The following table gives the number of trees required to stock one acre when set at different distances apart.

Distance of spacing	Number of trees per acre
3 by 3 feet.....	4840
4 by 4 feet.....	2723
5 by 5 feet.....	1742
6 by 6 feet.....	1210
7 by 7 feet.....	880

The general principles underlying spacing may be stated here and the planter may judge for himself what distance best meets his own requirements. Close planting forces the trees up in order to secure light, and thus produces a rapid height growth. At the same time it kills the lower limbs for lack of light, thus causing natural pruning. The result is a long, slender log fairly free from knots. Open planting, on the other hand, produces a large-branch system, a rapid diameter growth, especially near the base, and a rather slow height growth. The result is a short, thick log tapering rapidly from base to top and rather knotty. For the production of high-grade lumber the former is evidently to be advised; for a heavy production of fuel wood, pulpwood,

railroad ties, or other inferior materials, the open spacing may be more profitable. One should also remember that tolerant trees must be planted closer than intolerant trees in order to secure equally good pruning.

Fig. 24. — A block of 3-year-old white pine transplants; the best stock with which to start a commercial plantation.

Cost of planting varies enormously and depends primarily on the stock used, price of labor, spacing of the plants, and condition of the planting site. Often adverse weather conditions or other factors cause heavy losses, and extra expense is required to secure a complete reproduction. Good stands have been secured for less than \$5 per acre and sometimes more than \$30 per acre have been spent. On the average New England planting site, using three-year-old transplants at \$5.50 to \$6 per thousand, set six by six feet apart, and with labor at \$1.75 per day, the cost per acre should not exceed \$15; it can rarely be brought below \$11. This does not allow for the unusual losses which sometimes occur, due to prolonged droughts. Where areas as large as several thousand acres are to be planted and the stock is grown by the planter, the cost may be a few dollars an acre less than this estimate, which is based on stock that is purchased.

The success of seeding is governed so largely by chance and weather conditions that the cost of a successful sowing is more uncertain than that of a plantation, and cannot be figured accurately in advance. The few successful sowings which have come under the observation of the writers have cost more than the amount given for an average plantation. It is believed when sufficient care is taken in preparing the site, and securing the same success as would be obtained by planting, that the cost in every case would be higher than that of the plantation.

CHAPTER V.

IMPROVEMENT CUTTINGS.

IN Chapter II the different methods of cutting with the purpose of securing a new stand (reproduction cuttings) were discussed. Such cuttings are needed in mature timber in order that a young stand may replace the old one,¹ and occur only during the latter part of the life of the stand. There is then a long period extending from the time that the old stand is removed and the new one established until the new stand has itself developed to maturity and become ready for a reproduction cutting.

During this period, *i.e.*, between reproduction cuttings, there may be, and in a stand under management ordinarily are, several cuttings, which are termed improvement cuttings. Their purpose is to improve the existing stand in composition, rate of growth, and value of the final product, without any attempt to secure reproduction.

Improvement cuttings are made in immature stands, ranging from those only a year or two in age to stands nearly ready for reproduction cuttings.

Improvement cuttings may advantageously be divided into four kinds, as follows, each of which will be separately discussed:

1. Cleanings.
2. Liberation cuttings.
3. Thinnings.
4. Damage cuttings.

1. *Cleanings*. — As a stand begins to grow there are almost sure to be certain trees present which, because they threaten to injure better trees, are not wanted. These trees may be of an inferior species or they may simply be poor individuals of some

¹ Artificial reproduction, *i.e.*, planting or seeding is sometimes employed.

valuable species, or often worthless shrubs. In any case, they need to be removed in order that the stand may eventually be of the highest possible character. This type of cutting is called a cleaning, and always takes place in young stands, usually when they are from three to ten years of age. Frequently one cleaning is not sufficient and another must be made three to five years after the first.

The trees removed differ but little in age from those left and oftentimes are the same age but of more rapid growth. When a few years older they are usually of the type termed "advance growth," by which is meant trees that seeded in first and obtained a few years start of the rest of the stand. Because of their comparative freedom from side crowding they have rather branchy crowns and will not develop into high-grade trees.

The expense of the cleaning can often be reduced and the purpose as well accomplished by lopping off the tops of the trees instead of cutting them at the base. They should be lopped back far enough so that the tops of the trees to be freed are above them.

One is tempted in making a cleaning to remove all trees of inferior species, all shrubs, and all poor individuals from the stand. But from both the financial and silvicultural standpoints only the material should be cut which is actually hindering the development of better trees. If all inferior species were to be cut, great gaps might be left in the stand, since there may be no valuable trees in mixture with the poor ones. In such a place a cleaning need not be made.

A small hatchet or a brush hook is an excellent tool with which to make cleanings where the material is small or the tops are to be lopped, but often in stands five to ten years of age an axe is needed.

Inasmuch as a cleaning is in such young stands that no merchantable material is secured from the cutting it results in a present financial loss. Cleanings should only be made where a small expenditure will be justified by the improved development of the stand. A stand of white pine overtopped by gray birch is an example of where they are justifiable. The forest of

nearly pure pine which can be secured by removing the overtopping birch will be so valuable as to more than pay the expense of the cleaning.

The cost depends so largely upon the amount and size of the material to be removed that it may range from a few cents to several dollars per acre. An expenditure of more than \$3 per acre for a cleaning is usually unnecessary and the work can often be done for 25 to 50 cents per acre.

As a general rule cleanings should be made as needed in all plantations to protect the planted species, and wherever there is a wide difference in value between the species being injured and the one injuring it. A cleaning is an intensive forestry operation and hence in many places is impracticable.

By permission of the Connecticut State Forester.

Fig. 25. — The spreading hardwoods should be taken out to liberate the seedling growth.

2. *Liberation Cuttings.* — Liberation cuttings are used in young stands from a year or two old to those of middle age. The operation consists in removing older trees which, by their

widespreading crowns are interfering with a younger growth that it is desired to favor. Unlike cleanings where the trees removed differ in age from those left by only a few years, liberation

Fig. 26. — A liberation cutting is needed to remove the large oak to free the young growth which is already feeling the effects of the crowding.

cuttings remove trees of a much older age class than the remainder of the stand.

A study of the diagrams of cleanings and liberation cuttings on page 78 will make this point clear. Two diagrams of liberation cuttings are given. The first is in a very young stand of seedlings with large trees high above them. This form is very similar to the final cutting under the shelterwood system

Fig. 27. — A cleaning. The stand contains white pine 5-8 years old, overtopped by gray birch 6-10 years old. The gray birch should be cut out or lopped back. Two older white pines (18 years of age) forming "advance growth" should also be cut, as they will produce knotty lumber and suppress several most promising trees.

Fig. 28. — A liberation cutting in which the young stand has not yet been seriously affected by the overtopping trees.

Fig. 29. — A liberation cutting in a middle-aged stand, where the crowns are already de- formed by the large trees which should be at once cut to prevent further injury.

of reproduction. In Fig. 29 a middle-aged stand is shown with older trees interfering. Here the crowns of the main stand have reached the crowns of the interfering trees and are already somewhat deformed. If the cutting were delayed much longer the stand would be seriously injured.

The material removed in liberation cuttings is of merchantable size either for timber or cordwood, but is usually of poor quality, being knotty and frequently extremely limby. From the size of the trees to be cut it often appears that a handsome profit can be made, but owing to the scattered location of the trees singly among younger trees, the logging is usually expensive and the trees, on account of their widespreading crowns and large limbs, are hard to cut up. In most cases the trees can be disposed of for enough to at least pay the costs of the operation; so that no financial loss is ordinarily required in making liberation cuttings.

Liberation cuttings are needed especially in abandoned fields which have gradually reverted to forest, or on cut-over lands where in previous cuttings poor individuals had been allowed to stand.

As liberation cuttings pay for themselves they have a wider range of application in practical work than do cleanings, but at the same time, since the material removed is of a low grade, it cannot readily be sold where the markets are poor. A good rule is to make liberation cuttings wherever the material will at least cover the cost of removal.

3. *Thinnings*. — As a young stand of trees grows older, individuals which at first had ample space for development become crowded. There commences a struggle between them, which becomes more intense year by year, for light, growing space, moisture, and nourishment. As the struggle goes on certain trees obtain a slight advantage over their neighbors and may finally succeed in completely overtopping and killing them. In accomplishing this, however, the leading trees, as well as those overtopped, are inevitably restricted in crown development, and therefore are retarded in rate of growth and prevented from

attaining the size possible if they had not been so seriously hindered by the competition with neighboring trees.

In order to prevent part of this competition and to keep the leading trees in the stand growing at a rapid rate thinnings are made.¹ Thinnings remove the trees which have fallen behind

Fig. 30. — Plantation of white pine and European larch on first quality soil. The stand has just received a C grade thinning. Total yield 40 cords per acre. Amount cut 16 cords per acre. Age 27 years. In the foreground most of the pine was removed, leaving the larch,

the best trees of the stand but which still crowd them and hamper their development.

It is convenient in discussing thinnings to divide the trees in a stand into five classes, called crown classes, depending on the relative position of each class with respect to the other trees in the stand.

¹ The struggle for existence is best noticed in even-aged stands where trees of the same age are competing. It is in such stands (even-aged) that thinnings are particularly needed, although in forests of other forms there will be found small even-aged groups here and there in which thinnings are useful.

These crown classes are as follows:

Dominant; which contains the leading trees having comparatively symmetrical crowns and receiving full light.

Codominant; which includes trees a little shorter than the dominant ones and with smaller crowns crowded on the side.

Fig. 31. — The same plantation before thinning. Note the dense dark appearance of the stand in contrast to its appearance after thinning. Although the stand is 27 years old the dead branches still persist on the trees down to the ground. On the trees in the foreground the lower dead limbs have been knocked off.

Intermediate; comprising trees shorter than those in the preceding class and with crowns open to light only from above and seriously crowded on all sides.

Suppressed; including all living trees with crowns entirely overtopped. They can obtain only filtered light.

Dead; containing all standing dead trees.

There may be in a stand a wide range from dominant to dead trees and it may often be difficult to distinguish in which of two adjacent classes a tree belongs. This is especially true between dominant and codominant trees and between codominant and

intermediate. As a general rule dominant and the better co-dominant trees are favored in thinnings, while the other three classes are cut out. Just what is taken out depends mainly on the heaviness of the thinning, which may range from an extremely light cutting to one as heavy as a reproduction cutting. The

Fig. 32. — A stand of beech and oak in Europe, 40 to 50 years of age. A light thinning has just been finished.

following five classes of thinnings are recognized, depending on the heaviness of the cutting:

Grade A. — Light thinning; removing dead and suppressed trees.

Grade B. — Moderate thinning; removing dead, suppressed, and the poorer intermediate trees.

Grade C. — Heavy thinning, removing dead, suppressed, intermediate and a few codominant trees.

Grade D. — Very heavy thinning, removing dead, suppressed, intermediate and codominant trees.

Accretion Cutting. — Any thinning heavier than Grade D.

Which grade to use depends mainly on the purpose for which the stand is managed. Light and moderate thinnings favor the production of high-grade timber free from knots. This is the principal advantage of the competition between trees in a dense stand, and thinnings of Grades A and B do not greatly lessen the competition in a stand, since this is largely between trees of the intermediate, codominant, and dominant classes.

By permission of the Connecticut State Forester.

Fig. 33. — A white pine stand 34 years old secured by artificial seeding. A C grade thinning has just been made.

Heavy thinnings, by giving the trees ample growing space, result in the production of shorter-boled and more knotty trees; and, on account of the greater growing space, in more rapid growth and higher yield in a given time. Where quantity without regard to the highest quality is wanted heavier thinnings are needed than where timber of high technical quality is the primary consideration.

In general, as the thinnings increase in severity, the diameter

and hence volume growth of the trees rises, but there always is a point beyond which heavier thinnings, while possibly still increasing the rate of growth on the individual trees, lower the growth of the stand as a whole. This is because the gaps between trees become so large that the total growth per acre from the few fast-growing trees is less than would be secured from those left after a lighter thinning.

Accretion cuttings are too heavy to secure the highest growth per acre, although phenomenal growth on individual trees may result.

Thinnings of Grades A and B interfere so little with the natural competition that their effect in increasing the rate of growth of a stand is negligible. A Grade C thinning is needed to appreciably increase the growth rate, and at the same time this grade does not so open the stand as to prevent the production of clear timber. For most owners in New England, Grade C or occasionally Grade D thinnings will be the most valuable.

In making thinnings of whatever grade it should always be remembered that the trees to be cut are chosen on the basis of their crown development. Too often a beginner examines the spacing of the trees on the ground and endeavors to cut wherever the number of trees is great, with the object of securing a uniform spacing of the trunks. This is altogether wrong and can be easily avoided if the crowns of the trees are used as the guide in selection.

Another method of thinning, somewhat different from the one already described, is known as the French method because of its origin and use in France. By this method certain trees are selected, when the stand is about thirty years of age, which will be favored and are to form the final crop at the end of the rotation. The number of trees per acre to be selected varies with the species, the product to be produced, and various other factors, but for the purpose of this discussion may be said to range from one to two hundred.

When these trees have been picked out a thinning is made

with the object of giving them every opportunity for rapid growth. They are set free by cutting the surrounding trees which are at the time seriously crowding them. The cutting is made regardless of the crown class of those cut. Codominant and dominant trees as well as those of the lower crown classes are removed if hindering the chosen trees.

A second principle of the method is that practically nothing is removed unless it actually is interfering with the chosen in-

By permission of the Connecticut State Forester.

Fig. 34. — Same stand as in Fig. 33, but 2 years after the thinning. Poplar and gray birch have reproduced abundantly, largely owing to the abundant light which was admitted to the forest floor. A lighter thinning would have encouraged white pine reproduction.

dividual. The only exception is in the case of dead trees or those that will die in a very few years. These are cut but the suppressed and intermediate classes are allowed to remain if not hindering the chosen trees. The French method really amounts to a Grade D thinning in the upper crown classes, and a Grade A thinning in the lower classes, taking out the poorest material.

The chief advantage of the method is that the trees to form

the final crop being selected so early can be kept free and growing rapidly. It is thought that equally good timber can be produced faster under the French method of thinning than under that ordinarily used. Up to the present time there is no adequate data to conclusively prove this. With poor markets the method may sometimes be employed when another could not, since some larger-sized material is secured from the heavy cutting in the dominant and codominant classes, while the lower classes, furnishing cordwood principally, are left uncut.

Silviculturally the lower classes of trees assist in forcing the height growth of the chosen trees, and furnish a good cover to the soil which is in this way better protected than in Grades C and D thinnings as ordinarily made.

A practical disadvantage of the French method is that the numerous suppressed and intermediate trees left standing make the execution of the thinning difficult. The felling of the trees is often badly hampered, and considerable breakage of standing trees occurs. Moreover, the piling and removal of the wood is made more expensive by the many standing small trees.

In actually carrying out a thinning in the field it is often advantageous, and, in fact necessary, to secure the best results, not to hold rigidly to a thinning of any given grade. For instance, a Grade C thinning may be the kind desired, but where dominant trees of a worthless species or diseased trees occur, it is best to cut them, making in such places a heavier cutting. The theory of thinnings as given here is exceedingly simple but in application many problems will come up which cannot be covered in the space of this discussion, and are best solved through field experience.

The lessening of the competition between the individual trees which effects an increase in the rate of growth has already been mentioned as the chief purpose of thinnings, but the results which come through the aid of thinnings have not yet been fully stated.

The increase in rate of growth of the individual trees results in obtaining trees of merchantable size several years sooner than

is possible in an unthinned stand. In other words, thinnings enable the forester to shorten the rotation in which a given product is produced. This shortening may be as great as twenty-five per cent. For example, if an unthinned stand of pure

By permission of the Connecticut State Forester.

Fig. 35. — Portion of the same stand as shown in Fig. 33. Here a heavy D grade thinning was made and a large number of the trees were broken off by the wind. The trees were too slender for such a heavy thinning.

chestnut is merchantable for ties in forty years, a similar stand which has been properly thinned should have trees of the same size in thirty years.

Besides increasing the growth of the individual trees the total yield of the stand is raised, by which is meant that in a single rotation (or given number of years) more material is produced

by a thinned stand than by a similar one unthinned. There may be as much as thirty per cent added volume produced by the thinned stand. This increased production is made possible because the yield from the thinnings largely utilizes material which in an unthinned stand dies and decays before the final cutting. The struggle between the trees is slowly killing the weaker individuals. As the stand grows older, they pass from the co-dominant to the intermediate class, then to the suppressed, and finally are numbered among the dead. The great difference in number of trees per acre between young and mature stands (both fully stocked), which is apparent on the most casual investigation, gives an idea of the large number of trees and quantity of material lost through decay in an unthinned stand. Besides utilizing material otherwise wasted, the one thinned when ready for harvesting will have as great or sometimes even greater volume than the unthinned stand.

A higher grade product, taking the average for the whole stand, is furnished by the thinned than by the unthinned stand. In the latter there may be a few exceptionally fine trees, but with them are many inferior specimens, merchantable only for cordwood. In the former a smaller number of trees per acre will be found on which the growth has been concentrated. Individually none of them may contain such high-grade timber as the exceptional tree in the unthinned stand, but, on the other hand, every tree can be used for better products¹ than cordwood and the average value per tree is much higher.

Thinnings raise the grade of the final product in another way: by enabling the forester to eliminate worthless species from the stand when it is young. Oftentimes in unthinned stands a species of low lumber value will be found occupying a prominent place in mature stands, but in properly thinned stands this need never happen.

Theoretically thinnings should be begun as soon as the competition between the trees becomes strong. This occurs usually when a stand is ten to twenty years of age. Thinnings in such

¹ With light thinnings timber of high technical value can be produced.

young stands ordinarily do not yield material salable even as cordwood under present market conditions in New England. The first thinning should be deferred until the material taken out is large enough for cordwood and the returns will at least cover the cost of the operation. This will rarely occur before the stand is twenty years old, and not later than the thirtieth year.

Thinnings should be repeated whenever needed. Unless the thinning was very heavy this should be in five to ten years.

Fig. 36. — A C grade thinning in a 38-year-old stand of mixed hardwoods containing oak, chestnut, maple, black and yellow birches. Yield per acre 27 cords; actually cut 6½ cords per acre.

The time for making the next one can be judged by observing the crowns. If the openings left by the previous cutting have been filled and the crowns of the trees are once more in close contact, competition has again assumed serious proportions and it is time for another thinning.

The best method is to make small openings in the crown cover which will close together within a few years, necessitating an early repetition of the operation. When only small gaps in the cover are made there is no danger of the trees producing knotty

timber nor of the stand becoming insufficiently stocked with trees. The soil is best protected by light thinnings, frequently repeated. They should be carried on until the time comes to start reproduction cuttings.

At the present time in many quarters there is a prejudice against making thinnings through ignorance of their value and especially through belief that they are impracticable. One objection raised is that the uncut trees will be thrown by wind. There

Fig. 37. — The same stand as in the previous picture but 3 years after the thinning. The crowns have already closed together and another thinning could safely be made.

is sometimes danger of this on wet ground, with shallow-rooted species, on exposed sites and in stands past middle age when thinned for the first time. In such stands the trees often have very small crowns and root systems and depend on each other for support. If thinnings are begun when the stand is twenty to thirty years of age and made light there will not be any large loss due to windfall.

Another objection is made that the trees, in being cut and removed, will injure the standing trees. This arises through the mistaken idea that the smaller trees are left and the larger are

cut, while the reverse is true. Thinnings are often confused in the lay mind with the selection cutting described in Chapter II. As a matter of fact, the removal of the lower crown classes rarely inflicts a serious injury on a standing tree.

The cost of cutting and removing the material is somewhat greater than in cases where the stand is cut clear, but there is not the great difference sometimes assumed. The added cost will, of course, vary with the conditions, but ten to twenty-five per cent will represent the usual range. Frequently unfamiliarity with the style of cutting and unwillingness to learn on the part of the woodsmen are the chief factors in increasing the cost.

Thinnings in young stands yield only cordwood and in stands of all ages a large per cent of the material cut is cordwood. Where this cannot be sold at a profit, as is the case in portions of New England, thinnings are not practicable. Usually in coniferous stands they can be made under poorer market conditions than in hardwood forests, as in the former smaller-sized logs are cut into lumber or put into other products of greater value than cordwood.

4. *Damage Cuttings.* — Frequently a cutting is advisable in a stand with the purpose of removing and utilizing material which has been damaged by wind, insects, fungi, fire, or other causes. It is altogether too common a happening to have a large per cent of the trees in a stand killed by fire. Such a cutting, intended to take out injured material, is called a damage cutting. It is made without regard to the crown classes or species of the trees cut, simply taking out all injured individuals. As the extent of injury varies greatly so does the severity of damage cuttings. They may range from the removal of occasional trees to clear cuttings. In cases where the injured stand is mature or nearly mature it is often possible to begin the reproduction cuttings early, and arrange them so as to utilize the damaged trees. But in immature stands special damage cuttings are made in case of injury. Damage cuttings, so heavy as to remove a large percentage of the trees, call for a sacrifice in immature stands, as the trees are cut before reaching the most profitable

size. However, as long as fire, wind, insects, etc., cause extensive injury in the forests, damage cuttings are demanded as a regular part of management, to make the best of a bad situation.

When promptly made, before decay has progressed far, damage cuttings usually yield material of merchantable size. Where the returns from material taken out will not pay the expenses of removal, damage cuttings are not ordinarily recommended.

Fig. 38. — A damage cutting. Note the undergrowth of grass and weeds which has started as a result of the heavy cutting. To avoid such undergrowth improvement cuttings should be made as light as possible. The fallen tree, weakened at the base by fire and fungi, has been broken off by the wind.

Schedule of Improvement Cuttings. — In order to illustrate the relative time at which the different kinds of improvement cuttings are made, the following table has been drawn up for a planted stand of white pine, this particular type of forest serving as a good example for even-aged stands of other species. The rotation has been set at sixty years. If it was intended to reproduce the stand naturally, a reproduction cutting would be substituted for the last thinning.

SCHEDULE OF IMPROVEMENT CUTTINGS FOR A WHITE PINE PLANTATION.

Age of stand.	Cleanings.	Liberation cuttings.	Thinnings.	Damage cuttings.
Years.				
4	× ¹	In the case of a plantation the liberation cuttings, should any be needed, are best made just before it is established or within the first five years after.		Made only in case stand suffers injury.
7	×			
20	.....		×	
30	.....		×	
40	.....		×	
50	.....		×	
60	End of rotation. Stand cut clear and area planted, or regenerated naturally as described in Chapter II.			

¹ Crosses indicate cuttings.

Methods of Controlling Cuttings. — In order to be sure that the style of cutting desired is actually carried out on any particular tract, it is necessary to oversee the work with great care. This is so whether an improvement or reproduction cutting is made. It is especially true where the cutting is done by a contractor, or is in charge of old lumberjacks, trained to wasteful methods and unwilling to accept new ideas.

Control of the cutting can be assured best by marking all trees to be cut (or those to be left) and frequently inspecting the cuttings to see that the marking is being followed, or by outlining the general plan of cutting to a foreman and then frequently inspecting his work to be sure that he carries out the plan correctly.

The choice of the method of control will be mainly determined by the style of cutting.

In thinnings it is best to mark carefully either the trees to be cut or those to be left. Cleanings, liberation cuttings, and damage cuttings (because in making them it is usually a simpler proposition to recognize what should be removed) can often be satisfactorily controlled by furnishing the foremen in charge with general instructions and then looking over the work at frequent intervals. Many times, however, the trees to be cut in liberation and damage cuttings should be marked.

In reproduction cuttings, where clear cutting is to take place, laying out the areas to be cut suffices. Where seed trees are to be left, or the selection system or one calling for only a partial clearance is to be used, marking of the trees is advisable.

It may seem as though in a selection cutting the use of a diameter limit would take the place of marking, but there are so many cases in every operation where trees above the limit should be left and those below cut, that the trees should be marked, even when a diameter limit roughly controls the cutting.

Fig. 39. — A damage cutting in a stand of chestnut and oak. Fire has injured many trees and the chestnut bark disease was present. After the cutting, an open stand of the fire-resistant oak remained. The material cut was too small for anything but cordwood.

In marking the trees, either those to be cut or those to be left may be marked. Usually it is best to adopt the easiest method. Thus, on areas to be cut clear, with patches of seed trees to be left, the few seed trees should be marked; but in a selection cutting, where comparatively few trees are to be removed, these should be marked.

The trees can be marked by axe blazes or by dabs of paint. To insure full control of a cutting it is best to mark the base of the trees below the point of cutting, as well as a point easily seen

three to five feet above ground. Then, after the trees are felled, inspection of the stumps shows whether they were marked for removal.

If axe blazes are used for marks it is well to have a distinctive stamp on the head of the axe and stamp each blaze, thus preventing marking by unauthorized parties.

Pruning. — Pruning, as used in forestry, really should be classed as a type of improvement cutting, for its purpose is to improve the quality of the crop. It is an operation which as yet has been little used, and will be used only in occasional cases, where forest management can be on a highly intensive scale, and with certain species, like white pine, in which natural pruning is poor, even when grown in a crowded stand.

Pruning should only be practiced where clear lumber is wanted, and where such lumber is sufficiently valuable to pay the cost of the operation. The way in which pruning raises the value of the forest crop is through the early removal of lower limbs, allowing the production of clear lumber free from knots. (See Fig. 40.)

Forest pruning should be restricted to the removal of dead limbs. There are two reasons why the removal of live limbs is bad; first, because the wounds left by the pruning of live limbs offer good opportunities for the entrance of fungi or insects, and second, because the removal of live limbs disturbs the balance between the crown and root systems of the tree, and may often result in retarding its growth. It is claimed, also, that in the case of some species pruning of live limbs causes loose knots in the timber.

It is impracticable to prune higher than the first log length, or as high as a man can reach with his pruning tools. Pruning should be done at the earliest possible moment, as soon as the branches have died for the distance up the trunk that the trimming is to be done. In this way there will be a smaller knotty center inside the log. The pruning can ordinarily be done before the trees become twenty years of age.

Only the trees intended for the final crop should be pruned,

as to prune those of the subordinate crown classes, which will die or be removed in thinnings, would be a useless expense.

Various tools can be successfully used in forest pruning. As only dead limbs are removed, a blow from the back side of an axe

Fig. 40. — The results of pruning in producing clear lumber. The tree from which this lumber came was pruned up to, but not including, the set of knots marked *B*.

or a heavy stick will often do the work. On the higher limbs and where the limbs are small, pruning hooks do the best work. Where larger limbs are found, a saw is needed. The cuts should be smooth, and close to the trunk, so that they may readily heal over.

CHAPTER VI.

INJURIES FROM ANIMALS.

THE forest as a whole suffers relatively little from animals, their influence on its character being much less important than that of insects. Probably the most destructive wild animal is the porcupine, which in the northern woods girdles a great many trees, especially spruce. As these animals are very fond of old pork barrels they are often found in the vicinity of abandoned lumber camps, and, although in some states there is a reward for killing them, it is a question whether more harm is done by the porcupines or by the class of men who profit by this reward and are responsible for many forest fires.

While deer may damage some farm crops in parts of New England, it will be a long time before our forest management will reach that degree of intensiveness which has been reached in Germany, and which takes remedial measures against the occasional nipping of a forest bud or stripping of the bark from a sapling.

Squirrels, rabbits, and mice often nibble the bark from young trees and occasionally girdle them. The writers have seen plantations of locust and pitch pine in Connecticut killed in this way. Moles also injure the roots of trees and wounds of this kind furnish an easy entrance point for fungous spores. The greatest damage from these rodents is, however, in the forest nursery, where the seeds are often eaten in large numbers, especially the nuts and larger pine seed. Small birds, such as sparrows and goldfinches, frequently cause serious damage in forest nurseries by eating the seed just after germination and thus destroying the young plants. Provision against such damage can be made by coating the seed before sowing with red lead, a powder which will remain on the seed for a year and which is

distasteful to birds. In the large commercial nurseries where birds are a serious menace the seed beds are covered with a wire netting of three-fourths-inch mesh. Moles and mice in a nursery can be trapped. One of the simplest methods is to sink pails half full of water and covered with grain in the paths of the nursery,

Fig. 41. — A fine stand of hard maple and beech. Note absence of reproduction owing to heavy grazing and compare with next figure.

where the rodents will soon fall into them. Woodchucks, squirrels, and crows frequently damage seedlings in plantations, especially where nuts have been planted. Much of this injury can be obviated by coating the nuts with tar before planting.

More a matter of interest than of economic importance is the service squirrels sometimes render in helping in the collection of forest seeds. The Shakers of Enfield, Connecticut, used to seed down an area of sand plain each year to pine and buckwheat. After taking off the crop of buckwheat they allowed the area to

grow up to pine, and gathered the pine cones from the piles which the squirrels had collected in the woods.

Throughout New England much land formerly pastured is now growing up to brush and trees. For a long time this land was kept clean by cattle and sheep, but the rapid decline in the amount of live stock raised in the East has allowed the reversion of many pastures to forests. Where forest seedlings have come

Fig. 42. — A pure stand of hard maple ready for a selection cutting. Note the abundance of hard maple seedlings and saplings which have started owing to protection from grazing.

up in land still pastured, examination will show that many of them have been eaten or broken off by the animals. A common practice is to allow domestic animals to pasture in wood lots, where they do a great deal of damage, the character of which depends on the kind of animal.

Cattle are more inclined to rub against little pines and other conifers and thus break off their tops than to eat them. Sheep

and goats will often strip all foliage as high as they can reach. On steep slopes the trampling of the animals, overturning stones and cutting up the soil, results in preventing young seedlings from becoming established. Hogs destroy forest seedlings and eat the mast of nut trees and, in some sections of the West, this forms an important part of their diet. There may be times when the introduction of hogs into a forest is rather beneficial than otherwise. They will do much by their rooting to prepare the soil for germination before a heavy seed crop and it may even be advantageous for them to eat an undesirable kind of seed, as beech nuts, to keep down the percentage of a poor species. They also destroy innumerable grubs, many of which, like that of the June bug, are serious enemies of forest and nursery.

The presence of grass in a forest is a sign of poor management, as grass can only grow in openings exposed to sunlight and these openings should not exist in the forest. Grass, more than anything else, transpires moisture and tends to dry out the soil.

Another result of pasturing wood lots is a total absence of young seedlings and the consequent decline of the forest.

No area which has been planted to forest, or which has been covered with a natural growth of seedlings, should be pastured until the trees are ten feet high. If the stand is of proper density there will not then be sufficient browse to pay for pasturage. In other words, forestry and grazing can rarely be practiced on the same land to their mutual advantage.

CHAPTER VII.

FOREST INSECTS AND FUNGI.

THERE are numerous insects and fungi which attack the leaves, branches, trunks, or roots of forest trees. Some restrict their attack to dead or dying trees, while a smaller number are able to prey upon living healthy trees.

The insects and fungi considered in this chapter have been selected because they are among the most destructive to living forest trees. From the practical standpoint, the forester is less interested in enemies which prey only upon dead or badly injured trees.

For a complete list of the insect and fungous enemies of the New England forests, reference must be made to more advanced entomological and pathological works.

A. INSECTS.

WHITE PINE WEEVIL (*Pissodes strobi*).

This pest is found generally wherever the white pine grows.

Form of Damage. — The weevil invariably works in the main terminal shoot and causes it to wither, but seldom kills the tree. Depredations begin in July or early August. The next year one of the side branches straightens up and forms the leader, but there is always a slight crook in the tree. In badly infested regions the same tree may be attacked repeatedly, and numerous crooks will give it a deformed and stunted appearance. For timber purposes the value of the pine is much diminished. The insect seems to prefer trees under 30 feet in height, but it occasionally attacks taller ones, and those in old fields and open woods are more severely attacked than those in closed stands. The injurious effects are worse in the southern range of the species.

Appearance. — In its adult stage it is a reddish-brown beetle about one-quarter inch long with a pronounced snout. The pupa is creamy white and about the same length as the adult, and the grub is also white and of varying length up to one-quarter inch, according to development. The infested top of the tree is badly decayed at the close of the season and is riddled with tunnels that are filled with the borings. The wilting of the needles is the first evidence of the weevil's presence.

By permission of the U.S. Forest Service.

Fig. 43. — Leader of a young white pine killed by the white pine weevil. Several of the side branches have already begun to take the place of the leader.

Life History. — The beetles deposit their eggs under the bark of the main shoots in May or June, and the grubs, which hatch after a week or two, begin to bore inward and in a downward direction to the pith. In the grub stage they are greatly reduced in numbers by natural enemies, mostly parasitic insects. The transformation into pupæ and adults takes place during

July and August, after which the imprisoned beetles bore a way out to freedom and seek suitable abodes in which to pass the winter.

Treatment. — The best way to fight this enemy is to cut off the infested top during June, July, or early August, before the beetles have escaped. The surest way of extermination is to burn these tops, but as they often are the habitat of minute insects which prey upon the weevil, a modification has been suggested by Dr. Hopkins of the United States Bureau of Entomology. Obtain a perfectly tight box or barrel with but one opening (a large metal can is still better). In this, place the infested tops, and cover the opening with a very fine-wire mesh (one which an ordinary pinhead cannot pass through). The beetles cannot escape, but the parasites easily make their way out and attack other weevils. The box must not be exposed to the weather as it will check and allow the weevils to escape. Either form of treatment must be repeated several successive years as it is impossible to exterminate them in a single season.

In order to prevent the injured trees from developing two or more main stems, all the side branches of the top whorl, except one, should be cut off close to the main stem. This one side branch will straighten and develop into the trunk of the tree.

PINE-BARK APHID (*Chermes pinicorticis*).

Form of Damage. — This plant louse is sometimes present in such large numbers on pine stems as to weaken the vitality of the tree by sucking the sap. A sickly condition and occasionally death, in the case of young trees, results. This aphid occurs everywhere throughout the range of the white pine.

Appearance. — A cottony appearance on the twigs, and sometimes over the trunk of the tree, betrays the presence of the insect. It is sometimes mistaken for the exudations of the pitch.

The eggs occur in downy balls near the base of the needles and vary in number from five to sixty or more in each cluster. They are oval, and of a reddish-yellow color. As insects, some

are winged and some wingless. The young of the latter are oval in shape, somewhat flattened, and of a yellowish-brown tint. As these develop they become darker colored, and finally almost black. The wool-like covering serves to hide the insect and

By permission of the Connecticut State Forester.

Fig. 44. — A white pine tree 27 years old seriously attacked by the white pine aphid.

gives it the appearance of a ball of down. The winged species are of a light-reddish tinge; their white wings expanding rapidly become transparent, but the bodies become almost black.

Life History. — The eggs laid by the wingless females begin to hatch early in May, and the young, emerging in large numbers from the bulbs of wooly matter, spread over the bark at the base

of the needles. Individually they are almost too small to be seen with the naked eye, but their number at this stage is legion. They soon attach themselves to the tender bark of young twigs, increase rapidly in size and darken down to brown or black, and all the while exude a substance which nearly conceals them. Maturity is reached about the last of May when the females deposit eggs for another brood. During the summer there may be several broods and at last females with wings appear.

Treatment. — The aphid has several natural enemies, the most effective being certain varieties of ladybugs. Where a hydrant is near the insects can be washed off by a forcible stream of cold water. A spray of kerosene emulsion, or whale-oil soap, is efficient. One pound of the soap to four gallons of water makes a good mixture. However, in forestry it is usually impracticable as well as unnecessary to use preventive measures.

THE SPRUCE-DESTROYING BEETLE¹ (*Dendroctonus piceaperda*).

Form of Damage. — This insect, which has been prevalent in New England and New York since 1818, has destroyed much spruce timber by its borings in the cambium, the living tissue just beneath the bark. Here it makes its primary galleries, and lays its eggs. As soon as the eggs hatch the young broods make transverse galleries which effectually girdle the tree, and in time the withering leaves proclaim the death of the tree. The falling leaves are an outward sign of the damage; by removing the bark the galleries made by the insects may be plainly seen.

Appearance. — The adult is a reddish-brown or black beetle, varying in length from three-sixteenths to one-quarter of an inch. The egg, small and nearly white, is not distinguishable from that of other bark beetles. The larva, at first a minute white grub, becomes about one-quarter inch long. The pupa is nearly white

¹ See "Some of the Principal Insect Enemies of Coniferous Forests in the United States," by A. D. Hopkins, from Yearbook, U. S. Dept. of Agriculture, 1902.

and of about the same size and form as the adult; it is found in cavities in the bark.

Life History. — Simultaneously a large number of beetles will attack the lower part of a large-sized spruce. Trees over ten inches in diameter may be attacked. They bore through the bark and deposit their eggs in the galleries as already described. The eggs soon hatch and each larva bores its individual gallery where it matures. The period of development from egg to mature larva varies according to the season, from two to nine months, but the adult seldom develops sufficiently to emerge until another spring. The result is, when activity ceases in October, that a tree may contain the insect in all its stages of growth.

Treatment. — Nothing can be done to save a tree once infested with this borer, but much can be done to prevent the spread to other trees. Theoretically the best method is to make trap trees by hack girdling them in May or June. The beetles are thus led to concentrate on these weakened trees, and these are to be destroyed in the fall, winter, or early spring, either by the removal of the timber from the forest or by felling and removing the bark before the insects emerge. Intelligent lumbering of the areas of infected trees, and of all mature trees, is the most practicable way of keeping this insect in check.

THE SPRUCE BUDWORM (*Tortrix fumiferana*).

The spruce budworm is an insect which, within recent years at least, has not attracted widespread attention among foresters and landowners in New England. Extensive killing of the spruce about thirty years ago along the Maine coast is attributed largely by Packard to this insect. However, in Canada, in the neighboring province of Quebec, it is now a serious pest, and there is reason to believe that in New England also it may become dangerous.

Form of Damage. — The insect feeds in its caterpillar stage on the buds of the spruce, and after these are destroyed it eats off

the needles, attacking them at the base. Besides the spruce, other conifers may be attacked.

Trees may be killed outright by the spruce budworm, if defoliated repeatedly, but in the majority of cases the result is the checking of the growth of the tree and the weakening of its vitality. Indirectly this is of importance, since the weakening of the tree's vitality results in its falling an easy prey to the spruce-destroying bark beetle, which is a much more dangerous enemy. Branches attacked by the spruce budworm have a reddish-brown appearance, due to the bare twigs and to the dead leaves, which the caterpillars have fastened together to serve as a place in which to live.

Dr. C. Gordon Hewitt, F.E.S., Dominion Entomologist of Ottawa, Canada, has studied the spruce budworm and the following account of its life history is taken from one of his addresses published in the Report of the Canadian Forestry Convention for 1911:

"The winter is passed in the caterpillar stage, as a very small caterpillar, we believe, in a little shelter constructed near a bud. In the spring, when the buds begin to swell, the caterpillar begins to feed and becomes full-grown towards the end of May and beginning of June. They are then four-fifths of an inch long, of a reddish-brown color, and have small light-yellow warts on each segment of the body; the sides of the caterpillar are lighter in color. They transform into brown chrysalids inside the loosely made shelters. In six to ten days the small brown moth emerges from the chrysalis, dragging the empty case partially out of the larval shelter. The moths are found from the middle of June to the end of July. Shortly after emergence, they deposit their peculiar pale-green scale-like eggs in small oval patches on the undersides of the needles, and they are not conspicuous. The eggs hatch in about a week or ten days, and the young larvæ feed for a short time on the terminal shoots of the branches before hibernating. During July when the moths are flying, they occur in enormous numbers about the electric and other lights. . . . They are carried considerable distances by the wind, and this method of dispersal accounts for the rapid spread of the insect."

Treatment.—No practicable method of directly combating the spruce budworm is as yet known. Its greatest damage is done in connection with the spruce-destroying beetle. This beetle can be controlled as already described. Where the spruce budworm is found in abundance, especial watch should be kept to see whether the spruce-destroying beetle has attacked the weakened trees.

THE GIPSY MOTH (*Porthetria dispar*).

Form of Damage.—Since its importation into Massachusetts, the damage done by this insect has been most serious—damage, by the way, not confined either to forest or fruit trees, for it also attacks other forms of vegetation. The damage done is by defoliation which weakens the tree, and if repeated for two or three successive seasons results in its death.

The gipsy moth prefers such trees as the oak and maple, but conifers are not immune.¹ It does little damage to the compound leaf species, as the ash, hickory, and butternut. Experts, therefore, advise the encouragement in the infected regions, so far as possible, of species with compound leaves.

Appearance.—The presence of this insect is always apparent in the latter part of the season from the defoliation of the trees, but identification is easiest by the discovery of the large egg masses which are oval in shape, about an inch wide and two inches long, of a buff color, and presenting much the appearance of a piece of sponge. These may be found on the bark of trees or under leaves on the ground. The young caterpillar is about one-tenth inch long on emerging from the egg; when full grown it is from two to two and a half inches in length. It has a double row of tubercles down the back, eight blue and twelve red. The pupa is dark brown and from three-fourths to one and a half inches long. The male and the female moth differ widely in appearance. The former is small and of a brown color, with a wing spread of one and a half inches. The female, of a white

¹ The red pine is thought to be immune.

or buff color, and with a wing spread of about two inches, is too heavy to fly.

Life History. — In this country as well as in Europe this insect has but one generation a year. The minute eggs are laid in clusters of from four hundred to five hundred eggs each. Yellowish hairs give to these clusters a sponge-like appearance, and although they are usually on the trunk of the tree, or the side of a log, they are often concealed in crevices and under rocks. Eggs are laid in the latter part of the summer and usually do not hatch into caterpillars until the following spring, from the end of April until the middle of June. The caterpillars reach full growth in about ten days, spin filmy cocoons usually on the trunks of trees, and finally emerge as moths in late July or August. Most of the damage is done in the caterpillar stage, and the dissemination of the insect is also due largely to the activity of the caterpillar. Eggs and caterpillars are distributed by artificial means, as on cars, automobiles, etc.

Treatment. — The conspicuous color of the egg mass and the long duration of the insect in this stage make this the most vulnerable stage to combat. The masses may be collected and burned, or, as is most generally done now, they may be treated with a coating of creosote. In the woods, extreme vigilance is necessary to find these clusters. All brush, especially near stone walls, should first be removed.

Several methods of destroying the caterpillars are employed. During the month just after hatching — from the middle of May to the middle of June — the trees may be sprayed effectively with arsenate of lead. This spray will not injure the tenderest foliage when diluted with water in the ratio ten pounds to one hundred gallons of water. One method of preventing the caterpillars from climbing trees is either to bind the trunks with tar paper, or to smear the bark with fish oil or a sticky German product known as "raupenleim" (caterpillar glue). This glue remains viscid for months. Another kind of band, used as a trap, consists of a strip of common burlap a foot wide which is tied around the trunk with a single string at its middle and

about four feet from the ground. The upper part of the burlap is turned down over the twine, thus making a double fold around the tree. The caterpillars eat the foliage in the night, crawl down the tree and conceal themselves on the burlap through the day. Squads of men going through the forest crush them in these hiding places. Rubbish heaps and all breeding places should be destroyed. An effective method of protecting conifers is to remove all hardwoods, especially those with simple leaves. A number of parasitic insects have been introduced from Europe and set free in Massachusetts¹ and it is confidently hoped that they will in time obtain the mastery.

The gipsy moth has spread constantly, year by year, despite all the efforts that have been made to control it. At one time it was nearly under control when, unfortunately, Massachusetts politics interfered, appropriations for suppressing the insect were cut down and the evil spread unhindered. It now appears throughout the eastern half of Massachusetts nearly to the Berkshires, through southern Maine and southeastern New Hampshire, throughout Rhode Island, and has been discovered in Connecticut, but has been controlled there by the State Entomologist. The United States Department of Agriculture is now coöperating with the various states mentioned in an attempt to suppress this evil, and is laying special emphasis on the introduction of foreign parasites and enemies.

BROWN-TAIL MOTH (*Euproctis chrysorrhoea*).

Form of Damage. — Like the gipsy moth this insect defoliates both forest and fruit trees, but apparently does not attack conifers. Of forest trees, it prefers oak, maple, and elm. Besides the damage to trees, the hairs from the caterpillars are exceedingly irritating and poisonous to some people, and often cause severe illness.

Appearance. — The most conspicuous indication of this insect's presence, and one which distinguishes it at once from

¹ See Chapter XVII, Massachusetts.

the Gipsy moth, is the webs on the terminal twigs in which the partly grown caterpillars spend the winter. The male moth is pure white with a wing spread of about one and a fourth inches, and has a conspicuous reddish-brown tuft at the tip of the abdomen from which it gets its name. The female is somewhat larger, but is the same color as the male except that the tuft is larger and of lighter color. The full-grown caterpillars range from one to one and a fourth inches in length.

Life History. — The winter is passed in the partly grown caterpillar stage as indicated above. These begin work early in the spring, feeding downward from the tips of the branches and leaving the naked twigs and their gray tents as evidence of their sojourn. When numerous, they will devour green fruit as well as leaves and buds and blossoms. A number of caterpillars frequently pupate in a common cocoon of dry leaves at the tips of the branches and sometimes in masses under fences, clapboards, or on the trunks of trees. They pupate in June usually. Their webs may be distinguished from those of the tent caterpillar which are always at the forks of the branches. The eggs are laid during July in masses composed of two hundred to three hundred, usually on the underside of leaves. These eggs, which are covered with fine brown hairs, hatch in a short time, and the young marauders live on the foliage until it is time for them to make their winter tents.

Treatment. — As their hibernating nests are conspicuous particularly in early spring, they can then be cut off and burned. The species is killed also by spraying with arsenical mixtures. The range of this insect is similar to that of the gipsy moth, but scattered specimens have been found in Vermont and other sections outside the infected Gipsy moth belt.

THE LARCH SAWFLY (*Nematus erichsonii*).

This insect is distributed through the New England range of the tamarack, on the leaves of which it feeds. Complete defoliation often results from the attack of the sawfly, and the tamarack over a large region may be killed. In the early

80's, great destruction of the native larch was caused in New England. The insect will also attack the European larch.

The following account of the appearance and life history of the insect is quoted from an article by Dr. C. Gordon Hewitt, F.E.S., Dominion Entomologist of Ottawa, Canada, and published in the Report of the Canadian Forestry Convention for 1911:

"The habits and life history of the insect are such as to render it injurious in both the caterpillar or worm stage, and the fly stage. The winter is passed by the larva in a cocoon under the turf round the base of the tree. In May the larvæ transform into the perfect insect and the flies begin to emerge during that month. An interesting feature of the productive powers of the larch sawfly is that it can reproduce parthenogenetically, this means that the females can deposit eggs which, although they have not been fertilized by the males, are not infertile but produce larvæ of the sawfly. This interesting phenomenon, which also occurs in certain other insects, is of importance, as the productive power of the species is increased when the necessity of the female meeting a male is dispensed with. Shortly after emerging the females begin to deposit their eggs. The eggs are always deposited in the terminal green shoots of the larch and never on any other part of the tree. In laying the eggs the female sawfly makes an incision in the tender stem of the shoot by means of a pair of saw-like instruments at the end of the body, and into this incision the egg is pushed. The eggs are usually deposited in a double row in the shoot and as many as forty or fifty eggs may be found on a single green shoot. As they are usually deposited along one side of the shoot the injuries inflicted by the saw-like appendages of the female cause the shoot as it grows to curl. In many cases the injuries are so severe as to kill the shoot and the presence of the dead and reddish-brown shoots often serves as an indication of the presence of the insect. In about a week to ten days after deposition the eggs hatch and the young pale-green caterpillars emerge and immediately begin to feed upon the green verticles of the leaves. As they become older they feed in masses, sometimes as many as fifty or sixty caterpillars in a single cluster, and, feeding in this manner, they completely strip the branches of all green leaves which gives the tree a winter aspect in the middle

of summer. The caterpillars are full grown in three to four weeks and, during their lives, they cast their skins five times. . . . The full-grown caterpillar measures about two-thirds of an inch in length. Its color is bluish or glaucous green, the lower surface being a lighter green. The head and three pairs of thoracic legs are jet black. It also possesses seven pairs of abdominal legs. When the caterpillars are full-grown they either crawl down or drop from the tree and penetrate the turf round the base of the tree to the depth of a few inches. There they spin a brown oval cocoon about two-fifths of an inch in length, and in this the winter is passed, the caterpillar transforming into the perfect insect in the following year as previously described. The sawflies are black with the middle portion of the hind body or abdomen a bright resin red, and they measure about half an inch in length."

Treatment. — The prevention of the ravages of this insect must be left to natural factors, especially to various parasites which prey upon the sawfly. So completely does an outbreak of the sawfly destroy the larch, that the supply of food for the insect becomes scarce and it falls a victim of its own rapacity.

In Europe birds have been found to be important enemies of the sawfly, and special steps are taken to increase their numbers, but this will hardly be practicable as yet in this country, as the native larch is most abundant in sections where only extensive methods of management can be applied.

ELM-LEAF BEETLE (*Galerucella luteola*).

Form of Damage. — The elm leaves are skeletonized, and this gives the crown of the tree a brown, scorched appearance which detracts greatly from its beauty. If a tree is defoliated two or three seasons in succession, it is sure to die. The elms of southern New England, especially those in cities and towns, have suffered tremendously from this pest.

Appearance. — The damage is always done before its extent is apparent. By the middle of summer the infested trees are entirely defoliated. The beetle is about one-fourth inch long with head and wings marked with yellow. The yellow eggs are usually deposited in irregular rows on the under surface of the

leaf. The full-grown caterpillar is about one-half inch long with a broad, yellowish stripe down the center and a narrower strip of the same color on each side. The pupa is a bright orange yellow about one-fifth of an inch long.

Life History. — The transformations of this insect follow each other so rapidly that unless one knows just what to look for he is apt in combating the pest to do the wrong thing at the wrong time. The beetles pass the winter in sheds, attics, and in other sheltered places and emerge in the first warm spring weather. Late in April or with the appearance of elm leaves the beetles fly into the trees and begin defoliating. Before the latter part of June when the eggs are all laid, much damage may be done. Early in June the young grubs hatch out and begin to eat the leaves. They complete this stage in about three weeks and then pupate, developing into the beetle in a few days. As there are usually two broods in a season the foliage may be destroyed, renewed, and again destroyed, which is very weakening to the tree.

Treatment. — Many of these insects are killed by a fungus and by parasites. The success of any treatment depends on accurate observations. Much can be accomplished by spraying the underside of the leaves in early spring with arsenical poisons when the grubs begin to feed. There should be no delay in this work. When the caterpillars crawl down the trunk, large numbers of them may be killed by spraying with kerosene emulsion, soap solution, or by pouring boiling water on them. Banding the trees is of no use in combating the insect, since it works down the tree instead of up. The successful methods of fighting the elm-leaf beetle cannot be used in forestry work on account of the expense.

FOREST TENT CATERPILLAR,¹ OR MAPLE WORM (*Malacosoma disstria*).

Form of Damage. — A few years ago this insect caused a great deal of damage throughout the northeast by defoliating sugar-

¹ See New York State Museum Memoir 8, "Insects Affecting Park and Woodland Trees."

maple trees. Many sugar orchards were completely stripped of leaves by the caterpillar, resulting in the death of numerous trees, and an injury to sugar productivity which has not yet been fully compensated, after a period of ten years. The defoliation occurs for the most part in the early summer. While the insect prefers the foliage of the maple, it does not confine its ravages to this tree, but eats the foliage of oak, linden, locust, peach, plum, cherry, apple, elm, poplar, birch, and some of the shrubs.

Appearance. — The damage is done by the caterpillar which is blue-headed, with a line of silvery diamond-shaped spots down the middle of the back. When not feeding, they assemble in clusters on the sides of the larger limbs and trunks. This insect may be distinguished from the common tent caterpillar, *Malacosoma americana*, by the fact that it does not spin a conspicuous web tent as does the latter. The egg belts containing about 150 eggs encircle the slender twigs and have a brownish protective covering. The white or yellowish-white cocoons are spun in the leaves on the tree or on the ground, in crevices of the bark, under stones, in fence corners, etc. In the cocoons are dark-brown pupæ. The moths are light buff colored and active. The males are smaller than the females and of rich coloring.

Life History. — This insect passes the winter in the egg stage as a well-developed larva. In the warm weather of spring the young caterpillars emerge and await the unfolding of the leaves. As the young increase in size they molt, leaving their cast-off skins on the bark. The larvæ are found in clusters on the limbs when not feeding. When the limb is jarred they are easily knocked off. Early in June when the caterpillars are nearly full grown they may be seen in great numbers crawling over walks, piazzas, and the sides of buildings. The insect remains in the pupa stage about two weeks, and emerges as a moth about the last of June or in July, when the eggs are deposited.

Natural Enemies. — This insect is sometimes attacked by a fungous disease. It is also a favorite item of diet for robins,

orioles, chipping sparrows, catbirds, cuckoos, cedar birds, and nuthatches.

Treatment. — Something can be done by collecting and burning the egg masses in winter, but the method is of no great value. Many of the caterpillars can be brushed off the trees and crushed, or burned on the trees with a torch. Bands of tar paper or fly paper tied around the trees prevent the caterpillars from ascending. The masses of caterpillars on the trunks can also be killed by spraying with kerosene emulsion, whale-oil-soap solution (one pound to four gallons), or with the ordinary poisonous insecticides, as the arsenical sprays. In June great numbers of cocoons can be collected with little trouble. In some New York towns rewards have been paid the school children for collecting these cocoons. These methods are too expensive for use in forestry, except in the care of valuable sugar orchards.

THE JUNE BUG (*Lachnosterna*).¹

The June bug as a forest pest has gained prominence in New England only in the last few years since forest planting has been started on a large scale. For years it has been recognized as injurious to certain crops, particularly grass, its ravages being much worse in some localities than in others. During the last three years the attention of foresters has been directed to this bug because of the havoc it has wrought in certain nurseries.

Appearance. — The June bug in the pupa stage, as a whitish grub, eats the roots and bark on the roots of seedlings, transplants, and trees in plantations. Only the smallest and tenderest roots can be consumed, but larger roots, up to at least one-eighth inch in diameter, may be partially or completely stripped of their bark. The greatest damage is to seedlings where the entire root system may be consumed by this grub. Three- and four-year-old transplants in nurseries may lose all but a single main root and become so weakened that finally

¹ This is the generic name. There are ten or more species of the genus found in New England.

they die. In plantations the loss is less noticeable than in nurseries. No thorough study of the loss has been made so far as is known. Often the slow and stunted growth of certain trees may be traced to root injuries due to this insect.

Only plantations in open land not recently under forest are liable to the injury, as the June bug is not found commonly in forested soil.

When once familiar with its devastations, its presence can be readily detected. In seed-beds of very young plants the grub often eats off the roots and draws the stem of the plant into the ground leaving the top to rest on the surface. When these tops are taken out the roots are found to have been eaten entirely away. Older seedlings and transplants show the injury by wilting and turning yellow, when their tops are pulled up easily. An uninjured plant being held by its small roots offers resistance when pulled.

Life History. — The June bug appears in the beetle form during the latter part of the spring. In June or July it lays eggs in the ground, one to six inches below the surface. Open land and fields of old sod are its habitat. In the daytime the beetle prefers to remain in trees and at night to fly out into the adjoining fields where it lays its eggs. Fields bordered with shade trees which offer a shelter in the daytime are pretty sure to furnish numerous June-bug grubs. The eggs soon hatch into slender, whitish grubs, which at first are less than one-fourth of an inch in length; sometimes they grow to be over one and a half inches long. It is in this grub or pupa stage that the injury is done. The grubs are sluggish, work slowly, and never appear above ground. They do not remain at one depth, but in summer work from near the surface to ten or twelve inches below; in late fall and winter they bore much deeper and remain there until frost leaves the ground. They work at night and will be found nearer to the surface then than during the daytime.

In August or September the grubs begin to change into beetles, and as such remain in the ground until spring, when they emerge and are a familiar sight. Many remain in the grub

stage for more than one season, and do not change into beetles until the second August or September. This gives them a longer time to feed, and as they grow in size they become more injurious. Often they work until the ground is frozen and start in early again when it thaws in the spring.

Treatment. — A simple and cheap method of combating the June bug has not yet been worked out. At present in forest nurseries, when the grubs are found to be abundant, they are dug out by hand, the spot where they are working being easily determined by the appearance of the injured plants. This method can be used in transplant beds, but in thick beds of seedlings it is hardly practicable. Where land known to be infested with the grub is to be used for a nursery or a plantation, it is a good thing to turn in swine. They will uproot the ground thoroughly and eat the grubs. After that the field can be used safely.

Inasmuch as old sod and grass land is preferred by the beetles as a meeting place, such land should not be put into nursery use until after a year or two of preliminary cultivation.

In the case of a similar species, trapping and killing the beetles has been tried in Europe sometimes very successfully. In one section where the insects abounded, the cost of planting was in eight years reduced from the abnormal figure of \$53 per acre to between \$3 and \$4 per acre. In this case trap trees of a species which the beetles preferred were left in the open, and then the beetles, when in the trees, were shaken down upon sheets and destroyed.

B. FUNGI.

CHESTNUT BARK DISEASE (*Diaporthe parasitica*).

Without doubt this is one of the most threatening fungous diseases which ever attacked a forest tree. It is one of the few diseases which cause the certain death of healthy, vigorous trees. So virulent is it that the chestnut, on which it preys, has been practically exterminated in portions of New England, New York, Pennsylvania, and New Jersey. The worst injury has been

done on Long Island, and in the vicinity of New York City, from which as a center it is spreading. Only since 1905 has the disease been generally recognized, and in New England it was little noticed until 1907. Southwestern Connecticut is the most seriously infected region here; and in Fairfield County the chestnut has been nearly all killed. As we proceed from southwestern Connecticut, through that state and then into Massachusetts and northern New England, the number of infected trees is less and less noticeable. But the disease may be found practically over the entire New England range of the species. North of Connecticut no great amount of timber has as yet been killed.

The chestnut bark disease attacks and kills the cambium layer, which lies between the bark and the wood. This is the growing layer of the tree and when it is girdled, death of the portion above the injured place results. As the disease is distributed by the spores (virtually seeds) which are easily blown by winds, or carried by birds, its spread is rapid. These spores cannot attack a tree except through a wound, but as every tree has many slight wounds or openings in its bark, it is rarely that a tree is exempt from the disease. When a spore finds lodgment it quickly develops a fungous growth spreading in the cambium layer at first in a somewhat elliptical form until finally it girdles the branch or trunk. It may also work up and down the trunk.

Trees of all ages from the young sprout to those of lumber value are attacked. In an old tree with thick bark the disease usually enters at the top and works downward. On young trees, with easily wounded bark, the disease may start at any point. When old trees are injured by fire, even to a very slight extent, the disease will find entrance at the base.

There are several ways in which the work of this fungus can be recognized. The spots or cankers are apt to have an elliptical form, and the bark over the injured part is somewhat reddish and sometimes appears sunken. Pustules, of a yellowish or orange color, containing the spores can often be seen pro-

truding through the bark. These fruiting bodies are the only part of the fungus visible to the naked eye, and usually occur in the crevices of the bark. Often they may be seen near the base of a mature tree, which to the observer appears otherwise

Fig. 45. — A forest-grown chestnut on the edge of a recent cutting killed the previous season by the chestnut bark disease.

sound. These pustules are an unmistakable sign of the disease. When the trees are in foliage, diseased individuals may be recognized by their bare branches, or branches with partly shriveled leaves or burrs. Frequently half a tree or a limb

here and there may be dead, and the remainder of the tree be in full foliage.

Another sign of the disease is the presence of thrifty one-year sprouts on the trunks of fairly large trees. Usually on close examination near or above these sprouts can be found a spot with other characteristic symptoms.

As yet no method of successfully combating the chestnut bark disease is known. When a tree in the forest is attacked it is virtually doomed. In the case of valuable shade trees, cutting out the infected parts has in some cases been successful. The exposed face of the cutting must be covered with paint or tar. If this is done and all infected spots are completely removed, the tree may be saved. Such treatment is, of course, out of the question in handling forests on account of the expense. The fungus cannot be reached by spraying as it is protected by the bark of the tree. Several pathologists who have studied its ravages predict the extermination of the chestnut unless something unforeseen stops the disease.

If all the infected trees, in a section where the disease is just beginning to spread, could be cut down and the brush and infected bark burned, this evil might be checked in that locality, but, unfortunately, all injured trees cannot be found. In a forested region it is doubtful if any method will be successful. It should be stated that Dr. G. P. Clinton, Botanist for the Connecticut Agricultural Experiment Station, holds a somewhat different view of the situation¹ from that commonly expressed. He believes that the chestnut bark disease, although a virulent disease, would not have caused the damage to the chestnut, which has already resulted, had it not been powerfully assisted by some other cause. Such a cause he finds in the unusual weather conditions existing in Connecticut since the year 1902. Winter injury was especially noticeable following the winter of 1903-04. The severe droughts which have occurred in the last few years, especially in 1907 and 1911, have in-

¹ See Report of the Station Botanist: Connecticut Agricultural Experiment Station Report, 1908.

creased the injury due to winter killing. It is probable that much of the injury to the chestnut is due directly to winter killing, and the effects of the droughts which have injured other trees in the same region.

With such weakening of the chestnut, due to unfavorable weather conditions, the bark disease has been able to spread and develop far more rapidly and with more disastrous results than would ordinarily occur. Whether this relation between weather conditions and the activity of the disease actually exists is not yet proven. Within the next few years, however, providing severe droughts and abnormal winters do not occur, the truth should become apparent. If the seasons are normal and the disease does not develop with the same rapidity as in the past, Dr. Clinton's theory may be accepted. But if, after several normal seasons, the disease still continues its devastating progress, the injury must be attributed to the fungus alone. It is to be hoped that he is correct, and that the chestnut in New England will be saved from extermination.

Trametes pini.

Trametes pini is a fungus attacking practically all the important conifers of New England; red and white spruce, white pine, hemlock, larch, and balsam. Von Schrenk considers larch most susceptible to its attacks, the spruces next, and the balsam least. It is a common and extremely dangerous disease, entering living trees, old enough to form heartwood, through wounds or any opening in the bark. From the point of entry it spreads up and down the trunk, working both in the heartwood and the sapwood, except in white pine, where it flourishes only in the heartwood. Finally even the roots and the larger branches may be infected. As the wood is not entirely destroyed by the fungus the tree remains standing, but is so weakened that eventually it is broken off by a strong wind. The lumber value of the infected portion is entirely destroyed.

The fungus can be identified because the diseased wood is honeycombed and is filled with small holes. These holes often

have a shiny white lining, and between the holes will be thin layers of wood only partially destroyed. The best outward indication of the disease is the pitch which exudes on the bark, sometimes in considerable quantities.

The fungus¹ is spread by spores blown by the wind.

These come from fruiting bodies located usually at old knot holes and on the stubs of dead branches, although on spruce at least the fruiting bodies may form in dry crevices of the bark.

The light reddish-brown color of the lower surface of the fruiting bodies is characteristic, but their form varies from a bracket shape to that of a plate, following the configuration of the trunk or branch.

There is no practical method for use in forestry of combating *Trametes pini*. Diseased trees, as soon as discovered, should be cut and utilized, but as such trees are often scattered it is not always possible to remove them. If all diseased trees could be discovered quickly and removed the loss from this fungus would be greatly lessened.

Polyporus schweinitzii.

This fungus is common on balsam, red and white spruce, white pine, and arborvitæ; it attacks living trees of all ages and causes extensive losses.

The fungus first enters underground, through the root system, but soon spreads to the trunk, up which it may extend its growth for forty feet or more. Diseased trees are ordinarily found in groups, because the fungus spreads from tree to tree through the ground. As the disease progresses the root system and trunk become weakened and finally the tree is uprooted or broken off near the base.

Like *Trametes pini* this fungus destroys the lumber value of the infected portion. Probably the greatest loss is found in the balsam, of which species nearly all the older trees are attacked.

¹ A detailed description of *Trametes pini* will be found in U. S. Division of Vegetable Physiology and Pathology, Bull. 25, entitled, "Some Diseases of New England Conifers," by Von Schrenk.

Wood attacked by *Polyporus schweinitzii*¹ has a cheesy consistency, is yellowish in color, and is easily powdered when dry. In the last stages of decay it is very brittle. These characteristics of the diseased wood and the large, brightly colored fruiting bodies are the best means of field identification. The fruiting bodies when young are a yellowish-brown color, but in a few days become reddish brown. The underside is sometimes rose colored, and if bruised quickly turns dark red. They take the form of brackets, ordinarily several in number, fastened one above the other, usually arising from the roots of the tree, near the base of which they may be seen growing, in the months of July and August. Occasionally the fruiting bodies are borne on the trunk of the tree. Fully grown specimens range from four inches in diameter to about fourteen inches.

On account of its spreading underground, and entering the tree unseen, the fungus is hard to detect, until in the advanced stages, and hence difficult to combat. A European practice is to surround infected trees and groups with a deep trench which prevents the further spread of the fungus. Such a method is as yet impracticable in New England, and the best that can be done is to utilize diseased trees before their value is entirely gone.

THE WHITE PINE BLISTER RUST, or EUROPEAN CURRANT RUST (*Peridermium strobi*).²

Other species of *Peridermium* have been common in New England on pitch pine and Scotch pine, as well as other plants, but until recently the white pine was exempt.

As a result of the growing enthusiasm for forest planting which has spread so rapidly during the past few years, a large quantity of nursery stock has been imported from Europe.

¹ For a more detailed description of the fungus see Bull. 25, U. S. Division of Vegetable Physiology and Pathology, entitled, "Some Diseases of New England Conifers," by Von Schrenk.

² See Circular 38, U. S. Department of Agriculture Bureau of Plant Industry, "European Currant Rust on the White Pine in America," by Spaulding.

In June, 1909, some of the stock thus imported into New York State was found to be infected with this fungus and on examination it was discovered that stock imported into other states was likewise diseased. In fact the fungus has been found on trees imported several years previous to 1909, which makes its eradication somewhat more difficult. In nearly all cases the diseased stock has been traced to one European nursery, that of J. Heins Söhne, of Halstenbek, Germany. The fact that this immense nursery, one of the largest in the world, should knowingly export to this country diseased stock, should deter Americans from all future dealing with it, even after this disease has been exterminated.

In Europe this species of *Peridermium* has long been common on *Pinus cembra*, or stone pine, which is the European variety of white pine. Of late years with the multiplication of plantations of our American species throughout Europe the disease has attacked these. In some regions it has caused much havoc especially in nurseries. In certain places, notably, in Holland; at Oldenburg, Germany; and at Moscow, Russia, the disease is so serious that the cultivation of white pine has been abandoned. Young trees are killed outright by the disease, and the small branches of large trees are killed.

The affected seedlings have a peculiarly stunted appearance, and the stem is abnormally enlarged and swollen in places. New growth is very short. The orange fruiting bodies on the stem, which, however, occur only in the spring, furnish the best means of identification.

This fungus is one stage of the blister rust of currants and gooseberries known as *Cronatium rubicola*. In other words, like the wheat rust, cedar apple, and many similar fungi, it is a fungus which requires two hosts to complete its life history. The spores from an infested currant or gooseberry bush are blown to a neighboring white pine tree. Here they germinate and the mycelium vegetates in the inner bark until the second spring after infection. Then the diseased bark thickens and the stem becomes swollen. The fruiting bodies break through

the bark sometime between the middle of April and June, according to the locality and the season. They are of a light, orange color and project from the stem about one-eighth of an inch. They soon break open and the spores are scattered by the wind. After the spores are gone, the remains of the fruiting bodies are washed off, leaving empty fissures in the bark to show where they were. The spores from the pine, if they chance to fall upon currant leaves, infect them in turn. On these leaves in fifteen to forty days new fruiting bodies are formed, the spores of which may infect either currant or pine. The spores produced on the pine cannot directly infect pine, but must first infect currants. On the pine the fungus remains alive as long as the stem on which it grows; but in the currant it is not thought to be perennial. Fortunately the spores are not apt to be carried over one hundred yards.

The best means of combating the disease are:

(1) To examine all infested plantations and burn all currant or gooseberry bushes, wild or cultivated, within five hundred feet of the plantation. This should be done between the middle of July and the fall of the currant leaves.

(2) To inspect imported white pine trees and burn all that show any symptoms of the disease; or better yet use only native-grown plants.

(3) To inspect, for two years at least, all white pines located near infected currant bushes and burn all that become infected.

WHITE-HEART ROT. FALSE-TINDER FUNGUS, POPLAR DISEASE (*Fomes igniarius*).¹

The principal diseases of deciduous forest trees are caused by a group of fungi which grow in the heartwood of trees. This species is characteristic of the group. It is impossible to recognize the presence of the fungus during the early stages of the disease, in fact not until the fruiting bodies form on the exterior of the trunk. When these appear the tree is thoroughly diseased

¹ See Bull. 149, U. S. Department of Agriculture Bureau of Plant Industry, "Diseases of Deciduous Forest Trees."

for two or three feet above and below the fruiting bodies. In its final stages the heartwood is completely destroyed so that the tree is weakened and liable to be broken off by windstorms. On examination the center of the tree will be found of a pulpy consistency definitely limited on the outside by one or more narrow black layers.

Fig. 46. — The fallen chestnut, now 6 inches in diameter, was formerly injured by fire which allowed a fungus to enter. This fungus hollowed out the stem for over 2 feet from the ground leaving untouched a mere shell of wood on the outside. The first heavy wind broke the tree.

This disease causes greater damage to poplar than to other trees, but is by no means confined to the poplar. It occurs on more species of broadleaves than any similar fungus. It has been found on poplar from Maine to Oregon and from Canada to New Mexico, and undoubtedly exists wherever poplar lives. In New York and New England the beech also is very commonly affected.

It is one of the most conspicuous of our so-called punks, or shelf fungi, which grow upon living trees. The fruiting body is commonly more or less hoof shaped, the thickness being about equal to the width. The upper surface, at first smooth, becomes

concentrically marked with age. They grow to great age as indicated approximately by the number of layers. The lower surface is gray to reddish brown; the edge yellowish brown.

The spores enter the tree trunk through some wound, as an old branch stub. The fruiting bodies usually form at the point of original infection. It is not uncommon to find a dozen of these bodies on the trunk of an aspen. Examinations by Spaulding have proven that the fungus continues to thrive after the death of its host.

Fig. 47. — An oak broken off by the wind. The base of the tree was honeycombed by a fungus which entered through old fire scars. Wind cannot uproot an oak but frequently breaks off weakened trees.

A tree affected with white rot may live for a number of years, especially such long-lived species as oak and beech. But with such trees as aspen, where the disease may encroach upon the sapwood, the trees may be killed by the disease. The death of trees is a minor result of the disease compared with the great destruction of wood which it causes.

Two methods of prevention are possible: one consists in the prevention of wounds, and the other in the removal of the sources of infection. The former method is impracticable

except in the case of ornamental trees. Infected trees should always be removed as soon as the disease is apparent. Usually this will be soon enough to save part of the wood or lumber. It is of no avail to destroy the fruiting bodies alone as the fungus will continue to grow in the tree and produce other punks.

WHITE PINE BLIGHT.

It is now plain that this injury is not due to any insect, and apparently not to any fungus, but probably is caused by unfavorable weather conditions, such as winter injury due to extremely cold weather without much snow, or to extremely dry summers, or a combination of the two. This blight is characterized by the death of the end of the needles, from one-fourth to one-third thereof turning a bright reddish brown. Sometimes the whole needle dies, giving the tree a brown appearance, but the tip of the needle is always affected first. Trees that have been attacked look as if they had been scorched by fire. Young trees are more susceptible to this form of injury than old ones. On young trees, often the needles will wither and curl up much as if scorched, and very frequently the twigs also are killed back. In Maine,¹ in exposed localities, acres of young trees which were apparently healthy in the fall of 1907 were entirely dead by the last of May, 1908. Usually the injury was confined almost entirely to the north and northwest sides of the young trees. Injury here was not limited to pines, but spruces, firs, and other conifers showed the same trouble and in the same manner.

In most parts of New England the disease was first noticed in 1907. It was particularly widespread during the summer of 1907, and many feared the pine forests were doomed. It was thoroughly advertised throughout New England, and many young pine stands were unnecessarily cut. Few trees died, however, and conditions were much better the next year. By 1909 it had practically disappeared in most sections of New

¹ See Report of Forest Commissioner of Maine, 1909, pp. 22-24.

England, but curiously enough was much worse in certain localities, as, for example, in the region about Burlington, Vermont.

The pine woods belonging to the University of Vermont were carefully examined in August, 1909, and the affected trees were numbered. Another examination made in the summer of 1910 showed seven additional trees had been attacked, but of the 112 previously found to be diseased the conditions were as follows:

	Number of trees.	Per cent of trees.
Dead.....	6	5.3
Recovered.....	55	49.1
Recovering.....	13	11.6
Same as previous year.....	38	34.0
Total.....	112	100.0

This study shows that the condition of the stand is much improved, which would indicate that dry summers may have an important bearing on the malady, as the summers of 1908 and 1909 were very dry, while that of 1910 was normal in respect to rainfall. It is evident, therefore, that there is no real disease causing this blight, but that it is due to weather conditions.

CHAPTER VIII.

FOREST FIRES.

THIS chapter deals with forest fires in general. In later chapters under each region the particular fire problems of that region are discussed at length.

KINDS OF FIRES AND DAMAGE DONE.

American forests have suffered more from fires than those of any other country and few regions have entirely escaped. The character of these fires and the damage done by them depends very largely upon the type of forest. It is only in coniferous forests that fires assume immense proportions and become entirely uncontrollable and for this reason Maine, with its rolling hills of spruce, has from its earliest history suffered more from fires than most parts of New England. In these coniferous forests, fires often sweep through the tops of the trees, and, driven along by strong winds, advance over several miles of forest in a day. These are called "crown fires." Most of the evergreen trees are killed, but here and there a clump sometimes escapes. The fire may jump from one side of a ravine to the other leaving the trees in the bottom uninjured, and while the hardwoods adjoining conifers are usually severely scorched, large areas of these deciduous trees form an effective check to the spread of the flames in the tops.

The dry sand plains of Plymouth County, Massachusetts, have been an incessant breeding ground for forest fires, as the cranberry growers of the region have, until recently, taken little care for the forest. Fires burn over thousands of acres annually and the result has been that the forest growth has continually deteriorated until it is of very little value.

The hardwood forests of Connecticut and Massachusetts are largely composed of oak, which has a tendency to retain its foliage over winter. The result is that in the dry season, which invariably comes in April and May, these leaves form a ready tinder for the innumerable little fires of the region. These fires confined to the leaves and underbrush are called "surface fires." The birch and maple of Vermont and New Hampshire shed their leaves in the fall; they are matted down and rotted by the winter

Fig. 48. — A group of chestnuts killed outright by surface fires.

snows, which are much heavier than in southern New England, and the result is that these states, with few unbroken areas of conifers, are more free from forest fires than any other part of New England.

These surface fires seldom kill the trees of a forest outright, but wound them so severely that they become infested with fungous diseases, make little growth, and eventually die. The severity of the wounds inflicted depends very largely upon the strength of the wind at the time of the fire, the amount of inflammable material on the ground, and the kind and size of trees in the forest. With a strong wind the flames often lap around the trunk of a

tree and, in the case of a conifer, leap into the top. Some farmers claim that annual fires are a good thing, because the ground is thus kept free of material which would make a really hot fire. This, however, is not true, for every fire, in New England at any rate, does more harm than good. Some trees, as the chestnut, are much more easily damaged by fire than others, like the oak, hickory, and birch; and practically all trees are more tender in youth than later when the bark has thickened.

Besides the crown fire which leaps from tree top to tree top, and the surface fire which runs over the ground burning the litter, underbrush, etc., a third class of fire occurs in the coniferous forests of the north. In the forests composed of such trees as spruce and fir the ground is often covered with a thick layer of decaying vegetable matter, such as needles and twigs, which in seasons of drought become very dry. If a fire once starts in this "duff," as it is called, it may smoulder for weeks on a small area of less than a half acre. At any time such a "ground fire" is apt to flare up, if a strong wind arises, and may become a serious surface or even a crown fire.

Besides the damage to grown trees one of the worst effects of a forest fire is the killing of the small forest seedlings and saplings. This is a damage which is often overlooked and it is more responsible for the present worthless condition of millions of acres in the United States than any other cause. Forest seedlings, especially those of the evergreens, are practically sure to be destroyed by any fire passing through them. We do not realize the relatively long time required for seedlings to grow the first ten feet in height, as compared to that of subsequent growth. It requires from ten to twenty years for most trees to reach the height of ten feet, while many suppressed spruce and hemlock are fifty years old before they reach it. The destruction of seedlings, therefore, retards the growth of the forest. It often happens, too, that the seed trees have been removed in the meantime or are killed by the same fire. In this case natural reproduction of that species will be prevented for many years and the land will either be covered with a worthless tangle of brush or be

seeded in by some light-seeded tree, such as the paper birch or poplar, or must be planted.

The composition of a New England forest is invariably injured by fire, for it happens that the trees which first come up on burned areas in addition to huckleberry, raspberry, and other shrubs, are inferior, such as poplar, birch, and bird cherry. In northern New England these often form pure forests after a fire. Seedlings of the original conifers may finally come in, and in the course

By permission of the Massachusetts State Forester.

Fig. 49. — The start of a forest fire on dry, sandy, and brushy land. This could easily be put out now by a patrolman but if left alone soon will develop into a serious conflagration.

of fifty or one hundred years the original character of the forest reasserts itself. In regions where trees sprout after being killed back by fire the character of the forest is not so greatly changed, but the quality is seriously injured.

The question often arises why it is that softwoods so frequently succeed hardwoods when the latter are cut or burned off and *vice versa*. It is wholly a matter of seed supply, as may be easily demonstrated by proper cutting of a forest. Softwoods can be made to succeed themselves by leaving enough seed trees at the time of cutting, and this is one of the most interesting

problems of the forester about which the various silvicultural systems described in the first chapter have developed. A careful examination of any softwood forest will reveal a great many deciduous seedlings on the ground. These, together with the old hardwoods that the ordinary lumberman would leave, are amply able to change the appearance of a softwood to hardwood forest when the former is cut off, or when the evergreens are burned.

In a deciduous forest a surface fire may pass through and in a few hours burn out except in a few dead stumps. But in a coniferous forest, when a fire once gets in the duff, it becomes a ground fire which may smoulder for weeks or months and eventually be fanned into a serious blaze by a strong wind.

An examination of the soil just under the "duff" or leaf litter of a forest will show that the mineral particles are mixed with decomposed vegetable materials. The percentage of those materials grows less the deeper down one digs. This top soil is called humus, and it is very valuable as fertilizer, on account of the nitrogen it contains, and because of its water-absorbing power. One of the most serious effects of a forest fire is the burning out of this humus,¹ resulting in a drying out of the soil. On steep slopes, especially when this binding and absorptive agent has been removed, the soil is frequently washed off, leaving bare ledges which will probably never again be reclothed with soil. In such situations the snow melts rapidly in the spring and the water flows off immediately, so that, indirectly, these fires have an important bearing on water flow and freshets.

The most severe forest fires occur on tracts which have been lumbered, where the ground is covered with the tops of pines and other conifers. For this reason it is very desirable that these tops should be destroyed at the time of cutting, either by careful burning or by lopping off the branches so that they will at once come in contact with the soil and be rotted.

Fires are not as common in New England as formerly. The

¹ Where there is considerable soil with the humus and the fire is not very severe, the humus may not burn, but the removal of the litter prevents formation of more humus. If fires are repeated the humus may entirely disappear.

great forestry educational movement has done much to make people more careful; still there is room for a great deal of improvement, and not until the danger of fire is largely eliminated will land owners be induced to practice forestry extensively. Up to the present time, forest fire risk is so great that no insurance company in this country will insure standing timber. Every landowner must furnish his own insurance by introducing the preventive measures which are described under the different forest regions.

CAUSES OF FIRES.

In the different sections of the United States, the causes of forest fires differ according to the nature of the country. In large, unbroken forest areas, like the Adirondacks and the Maine woods, probably the largest percentage of fires has been set by locomotives on the railroads crossing the region. Heavy freight trains ascending steep grades are particularly apt to throw out live cinders which readily start a fire in the dry leaves and grass beside the right of way. On every railroad there are certain places where there is special danger, as, for example, on sharp curves between high banks, particularly if on a steep grade, where the engine is so much tipped that its cinders fall on the bank before they have had time to cool. No effective spark arrester has thus far gained general use, but extensive and very satisfactory experiments¹ have recently been conducted with new inventions in this line by the Chicago and Northwestern Railroad at Chicago and by the American Spark Arrester Company of Indianapolis at Purdue University. The best way of preventing these railroad fires is to keep the right of way as clean as possible, and during dry seasons to thoroughly patrol it. One man in a hand car closely following every freight train during such seasons can put out a great many incipient fires. In New York the State Public Utilities Commission has required the railroads operating in the Adirondacks and Catskills to burn only oil in their locomotives during certain months of the year.

¹ See Report State Forester of Wisconsin, 1909-10, p. 119.

In certain seasons in these large forest sections many fires are started by the carelessness of hunters and fishermen. Probably the most common kind of fires set by this class is due to abandoned camp fires. One cannot be too careful in the building of a fire in the woods to surround it with a ditch dug down to mineral soil, so that the fire cannot spread in the duff. When leaving a camp fire one should be certain that it is completely out. Hunters and fishermen, as well as others, also start a good

By permission of the Connecticut State Forester.

Fig. 50. — A train on an upgrade casting sparks on the adjoining woodland. Fortunately this has been burned over and is in condition to act as a fire line. At the left the work of burning over a strip next the track is in progress.

many fires by carelessly throwing down lighted stubs of cigars or cigarettes and burning matches. It is hard to realize how easily a fire may be set in this way in dry weather. Hunters, after hedgehogs and coons in the north and possums in the south, often start forest fires in trying to smoke the animals out of hollow trees.

In farm communities most forest fires start through carelessness in burning brush. Many people seem to be entirely lacking in common sense in selecting a time and place for burning brush

or rubbish. Such fires should never be started when there is a strong wind or in dry weather, wind or no wind.

In manufacturing communities mill hands in the woods on holidays and Sundays are responsible for starting numerous fires.

Besides these fires, due to various forms of carelessness, there is a class far more common than the uninitiated would suppose, namely, incendiary fires. In almost every sparsely-settled region of New England there are certain communities of run-out stock where a few characters, often of doubtful parentage, sometimes half-witted and less frequently vicious, hold the surrounding farmers in continual terror. They start forest fires either from a wild delight in seeing them burn or for spite, and, if interfered with, will wreak vengeance by next burning a barn or poisoning a horse. The better element in the community is usually too much afraid to furnish evidence that might lead to conviction. Not until this class is weeded out of our hill towns and a thrifty, self-respecting population is substituted, will the rural problem of New England be on a fair way to settlement. Here is the common field for forester and missionary;—for remunerative work, which in many of these regions can be furnished only by the forester, is a necessary accompaniment of better teaching.

In the West many forest fires are undoubtedly started by lightning, and it is certain that several were thus started in northern New England in the summer of 1911. It is maintained that fires are sometimes started by the sun's rays reflected from broken bottles and unquestionably they have been set by fire balloons and other fireworks.

FIRE PREVENTION.

Forest fires spread very rapidly if there is any wind, with an ever-increasing front, so that each hour wasted in attacking them increases many times the difficulty and expense of extinguishing. The most efficient method of preventing damage by forest fire is, therefore, to provide some means of attacking

them at once before they have time to spread. Watchmen in lookout stations or patrolling in dangerous localities are necessary in order to give notice immediately on the discovery of fire. A definite policy of establishing lookout stations on the summits of prominent mountains has been inaugurated in Maine, New Hampshire, Massachusetts, and New York and will be followed in Vermont and possibly Connecticut. At each station is a small building in which the watchman lives during the fire season. The station is equipped with a map of the surrounding country, a pair of field glasses, and a compass, and is connected by telephone with the fire warden. Upon discovery of a fire the watchman gets the compass bearing and the closest possible location of the fire. This is telephoned down to the warden and a crew is at once sent to extinguish the fire. An idea of the cost of such a station may be had from a report of the state forester of New Hampshire concerning the Mount Kearsarge station. The total cost of this station was as follows:

Wire and telephone equipment.....	\$96
Labor of installing same (including superintendence).....	140
Eight- by twelve-foot house (material, labor, and equipment)	70
Traverse table and field glasses.....	33
	<hr/>
	\$339

While a watchman located in one of these fire stations can overlook a large area, 50,000 to 200,000 acres according to the topography, in clear weather, the efficiency of such stations in smoky weather is very low. A system of fire patrols is, therefore, much better in very dry and dangerous seasons, although one man can of necessity protect only a small portion of the area that can be overlooked from a fire station in clear weather. There are various methods of patrolling according to the nature of the country and the kind of fire danger.

A very efficient method of patrolling railroads is to follow every train on a hand car or motor. As there is most danger from freights the patrolman should follow directly after these, if it is impossible to follow all trains. Following as closely as this the

patrolman will discover fires while they are still so small that he can extinguish them alone.

In a well-watered country where there is special danger from campers and fishermen, as in northern Maine, a patrol of the streams by boat or canoe is easiest and most efficient. The patrolman takes the names and addresses of all campers, and in that way not only has good evidence in case of subsequent fires, but warns parties so that they are more careful.

Fig. 51. — Fire station on Bald Mountain, Maine. A constant watch for forest fires is maintained during the dangerous season.

In many wooded sections well provided with trails a patrolman on horseback can cover considerable country, and in farm communities provided with roads he may be mounted on a bicycle.

In other regions where trails are lacking it is necessary for the patrolman to go on foot, but in any case the patrol must be so located as to provide inspection of the places most in danger of fire.

In the so-called "Weeks' Bill," which was passed by the United States Congress in the spring of 1911, to provide for the acquisition of national forests in the East, provision was also made for

the expenditure of \$200,000 in coöperation with the various states in the prevention of forest fires. Under this law any state which has an organized system for the prevention of forest fires, and which has forests protecting the headwaters of navigable rivers, may call upon the national government for some of this money. The federal government is authorized to appropriate to any state only so much as the state is expending in similar work in the same fiscal year. All the New England states with the exception of Rhode Island are eligible for this assistance, and are receiving sums ranging in 1911 from \$1000 to \$10,000. This federal money can be spent solely for hiring men to be employed either in patrol or lookout duty. The wages paid are fixed in an agreement between the state and national forest service. During wet weather when there is no immediate danger of forest fires these men may be employed in constructing trails and fire lines or in any other way that will tend toward fire protection.

Much can be accomplished toward preventing fires by improving the condition of the forest. As previously stated, most of our worst fires occur or, at least, gain their headway in cut-over coniferous forests where the ground is covered with dry, inflammable tops. In New York State a law has been enacted compelling lumbermen to lop the branches from these tops so that the material will at once come in contact with the ground and be rotted out by the snows of a few winters. Experience of lumbermen in the Adirondacks has demonstrated that this operation can be done for twelve to fifteen cents per cord of pulpwood cut. It was also found that many tops after being lopped were worth taking out; these would otherwise have been left in the woods, so there was considerable saving to the operators. In our large lumber operations, especially in spruce forests where the tops are very branching, some such lopping measure will be the best and most practical preventive. However, in smaller operations especially in the small pine wood lots of New England the more efficient measure can be adopted of burning the branches, either at the time of lumbering or soon afterwards. The cost of this work has been found to vary from twenty-five to fifty cents per

thousand feet of lumber cut according to the size of the trees. Of course, in most parts of New England the wood cut from the limbs has a sale value sufficient to more than pay for cutting, and in this way close utilization may considerably reduce the cost of brush burning.

While the conditions are such that measures of this sort are not always feasible, it may readily be seen that if this inflammable material is cleared from certain belts in the forest it would be comparatively easy to check a fire. Belts of this kind are called fire lines.

FIRE LINES.

A fire line or fire lane is a strip kept free from inflammable material, so that a fire will either go out of itself on reaching it, or can easily be extinguished at this line by a crew of fire fighters.

Fire lines may be of various widths and made in different ways, according to the forest and kinds of fire likely to occur. Investigation of the Vermont fires of 1908 showed that crown fires occurred only in coniferous forests, and that practically all of the worst fires started in slash made by lumbermen. One effective form of fire line could, therefore, be made by burning all the tops and dead-and-down timber and removing all conifers from the strip in question.

Of course surface fires would cross such a strip, if unprotected, upon the leaves and underbrush. It would, therefore, be well to cut from a narrow strip all growth of trees and brush and to burn the leaves annually.

This can be made still more effective by grubbing out the stumps and plowing a few furrows.

As an ideal fire line for mixed forests, we would suggest the following:

(a) A strip one hundred feet wide from which all coniferous trees and all underbrush and all dead-and-down timber are removed to prevent crown fires.

(b) One-third of this or a strip thirty-three feet wide to be annually burned over to prevent surface fires.

(c) A portion of this or a strip six to ten feet wide to be grubbed out, and, if possible, plowed to prevent ground fires.

Fig. 52. — A completely cleared fire line in a stand of mixed hardwoods on ground too rocky to plow. The line has recently been cleared of leaves and occasional sprouts from the old stumps. This is done twice a year.

The cost of a fire line of this kind would vary, according to the topography, the nature of the forest, and the thoroughness with which it is made, from \$25 to \$100 a mile. The maximum expenditure could hardly be justified except in the case of very valuable forests in extremely exposed situations, but there are

few forest areas that it would not pay to protect with some such kind of fire line.

On level, sandy soils, where fires run frequently and easily, forests should be divided into relatively small areas of from three hundred to six hundred acres in extent by fire lines. All extensive plantations should also be protected by fire lines. These lines need be only ten to fifteen feet wide. They should

Fig. 53. — A ground cleared fire line with the larger trees left standing on the line. The shade checks the growth of grass and herbs which is apt to spring up on an open line.

have all growth removed except trees over four inches in diameter, breast high, and the mineral soil exposed. Frequently this can be accomplished by cutting out the brush and small trees and then plowing the line. Once established in a sandy soil such a line can be cheaply maintained by an occasional harrowing. If plowing is impossible a clear line can be secured by burning over the line or by hoeing and raking away the litter. If burned over great care must be taken to prevent the escape of the fire. Narrow lines should be raked free of litter on each edge of the fire line and then the area inside burned over on a quiet day. Roads make the best kind of a fire line and can, in many cases,

be utilized for this purpose. The original cost of construction will vary greatly with the amount and character of the growth to be cleared, and whether the line is plowed, burned over, or raked. Under the best conditions a ten- to fifteen-foot line cannot be constructed for less than \$10 per mile, while in less favorable places the cost may easily run up to \$50 or \$75 per mile.

By permission of the U. S. Forest Service.

Fig. 54. — Fire line cleared through a hardwood stand. The line has not been properly maintained and is covered with a thick growth of weeds. The fire hazard is now greater on the line than in the forest.

After it is constructed the cost of maintenance should be below \$10 per mile per annum.

The location of fire lines is largely controlled by natural conditions. It is well to take advantage of brook beds which form a barrier in themselves and where water can be obtained for fighting fires; also of roads and trails; and especially of ridge tops. Fires burn downhill very slowly and can, therefore, be most easily checked at the top of a ridge.

ROADS AND TRAILS.

Roads and trails are of great benefit in the prevention of fires, not only serving for fire lines but furnishing means of communication between various parts of a forest. A large forest area without such roads is very hard to protect, as a long time may be wasted before men and tools can reach the source of danger.

By permission of the U. S. Forest Service.

Fig. 55. — Fighting a ground fire by trenching through the thick duff to mineral soil.

EXTINGUISHING FIRES.

We have considered already the most efficient means of so improving the condition of the forest that not only fires will burn with less severity but that men can gain access to them more easily. Even under the most favorable conditions a well-organized fighting crew is also necessary, under the leadership of someone who understands fire fighting. Certain equipment can

be of great service and should be kept at vantage points in the forest where it is easily obtainable in case of fire.

The best tools to be kept for such purposes are: long-handled shovels, rakes, axes, mattocks, brooms, pails, and spray pumps. Chemical fire extinguishers are also of great value for surface fires, and it is a much-discussed question whether such extinguishers or spray pumps are more efficient in extinguishing forest fires. The chemical extinguishers employed for this purpose are

By permission of the Connecticut State Forester.

Fig. 56. — The fire wardens of a Connecticut town and their fire fighting outfit of bucket pumps. They have been burning over a fire line adjacent to the railroad track.

fairly light, portable ones, weighing about thirty-seven pounds when charged, and provided with a short hose and nozzle. Various makes of extinguishers are on the market but all based on the same principle. Briefly, the extinguisher contains in the top a small bottle of sulphuric acid, while beneath is a mixture of water and calcium bicarbonate. In working the extinguisher it is inverted and the sulphuric acid mixes with the liquid, resulting in the formation of carbonic acid gas and calcium sulphate. The chemical reaction forces out through the hose a mixture of water and carbonic acid gas, which, theoretically, stops combus-

tion quicker than water alone. The bucket or spray pump is a small suction pump fitted with a hose and nozzle, and with a clamp so that the pump can be securely fastened into a large pail. The pail should be covered with a wire netting or cloth to strain the water and keep out sticks and dirt. Both the extinguisher and bucket pump are used in the same way in fighting a surface fire. The operator walks rapidly along the line of the fire and deadens the blaze; a helper, who beats

By permission of the Connecticut State Forester.

Fig. 57. — Fighting a surface fire with a bucket pump.

out with a shovel the last remnants of the fire, should come behind him.

Both are extremely effective methods of extinguishing surface fires, even of such severity that beating out, shoveling on dirt, etc., cannot be employed alone.

Which is the better, bucket pump or chemical extinguisher? Each has its supporters and usually in a locality where one is employed the other is not used. Each has its advantages and disadvantages, which have been placed in two parallel columns for the purpose of comparison.

COMPARATIVE EFFICIENCY OF CHEMICAL EXTINGUISHER
AND SPRAY PUMP.

	Bucket pump.	Chemical extinguisher.
<i>Cost</i>	\$5	\$9
<i>Capacity</i>	Depends on size of pail. Should use large pail holding 3 to 4 gallons.	Between 2½ and 3 gallons.
<i>Weight when full.</i>	A 4-gallon galvanized pail, with pump, containing 3 gallons of water, weighs under 35 pounds.	Approximately 37 pounds. It is a much harder article to carry than pail and pump.
<i>Length of line of fire put out.</i>	50 to 150 feet. Skill of operator in using only a little water in the right spot governs the length of line which can be put out.	50 to 200 feet. This depends mainly on how fast the operator walks and his skill.
	The severity of the fire influences length of line with both. If very carefully handled and the country is easy to get over, making rapid walking possible, the extinguisher should put out a longer line of fire than the bucket pump.	
<i>Material used.</i>	Water.	Water, sulphuric acid, bicarbonate of soda.
	Practically same amount of water needed to recharge either of the two.	
<i>Cash outlay for recharging.</i>	Nothing.	10 to 25 cents per charge.
<i>Accompanying equipment.</i>	In order to make either the bucket pump or chemical extinguisher most effective there must be facilities for refilling. Several empty cans (big milk cans are among the best) or pails for bringing water are necessary. Besides this for the chemical extinguisher there must be extra supplies of sulphuric acid and bicarbonate of soda.	

The statement is frequently made that the chemical extinguisher is forty times as effective as water in extinguishing fire, *i.e.*, one hundred and twenty gallons of water would be needed to do the work which one charge (three gallons) of the chemical extinguisher accomplishes. Whether this is so in the case of a fire in a building in which a great volume of fire is concentrated in a comparatively small space, the authors do not know, but

it is certain that nothing so disproportionate exists in the case of the ordinary forest fire, which extends as a narrow line. Here the extinguisher is not even twice as effective.

The lower cost (both the initial cost and that of maintenance) and freedom from trouble in recharging with chemicals make the bucket pump more desirable for general use than the chemical

By permission of the Massachusetts State Forester.

Fig. 58. — Special forest fire wagon; small size for one horse.

extinguisher, although the latter can put out a somewhat longer line of fire.

There are special circumstances under which the chemical extinguisher is preferable, as when water is extremely scarce, for it uses a little less water; or where all parts of a tract are accessible by good roads, for then a wagon can go along and transport a supply of extra chemicals easily and without danger of breakage.

The most intensive development of this method of fire fighting is found in certain Massachusetts towns, located mainly through the eastern part of the state and especially in the level, sandy southeastern section, where transportation by wagon is easy. In these towns, special forest fire wagons are maintained. They vary in style somewhat in different towns, but two types built by

the state forester of Massachusetts as special forest fire wagons may be considered as standard. The following quotation from the Seventh Annual Report of the State Forester of Massachusetts briefly describes the two wagons and their equipment.

"The larger wagon is intended for two horses and costs, all equipped, about \$450. The equipment consists of fourteen chemical extinguishers; fourteen galvanized cans, each holding two extra charges of water and chemicals; shovels, rakes, mattocks, and spare chemical charges. This equipment is carried in racks and cases, not only so that it will ride safely, but also so that it can be conveniently carried into the woods. Eight men can find accommodation on this wagon.

"The smaller wagon, drawn by one horse, has all the equipment of the larger, but less in amount. It will carry four men and costs, all equipped, about \$300."

By permission of the Massachusetts State Forester.

Fig. 59. — Special forest fire wagon; large size, for two horses.

Raking the leaves and litter away from the advancing flames is another good way of checking surface fires. This makes a rough sort of fire line where the fire stops for lack of inflammable material.

Perhaps the most common method of checking a fire, and the most effective under certain conditions, is beating it out with brooms or evergreen boughs or bran sacks. These sacks when wet can be used to good advantage.

One experience in fighting fire will suggest the best methods for certain conditions. The chief thing to remember is that a fire is not out when the flames are stopped. It will often smoulder for a long time in some old stump and finally blaze out again, perhaps after several days. Fire wardens should

remember this and always have someone to watch a fire for some time after it is supposedly out.

The most effective time to fight fire is in the night when there is usually less wind and the ground is damp with dew. A small force of men can often accomplish more at this time than a large force in the daytime.

It is easier to put out a fire spreading downhill than in the opposite direction, because hot air rises and an ascending fire is fanned by the draft which it creates.

Fortunately crown fires are not very common in New England. About the only way to prevent a serious crown fire with a strong wind is by "back firing," but this should never be resorted to except as a last resort and at points of vantage. To have a back fire effective it must be started far enough ahead of the main fire to clear a considerable strip of all inflammable material before the main fire reaches it. This distance, therefore, depends upon the rate of advance of the main fire. A fire advancing at the rate of a mile an hour could probably be checked by a back fire set one-half mile ahead; while to check one traveling at twice that rate a greater distance would be required. Great care must be used in starting a back fire that this does not escape with the wind and go tearing through the forest, increasing the damage done by the main fire.

The purpose is to burn back against the wind toward the main fire and thus destroy all inflammable material in the track of the main fire and cause its death through lack of fuel. A back fire should only be started on the side of a road, brook, ledge, or some other obstacle which would help to control it.

ESTIMATING THE DAMAGE DONE BY FOREST FIRES.

In almost all states persons who set forest fires are responsible for damages, and civil suit for such may be brought against them. From the first part of this chapter it will be seen that fires seldom kill standing timber outright and that the damage thereto is often small compared to that done the younger growing stock, the reproduction, and the soil itself. Inasmuch as this young

growth seldom has any market value until of lumber, or at least of cordwood size, it has been quite common to overlook these more serious forms of damage in appraising the results of a fire. Neither is it an easy matter to determine the damage to young growth and soil. The only just method of determining this damage is to estimate, (*a*) what the forest would have been worth after a given length of time if not burned, and (*b*) what it will be worth in that same time now that it has been burned, and deduct the latter from the former. The result is the amount of damage at the end of this period caused by the present fire. In order to determine the present value of this damage it is necessary to discount the amount to the present time, at the same rate of interest as the forest is yielding on the capital invested. To illustrate:

Suppose on a tract of twenty acres of spruce burned over this year, 200,000 feet of lumber were destroyed worth \$7 per M. The damage to timber is \$1400. If it is estimated that the young growth would have produced 200,000 feet more in thirty years without the fire and will now not produce over 30,000 feet in that time; and it is estimated that stumpage will be worth \$10 per M. in thirty years, the damage at the end of the period would be equivalent to 170,000 feet at \$10 = \$1700. From tables of interest it is found that the present value of \$1700 discounted at five per cent for thirty years is \$390. Therefore the total present damage is $\$1400 + \$390 = \$1790$. To execute the field work necessary for an estimate of this sort of the damages done by fire the chapter on timber estimating must be understood. As a rule our New England fires do not destroy the trees, so it is possible after a fire to estimate the amount of lumber killed just as live timber is estimated. To determine the damage to reproduction is somewhat more difficult, depending on whether the young seedlings are wholly destroyed or simply killed. If they are still present it is possible to estimate the percentage of the area which was stocked. If they have been destroyed it will be necessary to judge the former condition of the reproduction by that on similar adjoining tracts which have

not been burned over. After ascertaining the percentage of the area formerly stocked it will be possible by the use of yield tables, discussed in Chapter X, to estimate what the yield would have been had the land escaped fire.

It will be realized that there are many opportunities for inaccuracies in determining damage in this way, especially in our American forests where so little is known as yet of exact rate of growth and the future value of stumpage. One of the main chances for mistake is in selecting the rate of interest. In the example given it will be seen that the present value of \$1700 discounted at 4 per cent for 30 years would be \$525, or, at 5 per cent, \$295, making the total damage respectively \$1925 or \$1695 instead of \$1790. Of course where forests are managed under scientific working plans, as is the case in many European forests, and only a portion of the forest is removed equal to the amount grown in that time, a definite income is derived. In such a forest the rate of interest corresponds fairly well to the income divided by the capital. For example, in a forest having an estimated stand of 40 cords per acre in which there is an annual growth of one cord and where wood is worth \$1 per cord, the rate of interest at which the forest is growing would be one fortieth = two and one half per cent. In this country the rate of interest used will usually be not less than that paid by savings banks since our forest management is in such an unsettled state.

It is only recently that the destruction of reproduction has been recognized by the courts as a damage for which reimbursement could be claimed. Hitherto damages allowed by courts have been based entirely on the stumpage value of the timber destroyed. This, however, is only a part of the actual damage, as the young growth and productive capacity of the soil is also injured. For this reason a recent decision of the United States Circuit Court at Deadwood, South Dakota, is of interest.

"The government in the summer of 1910, won a signal victory in the case against the receiver of the Missouri River and Northwestern Railroad Company, in which damages were claimed for

the destruction of timber by sparks from the defendant's locomotives. The jury brought in a verdict for the plaintiff allowing practically the full amount asked. The total sum demanded was \$3728.85 and the verdict was for \$3659.45, a difference of but \$69.45. This item was the alleged value of the cordwood destroyed, amounting to $231\frac{1}{2}$ cords at 30 cents per cord. The government claimed that the wood before the fire was worth 60 cents per cord and as it was subsequently sold for 30 cents they claimed the difference, which was not allowed.

"The important feature of the case was the allowing of \$12 per acre for reproduction and the suit was unique in that this establishes a precedent of the greatest value to the Forest Service. It is the first time that a court in the United States has decided that trees of such immature growth have a value that may be determined and for which damage may be estimated and allowed.

"The item of reproduction in this case was \$1094.40 or \$12 per acre for 91.2 acres and it was allowed by the jury in full. The other item allowed was for the partial destruction of 675,000 feet of mature timber, originally valued at \$6 per thousand, but a credit of \$2.20 per thousand was allowed the defendant as the fire-killed timber was subsequently sold at that price. This added \$2565 to the reproduction allowance.

"The basis for the valuation of the reproduction were the figures derived from the actual operations of this kind in the Black Hills National Forest during the past season, when 1500 acres were reforested by seeding. Thus the forest officers, in their testimony, were able to give exact figures for the work already performed and thereby put a definite value on young trees, which to practical lumbermen would be worthless."¹

¹ This quotation is taken from *Forestry Quarterly*, Vol. VIII, p. 566.

CHAPTER IX.

TIMBER ESTIMATING AND VALUATION.

METHODS of timber estimating are numerous and of varying degrees of accuracy. The method which should be employed depends very largely upon conditions. Usually there is not the same need of exactness in estimating timber on a large tract that there is on a small one, since the large tracts, as a rule, do not have a very heavy average yield per acre, and they are situated in remote regions where the stumpage price is comparatively low. Some small tracts, on the other hand, are worth from \$100 to \$500 per acre, on account of heavy yield and proximity to the market. Naturally one would employ more exact methods of estimating the stand on a fifty-acre tract priced at \$5000 than on a ten-thousand-acre tract valued at \$100,000. As a general thing the more valuable the timber the greater the need of an accurate and elaborate estimate.

Estimating lumber is like every other business; the more experience a man has in it, the more accurately he can estimate and the simpler the methods he can use. Many lumbermen, or, more correctly, timber cruisers can go over a large tract in a casual way and estimate fairly well the total amount of timber upon it. They are able to do this because they have had experience in cutting off many similar tracts and know the amount of lumber taken from them. The roughest method is simply to compare in one's mind the tract under consideration with those with which one has had experience. This method is liable to errors of twenty-five per cent even when used by experienced men. Stumpage prices of timber have now advanced so much and competition is so great that practically all cruisers now use some more accurate system.

It should be said at the outset that the land owner or pro-

spective purchaser can usually secure the services of a timber cruiser, but as the business of estimating offers unequaled opportunity for dishonesty, the employer should be sure that the estimator is working for his interests. It must also be borne in mind that most of these men look at the forest from the lumberman's rather than the forester's standpoint, and are, therefore, not inclined to place much value on young growth or to appreciate the probable rise in prices. For these reasons they are more likely to underestimate than overestimate and their judgment is worth more to the purchaser than to the seller.

As the purpose of this chapter is to point out methods of estimating which can be applied by one of little experience, rather than to describe the cruisers' methods, the latter will be omitted.

A. ESTIMATING TIMBER ON SMALL WOOD LOTS.

The most accurate way of estimating timber and one wholly practicable on small wood lots, as areas of less than one hundred acres, is to measure the diameters of all the trees and the heights of as many as will establish an average. The diameters are measured with calipers, always at breast height. Heights may be measured accurately with an instrument known as a hypsometer,¹ or, after a little practice, may be estimated fairly accurately. This work can be done best by two men crossing and recrossing the wood lot on parallel strips. To avoid mistakes it is well to mark the trees measured with a piece of carpenter's chalk.

The most convenient form of tallying the trees measured under this system is to use a sheet ruled horizontally and vertically; the vertical columns for the various species, the horizontal lines for diameters. A dot is made for each tree measured and after four dots are made under the same diameter and species, the next trees are designated by connecting lines and diagonal lines until ten trees are tallied. The following table illustrates this method:

¹ There are several kinds of hypsometers. The one commonly used in this country is called the Faustman and can be purchased from Keuffel & Esser Co. of New York.

Diameter, breast high, inches.	Spruce.	Birch.	Maple.	Hemlock.	Beech.	Fir.
4.....	: : (5)	.....	.....	• (1)	.....	☒ • (11)
5.....	: : (4)	: (2)	.....	•• (3)	.....	☒ • (6)
6.....	: (2)	.....	.....	.....	.....	☒ (8)
7.....	.....	.....	☒ (7)	.....	.....	.....
8.....	.....	.....	• (1)	.....	.....	.....
9.....	.....	.....	.....	.....	.....	.....
10.....	.....	.....	.....	.....	.....	.....
11.....	.....	.....	.....	.....	.....	.....
12.....	.....	.....	.....	.....	.....	.....

On the area tallied there was one hemlock 4 inches, one maple 8 inches, two spruces 6 inches, two birches 5 inches, three hemlocks 5 inches, four spruces 5 inches, etc.

After all the trees on a lot have been measured in this way their volumes can be best ascertained by the use of "volume tables,"¹ if they are available. Volume tables have now been constructed for many of our important species. They are based on the measurements taken in lumber jobs of several hundred felled trees and give the average volume, either in board feet or some other unit, for trees of different diameters and heights. With such tables the total volume of each species on the lot is obtained separately, a table being constructed similar to the one below.

In the application of volume tables it will be seen that some give cubic feet instead of fractions of a cord or board feet. The number of cords can be secured by dividing the number of cubic feet by 90 on the principle that a cord of wood (128-stacked cubic feet) contains 70 per cent solid wood, which amounts virtually to 90 cubic feet. Board feet can be converted to cords by allowing 500 board feet as the equivalent of a cord. This varies from 400 feet for small logs to 600 feet for large ones; but it must be remembered that the rule will not always work backwards, for a cord of wood may be composed of sticks too small to be sawed.

¹ A number of such tables are included in the Appendix.

TABLE SHOWING THE APPLICATION OF A VOLUME TABLE
TO SECURE THE STAND OF SPRUCE ON A WOOD LOT.

Diameter, breast high, inches.	Number of trees.	Volume ¹ per tree in board feet, from volume table.	Total volume, board feet.
5	500	6	3,000
6	420	12	5,040
7	430	18	7,740
8	300	38	11,400
9	170	61	10,370
10	200	78	15,600
11	220	96	21,120
12	140	110	15,400
Total.....	2,380		89,670

¹ Volumes taken from volume table by T. S. Woolsey, Jr., made in Grafton, N. H.

In the case of trees for which no volume tables have been constructed a table should be made. A rough table that will be fairly accurate for any wood lot can be made by cutting on the tract a number of trees of different diameters of the species in question, only taking care that a good range of diameters from the smallest to the largest is included. After these sample trees are felled they are measured into log lengths, and the logs of each tree scaled by the log rule in general use in the community. A log rule is a table, generally laid out on a measuring stick, which gives the number of feet, board measure, in logs of different diameters and lengths. A number of such log rules¹ are in use in different parts of the country. The most common rules² used in New England are the Doyle, the Scribner, the Bangor or Maine, the Blodgett, and the Vermont. After scaling the logs of a tree their volumes are added to give the volume of the whole tree. The volumes of the various felled sample trees are then plotted on cross-section paper, and a curve is drawn designating the average, as shown below. Of the five trees measured in this case, the 7-inch tree contained 30 board feet; one of the 9-inch trees 40, and the other 60 board feet, etc.

¹ See Woodman's Handbook, Bulletin 36, U. S. Forest Service.

² Copies of these rules are given in the Appendix.

From this curve it is possible to make the rough volume table (called a "local" volume table) as follows:

LOCAL VOLUME TABLE.

Diameter, breast high, inches.	Volume, board feet.
6	15
7	30
8	35
9	50
10	65
11	85
12	120

With such a volume table the total contents of the trees on the wood lot of this species are obtained as already explained.

Still another method of obtaining the volume of the stand without the use of any volume table is based on estimating, at the same time with the breast high diameters, the top diameter of every 16-foot log. To do this accurately requires some practice in judging 16-foot lengths and diameters at different distances. As a result of this method the note keeper has not only the diameter of each tree but also the estimated top diameter of each log. The volumes of logs of different diameters are given by the log rules, and the total amount of lumber for the tract is obtained by multiplying the volume of the log of each diameter by the number of logs of that diameter, and adding all together. The following table illustrates the final result by this method.

Top diameter of 16-foot logs, inches.	Number of logs.	Volume per log, board feet.	Total volume, board feet.
8	50	32	1,600
9	62	36	2,232
10	70	60	4,200

B. ESTIMATING TIMBER ON LARGE WOOD LOTS.

On large wood lots, as those over one hundred acres in extent, very likely it would be impracticable to measure all the trees. A system somewhat less accurate can be applied in such cases depending upon two operations carried on together, as follows:

1. Count all the trees on the lot.
2. Measure all the trees on certain plots.

Two men by walking through a forest on a compass course can very rapidly count the trees on a strip four rods wide. Those on the outside should be marked so as to avoid confusion when returning on the parallel strip. At regular distances, as every two hundred paces, a plot is laid off and all the trees on this plot measured as described under *A*. Circular plots are conveniently laid off by pacing from the center the distance of the required radius in different directions. A circle with a radius of 59 feet contains a quarter acre; with a radius of 85 feet, a half acre. After all the trees on the wood lot have been counted in this way, and the trees on several sample plots have been measured, the volumes of the various sample plots are worked up by one of the methods described under *A*. The total volume of the lot is obtained by ratio:

$$X : V :: N : n$$

in which

X = total volume of the wood lot.

V = volume of the sample plots.

N = total number of trees on the wood lot.

n = number of trees on the sample plots.

C. ESTIMATING TIMBER ON LARGE FOREST TRACTS.

The methods described above rely upon a census of the total number of trees on the wood lot. In the case of large timber tracts such an enumeration is impossible, and some method must be employed based on an accurate estimate of certain parts of the tract and a knowledge of what proportion these areas form of the

whole. In order to determine this proportion a map is necessary, from which the total area of each portion or type can be obtained. For example, a 10,000-acre tract in northern New England might be found to comprise 2000 acres of second-growth pine, 1000 acres abandoned pastures, 4000 acres mixed birch, beech, and maple, and 3000 acres second-growth spruce. A knowledge of the area of each of these types is necessary. There might also be subdivisions according to age, which would have to be estimated separately. Thus in the second-growth spruce and pine types, certain blocks might occur containing timber twenty to fifty years old, while the remainder was less than twenty years of age. The only accurate way to determine these areas is to map them, and consequently a map must be secured by the estimator.¹ In an open country, undoubtedly, it is better to map the area first with a plane table and do the estimating separately, but there can be no question that for those sections of New England where large forests occur, the so-called "strip system," or "valuation survey," devised by the United States Forest Service, is unsurpassed. By this method the data for making the map are secured at the same time that measurements of the timber are being taken. To carry out this method a crew of four men is best, although it can be done with a smaller or a larger number. The necessary equipment is a surveyor's chain, a hand compass (for more accurate work a staff compass), two pairs of calipers, a tally board, some record sheets or a notebook, and a pencil. A hypsometer is a valuable addition as will be explained later. The crew may be arranged in various ways. The main object is to run a straight compass course through the forest and this is done by the head man. The other two men carry the calipers and measure the diameters of all trees for a distance of one-half chain length, two rods on either side. At first this distance should be checked frequently, by carrying the chain out to the side or by pacing; but with practice the men soon are able to judge very closely, and the few inaccuracies balance

¹ For methods of mapping forests, see "A Manual for Northern Woodmen," by Austin Cary, published by Harvard University, Cambridge, 1909.

themselves. The trees on this strip, 66 feet long and 66 feet wide, are calipered and tallied as described under *A*.

This square of 66 feet each way is one-tenth of an acre. When all the trees on this area have been measured the crew moves on another chain length in the fixed compass direction. The chains are tallied after moving forward. Ten chains complete the acre, which is all that is tallied on one sheet. A description of the

By permission of the Connecticut State Forester.

Fig. 60. — A portable sawmill of small capacity, such as is commonly used in southern New England.

forest is written on the back of the sheet with special reference to the type, so that all acres measured in a certain type can be averaged together. If there is a marked change in type in the course of an acre, it is better to start a new sheet, the tally of chains showing that this sheet represents .6 or .8 of an acre, etc., as the case may be. A continuous strip of eight acres covers a mile of distance: $66 \times 10 \times 8 = 5280$ feet. The tract is gridironed with these strips. The distance apart of the lines depends upon

the intended accuracy of the estimate. Lines run one mile apart give a measurement of one and one-quarter per cent of the entire area; one-half mile apart two and five-tenths per cent; one-quarter mile apart five per cent; one-eighth mile ten per cent, etc. However, in practice, the lines are rarely run nearer than one-quarter mile, and usually two and five-tenths per cent of the area is considered sufficient. By making note of changes of type, topography, streams, etc., it is possible to make a fairly accurate map of the tract. The areas of the different types can be determined from this map. Along with the survey the crew should take the height measurements of a few hundred trees of the most important species, to obtain the average height for each diameter class.

When all the required valuation surveys have been secured there remains a large amount of work to be done. In the first place, the tally sheets are assorted according to the type of land they represent. Of the 500 acres measured in the 10,000-acre tract, suppose 100 fall into the second-growth pine type, 150 into mixed hardwoods, 200 into second-growth spruce, and 50 into abandoned pasture. The sheets representing each of these types are averaged together, giving an average acre for each type. This shows the average number of trees of each diameter and species for the type, and the contents can be obtained from volume tables as discussed under *A*. The total volume of each species is then multiplied by the number of acres in the whole type, giving a total for the type.

The valuation survey method of estimating, described above, undoubtedly surpasses, for accuracy and cheapness, any other method and admits of considerable variation in detail. There are now forestry companies whose main business is to estimate timber, and, as far as known, they all use some modification of this system.

Another method applicable for large tracts, by which the data for a map are secured along with the estimate, is a combination of the strip system and the circular plot method outlined under *B*. The chief advantage of this method is that it can be done

by one man. In principle it does not differ from the method just described. The estimator secures his distances by pacing, guiding his course by a pocket compass. Instead of measuring the timber in a continuous strip he takes measurements only at certain points, as at the end of every quarter mile. At these points circular plots are laid off as described under *B*. In open forest and with mature timber it soon becomes possible to locate the boundaries of the plot by the eye. The trees are either

Fig. 61. — Estimating timber by use of the strip method.

calipered and the volume of the types ascertained, as in the valuation survey method, or after sufficient practice the volume of each tree can be estimated and tallied. After the volumes of all the sample plots in a type have been found, the average volume per acre is obtained and this is multiplied by the number of acres in the type, as secured from the map.

THE MONEY VALUE OF STANDING TIMBER.

After the amount of standing timber or wood on a given tract has been estimated, the final object usually is to determine its money value.

Timber is bought and sold under so many different conditions that when a price is mentioned it is always necessary to define the conditions under which the price applies. Timber standing is spoken of as stumpage, and the price paid for trees standing is called stumpage price, which is expressed generally as so much per thousand board feet, cord, or other unit. It is customary in European practice, and in some cases in this country, to sell logs in the woods when piled alongside the logging road. In America this is spoken of as being on the skidway. Again, the transaction may be of logs delivered at the mill, or loaded on a car, or skidded on the bank of a river.

Naturally the price of stumpage is lowest, that paid for logs delivered at the mill is highest; other prices range between the two. The value of timber may also be figured at its price when manufactured and placed on the market. This, of course, is the highest of all, but is the easiest to arrive at and should serve as the basis from which the value of the standing timber can be computed as described below.

The market value of manufactured lumber fluctuates considerably with national supply and demand. In years of business depression, like 1908, when there is less building, prices decline. As a general tendency, however, the prices of lumber are rising. Prices paid for lumber, wood, and other forest products, as for everything else, vary according to local conditions, and the first step in valuation of timber is to ascertain the prices that can be secured either for the manufactured article or for the logs delivered at the mill. For example, the following prices per thousand board feet are average prices for logs delivered at the mill in northern Vermont. Birch, beech, and maple, \$9 per thousand board feet; hemlock, \$9.50; ash, spruce, and fir, \$10.50; white pine, \$11; but in any given case the actual prices may be considerably above or below these. Hence inquiry is necessary whenever an estimate of the value of standing timber is to be made. Where there are special industries requiring a large amount of any special timber, the prices paid for that species are higher. As we have stated, a timber

owner having had his logs sawed may sell the manufactured lumber. In order to show the average relation between prices paid for logs at the mill and prices paid for rough lumber, loaded on the car at the mill, the following prices of rough, manufactured lumber are given, to compare with those above: Spruce, \$16 to \$18; second-growth pine, \$20 to \$22; fir, \$16 to \$18; basswood, \$16 to \$18; birch and maple, \$13 to \$15; ash,

Fig. 62. — A selected lot of the best grade spruce logs for manufacture into clapboards.

\$16 to \$18; hemlock, \$16; oak, \$20 to \$25. Sawmill owners in the above section usually charge from \$2.50 to \$3 per thousand feet, board measure, for sawing softwood lumber and from \$3 to \$4 for hardwoods. These figures indicate the possible profit of selling manufactured lumber over logs, but the owners should realize that it is often difficult for them to find a ready market, while the millmen are in constant communication with dealers.

Lumbering is a form of business in which there are many chances of loss and in which experience and the judgment ac-

quired thereby are of great value. Without these there is a large chance of failure. The inexperienced man may well prefer to pay a lumberman a commission on an operation, which he practically does when he sells the stumpage, instead of acting as his own lumberman. In determining the value of stumpage it is necessary to make a distinction between the price which the owner could get for it if he sold to a lumberman or jobber, and what he could realize if he acted as his own jobber. If successful in the latter capacity he would have the additional profit which the lumberman would expect to make by the operation.

In most communities there are men who make a business in winter of hauling logs and wood. They will take a contract to haul the given distance at a certain price per thousand feet or per cord. The prices charged are usually based on a fair day's wage for men and teams, and this, of course, varies in different sections. The margin for profit is so small that unless the landowner has plenty of men and teams this contract method will be cheaper for him. For a six-mile haul in northern Vermont the price is usually about \$3 per thousand, or from \$1.50 to \$2.00 a cord. For short hauls, where two trips a day can be made, the cost will be about half these figures. By deducting the cost of haul from the price to be received at the mill, the value of the felled timber is obtained. If it is to be transported by railroad or river, the further charges for such freightage must be added. In southern New England most of the lumbering is done with portable sawmills. In this case the price paid for logs at the mill is less because the manufactured lumber has to be transported to the railway or market.

To obtain the value of standing timber, a further deduction for the cost of cutting and logging is necessary. It usually costs about \$1.25 per thousand board feet for cutting the trees. Logging¹ in the north woods, where the logs are piled on skids near the cutting, is cheap—usually not over \$1.50 per M²—

¹ Logging as here used refers to the operation of removing the log from the place where the tree grew to the skidway or portable mill; it does not include cutting or hauling from the skidway to the permanent mill or railroad.

² M stands for thousand feet, board measure.

but logging to the portable mill averages about \$2 per M. Cutting cordwood costs from 90 cents to \$1.25 per cord.

As said before, when the cost of cutting, logging, and hauling has been deducted from the price to be received for the logs, the stumpage value is secured, which is the value to the owner acting as his own jobber. A lumberman would not pay so much as this, as he must necessarily make his own profit also, which may be considered as a commission paid the lumberman by the owner.

The commission paid to a lumberman when stumpage is sold him varies considerably, but averages about one-half the net value of the standing timber. For example, if logs are worth \$12 a thousand feet at the mill and it costs \$6 to get them to the mill, they will be worth to the owner about \$6, if he is a successful lumberman. If he sells the stumpage, however, he will rarely receive over \$3 per thousand. In other words, he pays a commission of \$3 to the lumberman.

The following is a summary of prices and costs for an average lumber operation, when the price of logs at the mill is \$12 and for sawed lumber delivered is \$20 per M.

	Per M.	Per M.
Stumpage price.....	\$3.00	
Lumberman's profit.....	3.00	
Cost of cutting, skidding, and hauling....	6.00	
Cost of logs at the mill.....	<hr/>	\$12.00
Cost of sawing.....	3.00	
Cost of transporting.....	2.00	
Millman's profit.....	3.00	
	<hr/>	8.00
Sawed lumber delivered.....		<hr/> \$20.00

In the future this method will largely give way to that of selling at a definite rate per thousand feet, board measure (or other unit), based on the actual cut at the mill.

When the stumpage value per thousand feet and per cord has been ascertained, it is an easy matter to determine the value of the standing timber on a lot by simply multiplying by the amount obtained in the estimate.

In many cases when lumbermen make an offer for the stump-

age the computations above referred to will be useful to ascertain whether offers are satisfactory or not. The experienced lumberman does not make these detailed computations but knows from past experience about what he can give for stumpage to make a fair profit.

Most timber in the past has been sold by the lot and not by stumpage price, but even in this case both the purchaser and the seller have their estimates of the amount of lumber on the lot, and regulate their prices accordingly.

CHAPTER X.

GROWTH OF TREES AND FORESTS.

THE study of the growth of trees and forests is, perhaps, the most difficult one in forestry and it is not proposed to attempt any complete presentation of the subject here. Several technical works,¹ in English and in other languages, can be consulted for detailed information. The purpose of this chapter is rather to indicate the various kinds of growth and the general methods of study. For convenience the chapter is divided into two sections: A. Growth of trees; B. Growth of stands. A knowledge of the latter must rest upon a knowledge of the former.

For scientific purposes foresters speak of increase in volume of a tree or stand as "increment"; and the increase in diameter, sectional area, or height, as "accretion"; but ordinarily "growth" is used to cover both terms. The growth of a tree or stand may be the growth of a specific year, when it is called "current annual growth"; or of a specified period of years, called "periodic growth." By dividing the total volume by the age the "mean annual growth" is obtained.

A. GROWTH OF TREES.

There are many incentives for the study of tree growth, the chief being to establish a basis for forest-growth studies. For the forester to have a knowledge of the relative rates of growth of the more important species with which he deals is not only interesting, but very necessary. It is also advisable to know something of the relative growth of the same species under different conditions. Height growth is the best indication of

¹ The most important American book dealing with this subject is, "Forest Mensuration," by Graves. Wiley & Sons.

the quality of the soil for any species, and consequently a table showing the average height of trees of different diameters and on different sites furnishes a ready means of determining the relative value of the sites for the species in question. In fact the three quality sites commonly recognized are usually determined by a classification of heights.

1. *Age of Trees.*

The age of a second-growth pine tree and of some other species up to fifty or sixty years can be obtained with fair accuracy by counting the whorls of branches, since the pine makes but one whorl each year. The buds of winter develop in the spring into branches and leader. Height growth is made entirely at the top. One can only approximate the age of most trees without cutting and counting the rings on the stump. Every fall, in our climate, the growth ceases and the tree remains at rest until spring. When activity in the cambium (the tissue just inside the bark) recommences, large wood cells are made with comparatively thin walls. Throughout the growing season new layers of cells are formed, but as the season advances these cells become smaller and their walls relatively thicker. On account of this difference in structure the wood formed in spring and early summer is lighter colored than that formed at the end of the season. A sharp, well-defined line in most species separates the dark growth of the fall from the light growth of the next spring, and the belt between these dark lines is called the annual ring. In the tropics where there are no well-defined seasons, no distinct rings occur, and the age of trees cannot be ascertained in this way. The distinctness of the rings in trees varies with the texture of the wood. In such woods as the spruce, pine, oak, ash and chestnut the rings are easily distinguishable, although slow growth in some cases may require the use of a magnifying glass. With such fine-grained trees as beech, birch and maple, on the other hand, it is often very difficult to distinguish the rings. In obtaining the age of a tree by counting the rings on the stump it must be

remembered that seedlings grow very slowly at first, especially under shade, and that a number of years may have been required for the seedling to reach the height of the stump. For this reason stumps to be analyzed should be cut as low as possible.

By permission of S. J. Record.

Fig. 63. — Cross section of a conifer (hemlock) highly magnified showing the annual rings of growth. *A* to *B* is one season's growth.

The average period required by different species to reach stump height can be ascertained by studying the ages of a few seedlings of the desired height. The average age thus obtained should be added to the age of the tree as found on the stump. Thus, if there are one hundred and sixty rings on a hemlock stump, two feet high, and a study has shown that it requires

fifteen years for hemlock under similar conditions to reach the height of two feet, then the total age of the tree will be estimated to be one hundred and seventy-five years.

By permission of S. J. Record.

Fig. 64. — Cross section of a hardwood (black ash) highly magnified showing the annual rings of growth. *A* to *B* is one season's growth.

2. *Diameter Growth.*

For scientific purposes diameter growth should always be studied at a cross section taken at breast height, but as a matter of fact it is usually studied on the stumps of trees cut for lumbering. As the growth near the swelling of the roots is slightly greater than that higher up, the results are not entirely accurate. The

rings should be counted and the growth measured on the average radius, in order to secure the average growth on all sides. The results of a study of this kind may be expressed in various ways as, for example: the average diameter of trees of different ages; the average age of trees of different diameters; the number of rings in the last inch of radius for trees of different diameters; the number of years required for each diameter inch class to increase one inch. Frequently confusion arises among amateurs between the first and the second of these expressions. They are apt to infer because the average diameter of a species fifty years old is fifteen inches that conversely the average age of trees of that species fifteen inches in diameter is fifty years. It is impossible to use the tables in this way, since one is made by averaging all trees that are fifteen inches in diameter, and the other is made by averaging a different set of trees that happen to be fifty years old. Among these, many that have been suppressed may be only eight or ten inches in diameter, and others that have grown rapidly may be correspondingly larger.

3. *Height Growth.*

By means of a hypsometer,¹ the heights of standing trees can be rapidly and easily obtained. A table made from these results will show the average height of trees of different diameters, and as the method of determining the average age of different diameters has already been given, the average height growth can be ascertained by combining the two in the following manner.

Diameter, breast high, inches.	Average height, feet.	Average age of diameter classes, years.	Height growth per year, feet.
5	25	20	...
6	32	26	1.1
7	40	32	1.3
8	48	40	1.0
9	57	44	2.2
10	69	50	2.0

¹ See note, Chapter IX.

The height growth of individual trees can be obtained by counting the rings at the various sections into which the tree is cut. The number of rings on the stump represents the total age of the portion of the tree above the stump cut. Obviously a tree two hundred years old would have that number of rings at its base, but it would have only one ring at the very tip for the growth made the last year. Since the first ring is made by the leader, the number of rings in any section of the tree represents the number of years since the leader reached that point. Each section cut from the base up has, therefore, a diminishing number of rings. This difference in age at various sections is the number of years required by the tree to grow the distance between the sections. By cutting felled trees into sections it is possible to read the record of their height growth.

4. *Volume Growth.*

To compute the mean annual growth of a tree after the volume and age are obtained, one divides the volume by the total age. The figures below, which are actual measurements of a few trees of different species, illustrate this method.

Species.	Total volume, cubic feet.	Total volume, board feet.	Age, years.	Mean annual growth.	
				cubic feet.	board feet.
White pine.....	10	48	42	.23	1.14
White pine.....	6	32	40	.15	.80
White pine.....	13	72	44	.18	1.60
Hemlock.....	73	370	314	.23	1.16
Hemlock.....	103	552	294	.36	1.90
Hemlock.....	92	480	255	.36	1.50
Beech.....	..	225	202	...	1.00

In the life of most trees, there are periods of slow growth due to suppression by neighboring trees, or to other causes. For this reason the mean annual growth is always low. Foresters sometimes speak of the economic age of a tree as referring to that part of the tree's life during which it made a normal growth.

The chief purpose of studying tree volume growth is to be able to predict future growth for a coming period. This can best be done by a study of periodic growth made under conditions similar to those which are likely to obtain during the period to be predicted. Unless there is a radical change of conditions, the rate of growth during the ten coming years may fairly be expected to approximate that of the past ten years. The growth

Fig. 65. — A study of the growth of an individual pitch pine tree is in progress.

of a past period is easily obtained, (1) by determining the present volume of the tree; (2) by counting the desired number of rings from the bark inward at both ends of the logs, and obtaining the volume of the tree at the beginning of the period; (3) by subtracting the second volume from the first. If the percentage of growth is desired, this remainder is divided by the volume at the beginning of the period. For example, a red oak sixty years old had a volume of 8.4 cubic feet. Its volume ten years ago was 6 cubic feet, and the tree grew at the rate of $\frac{2.4}{6}$ or 40 per cent. But the annual growth was .24 cubic foot, and hence its annual rate was 4 per cent. Usually the rate of growth of a

tree in percentage falls with increasing age, in spite of the fact that it lays on more wood each year even if the width of the rings remains the same. Although the actual amount of wood made may increase, this increase is an ever-decreasing proportion of the total volume of the tree. Suppose, for example, that the red oak mentioned above grew 3 cubic feet during the decade between sixty and seventy years, the percentage of growth would be $\frac{3}{8.4}$ or 35 per cent.

B. GROWTH OF STANDS.

Thus far the growth of individual trees has been considered; it is important for many purposes to ascertain the growth of stands or whole forests. Forest management depends very largely on this knowledge, especially the more intensive forms of management, such as are in use in Europe. In Austria, for example, the policy is to cut and reproduce a stand as soon as it ceases to yield a satisfactory rate of interest. This is called the financial maturity of the stand. In Baden and other countries the forest working plans prescribe the cutting of an equal amount of wood each year, while in Württemberg, an equal area is cut over annually. A knowledge of the growth of the different stands is essential for the Baden system. In our own country, forestry which aims at a permanent income must rest on this kind of knowledge.

Just as we have considered the growth in diameter, height and volume of individual trees, so the growth of whole stands should be discussed under similar headings.

1. *Age of Stands.*

The age of a stand is usually considered to coincide with the age of the tree of average size in the stand. Such a tree is selected and its age ascertained as already described. This result is taken as the average age of the stand. Such a figure has more value in even-aged than in uneven-aged stands.

2. *Diameter Growth.*

The only accurate method of determining the diameter growth of a stand is to measure carefully all the trees in a stand, mark the points at which the measurements are taken, and remeasure after a series of years. Usually, for accurate purposes of this kind, the circumferences are measured and the diameter growth calculated from the growth in circumference. This, of course, is impracticable for immediate purposes. Fairly accurate data may be obtained from the mean sample tree or tree of average diameter. If the growth for the whole life of the stand is desired, the sample tree is felled and the rings counted and measured; but if the growth for the past few years only is required, a gash can be cut in an inch or so and the radial growth measured. The measurements from this sample tree are considered as representing the diameter growth of the average tree in the stand. Care must be taken that the average tree is normal in other respects as well as diameter.

3. *Height Growth.*

The height growth of a second-growth pine forest can easily be obtained by counting the whorls of branches of a few average trees. With other species it is necessary to cut and measure a few trees of average height.

4. *Volume Growth.*

One of the simplest methods of determining the volume growth of a stand is to obtain the growth per cent of a mean sample tree, that is, a tree of average size, and apply this per cent to the total estimated volume of the stand. Thus, if the sample tree is growing at the rate of 4 per cent and the total volume of the stand per acre is 20 cords, the growth of the stand may be considered as .8 of a cord per acre.

Often the mean annual growth of a stand is found and used as a basis for predicting the future growth. To secure this the stand is carefully estimated, and the total volume divided by

the average age, which may be considered as the age of the average sized tree. For example, a stand which has produced forty cords to the acre in thirty years may be expected to produce about one and one-third cords per acre a year, for the next few years. This method of predicting growth is only approximate because the growth of a stand is not uniform throughout its life. During the first part of its life the annual growth would exceed the mean annual growth, but in later years it would be less.

As a basis of forest management to indicate what different types of forest can produce under various conditions, and at different ages, so-called, yield tables¹ are in use. Comparatively few of these have as yet been constructed in this country, but their construction is one of the most important lines of forestry research open to the forester. These tables are based on the measurements of many stands of a given type at different ages, and express the average volume per acre that can be expected at different ages. Such tables may be "local," if based on stands in a single community, or "general," when the data is secured over a large area, as a whole forest region. It will be readily seen that yield tables, for even-aged stands, not only are more easily made, but are of wider application than those for uneven-aged stands. Since the chief use of yield tables is to predict what forests will produce under favorable circumstances, they are based usually on the measurements of fully stocked stands, and then are called "normal." Often it is impossible in our irregular forests to find acres that are fully stocked, and consequently fractions of acres are measured rather than entire acres which include open areas. Three classes of forests need to be studied for the construction of such yield tables: (a) unthinned pure forests; (b) unthinned mixed forests; (c) thinned stands. Thus far all of the yield tables made in this country have been for the first and second classes, especially for pure forests, and do not indicate what these forests can produce when properly treated. In the future this last (c)

¹ Several yield tables are included in the appendix.

class of yield tables will be chiefly needed, especially in forest regions with the best market conditions.

Normal yield tables cannot be made for uneven-aged forests, since cuttings in such forests are made at regular intervals when only a part of the stand is removed. For rough yield tables with which to estimate the growth of such stands, it is customary in this country to designate in tabular form the number of years required for each diameter inch class to grow one inch, and from this to estimate the amount of timber that can be produced in a given period. Since the rate of growth is based almost entirely on conditions different from those which will prevail in the future, these tables should not be taken too seriously.

PART II.

NEW ENGLAND FORESTS AND THEIR MANAGEMENT.

CHAPTER XI.

THE ORIGINAL FORESTS AND THEIR EARLY DEVELOPMENT.

WHILE the early history of New England abounds with references to the forest, they are unsatisfactory as far as yielding light on the real character of those forests. We can, however, gain a fair picture of them from the records of the early forest industries and from the laws which were passed regulating their use.

There can be no question that there was an immense white pine forest stretching across Massachusetts to the foot of the Berkshires and extending well up the rivers of Maine and to Lake Winnepesaukee in New Hampshire. It reached still farther north through the Connecticut valley and its tributaries, such as the Ammonoosuc and Passumpsic, and from the borders of Lake Champlain as far inland as the base of the Green Mountains. On the better soils, hardwoods were frequently mixed with the pines; birch, maple, beech in the north; oak, hickory, chestnut in the south. On some of the drier sandy lands the pitch pine was perhaps even more common than the white pine, as in the Cape Cod district and the Connecticut valley near Hartford.

The pine was always confined to the warmer soils and seldom reached good development on elevations exceeding 1500 feet. Bordering the pine country in the north or in the mountains was spruce, forming pure forests throughout much of the northern portion of Maine and of the White Mountains, but usually mixed, in Vermont, with the hardwoods. Even in the swamps and

lower slopes of northern Maine giant pines were often mixed in with the spruce. But a more common companion of the spruce was the fir, which probably formed a smaller percentage of the mixture in the virgin forests than it now does owing to its remarkable reproduction. For the same reason the hardwood forests of southern New England had a larger percentage of oak and hickory than at present, for with every succeeding cutting the chestnut, owing to its unequaled sprouting capacity, has gained on its competitors.

The forests of England had ceased to be important timber producers centuries before the settlement of America. With her forests handled even in those days chiefly as game preserves of the nobility, England had been obliged to rely largely on Scotland and Scandinavia for lumber.

The English Government undoubtedly appreciated her new-found American possessions more for these great forest resources than for their possibilities for colonization. While at this period the West Indies probably occupied a greater place in the estimation of that Government than did New England, there was no lack of appreciation of the value to the English navy of our timber. In fact, the navy which made possible England's supremacy of the sea through the seventeenth and eighteenth centuries and which alone prevented an invasion of England by Napoleon, was largely made of New England timber and relied even more completely on this country for masts. Many interesting incidents bearing light on the timber supply are mentioned in the famous diary of Samuel Pepys, who, in the days of Charles II, was Secretary of the Navy, as for example, the following:

"Dec. 2, 1666. I went to Sir W. Batten's and there I hear more ill news still: that all our New England fleete, which went out lately, are put back a third time by foul weather, and dispersed some to one port and some to another; and their convoys also to Plymouth; and whether any of them be lost or not we do not know. This added to all the rest do lay us flat in our hopes and courages, everybody prophesying destruction to the nation."

"Dec. 3, 1666. At noon home, more cheerful than I have been a good while, to hear that for certain the Scotch rebels are

all routed; . . . There is also the very good news come of four New England ships come home safe to Falmouth with masts for the King; which is a blessing mighty unexpected, and without which, if for nothing else, we must have failed the next year. But God be praised for this much good fortune, and send us the continuance of his favour in other things."

It was in this same year that the great fire of London, necessitating the use of a large amount of lumber, brought the whole question of lumber supply prominently before the English nation. Charles II, inspired by the example of Louis XIV, that great patron of the arts and sciences, had created the Royal Society, and John Evelyn had brought forth in 1662 his "*Silva*," the first work on forestry in the English language. In the dedication of this most interesting volume to the King in 1678, Evelyn says: "I need not acquaint your Majesty how many millions of timber trees have been propagated and planted throughout your vast Dominions, at the instigation, and by the sole direction of this work; because your Gracious Majesty, has been pleased to own it Publickly for my Encouragement, who, in all that I here pretend to say deliver only those Precepts which your Majesty has put into Practice; as having (like another Cyrus) by your own Royal Example, exceeded all your Predecessors in the Plantations you have made, beyond (I dare assert it) all the Monarchs of this Nation, since the Conquest of it."

It is not surprising that a government thus solicitous of forestry interests should have imposed many regulations on the cutting of the forests in the new land, nor is it strange that the settlers coming from a country where they fully realized the need of forest conservation, should have humbly submitted to these regulations and indeed imposed rules and by-laws of their own.

It is probable that the first sawmill in New England, and very likely in America, was built at Agamentico, later known as York, Maine, in 1623, or the following year, under the direction of Sir Ferdinando Gorges, from whom is quoted: "I sent over my son

and my nephew, Capt. Wm. Gorges, who had been my lieutenant in the Fort at Plymouth, with some other craftsmen for the building of houses and the erecting of sawmills.”¹ The second mill was probably erected at Salmon Falls River in what is now South Berwick Township, Maine, in 1631 or the year following. Of this and other mills it is said that “Capt. Mason sent into this country eight Danes to build mills, to saw timber and tend them, and to make potashes.” It is altogether probable that all the first sawmills were Scandinavian institutions, as there were none in England until 1663, at which time hundreds of them were in use in New England. While sawmills had been used in Europe from the earliest times, conditions of timber supply and labor in England were such that, even as late as 1767, a sawmill was destroyed by an English mob because it represented too great a saving of labor.

The first sawmill in Massachusetts was erected about 1633; the first in New Hampshire near Portsmouth, before 1635; the French settlers had sawmills at Ticonderoga at an early date. Between 1640 and 1650 several sawmills were erected in Massachusetts Bay Colony; and Connecticut was not far behind in the use of power for making lumber, for the younger Winthrop, afterwards Governor of Connecticut, brought a millwright to New London and put up a sawmill in 1651. Before the close of the century there were several in Connecticut.

After about 1650 the sawmill almost immediately followed settlement in any portion of New England, usually in connection with a grist mill, and the location of a water power often determined the location of the settlement. The right to erect and operate sawmills was, in the early days, granted by town meetings, and it is evident that the people were wide awake to the benefit of having a local mill. In a grant by the “townsmen of Saco” to Roger Spender, it was stipulated that he should build his mill within a year, that all the “townsmen should have bordes 12 pence in a hundred cheaper than any stranger,” and

¹ For much of this material we are indebted to a “History of the Lumber Industry of America,” by Defebaugh.

that the townsmen who would work erecting the mill "as cheap as a stranger" should have preference.

Commerce and shipbuilding had an early beginning in New England. An early record states that in 1623 a ship of a hundred and forty tons, called the *Anne*, was freighted at Plymouth and returned to England with a cargo consisting of clapboards with a few beaver skins and other furs.

These clapboards were oak staves for wine casks and had a good sale in London. The settlers of the West Indies also depended upon New England for their supplies of barrels and boxes in which to export their molasses and sugar. As early as 1629 there were six shipwrights at work in Boston, and on July 4, 1631, Governor John Winthrop launched at Mystic, now Somerville, a vessel of sixty tons, called the *Blessing of the Bay*. It was the first vessel built in the Massachusetts Bay Colony and demonstrated the excellence of New England timber for this purpose. Medford, Marblehead, and Salem soon began to build ships. Gradually all the seacoast settlements took up this industry, from Maine to Connecticut. The industry, besides requiring a large amount of first-class white oak lumber, also depended upon a ready supply of the so-called "naval stores" such as pitch, tar, and turpentine. These materials have long since been considered special products of the south, but for a century after the first settlement of Windsor, Connecticut, and the neighboring region the manufacture of these products from the pitch pine was an extensive industry.¹ In fact, the first Indian deed in this territory had its origin in this business, for it seems that in 1643, John Griffin and Michael Humphrey commenced the manufacture of pitch and tar and the collecting of turpentine. Manahanoose, an Indian chief, was so unfortunate a few years later as to kindle a fire which in its progress consumed a large quantity of pitch and tar belonging to Mr. Griffin. To make amends for this the chief deeded to the injured party all his lands at Masscoie. The General Court early recognized the

¹ "The Forests of Connecticut," by A. F. Hawes, *Connecticut Magazine*, Vol. X, No. 2.

importance of this industry by granting in 1663 to Mr. Griffin, two hundred acres in consideration "that he was the first that perfected the art of making pitch and tar in those parts." These materials were in great demand for the uses of the British navy as well as for shipbuilding generally. They commanded a ready sale at high prices, and were nearly the only articles allowed by England to be exported. The town of Enfield and probably others granted the privilege to box a certain number of trees, but this grant did not convey the land nor the trees. The record of such grants reads as follows:

"July, 1705. Mr. Joseph Sexton is posed of so many pine trees as may aford three thousand boxes which are a littel southward of or south est of buk horn and ye same sid of wedow glesons medow, these afored trees are bounded on every with common land." The industry was so important that we find an act in the Public Records of the Colony of Connecticut providing for inspection of all barrels of tar and turpentine. In 1709, the inhabitants of Hartford voted "if any persons shall box any pine trees within the bounds of the town of Hartford, either on the comons, or undivided lands, he shall forfeit to the towns use the sum of five shillings for every tree so improved." This act of restriction probably marks the beginning of the end, such measures usually coming after a scarcity has begun to be felt.

The settlement of Massachusetts was so rapid that most of the lumber was required for domestic purposes, but a great exporting lumber business grew up in Maine at an early date. By 1682, there were twenty-four mills in the territory now known as Maine. The most important lumber-shipping port of the colonies during the seventeenth century was that of the Piscataquis River. During the ten months ending April 12, 1681, according to statements made by the King's Council to the Lords of Trade, there were entered at that port "twenty-two ships, eighteen ketches, two barkes, one scallop, and one flyboat, — in all forty-seven." . . . "The Trade of the province is in masts, planks and staves and all other lumber." Pine for masts and oak and tamarack for shipbuilding were cut not only on the Piscataquis

but the St. Croix and other rivers of Maine. Later the Penobscot became the most important lumber stream.

The destruction of white pine early became a subject of solicitation on the part of the government. In King William's reign a surveyor of the woods was appointed by the crown and an order was sent to the governor-general to cause an act to be passed in the several governments for the preservation of the white pines. In fact the crown claimed the pick of all the forest and no one but officers were supposed to cut the pines. Many conflicts arose between the people and these officers. The woodsmen, asserting a "Swamp Law," cut their share. Forestry regulations of this sort were imposed not only by the crown but by the colonies.

The lumber industry of the colonies steadily grew up to the time of the Revolution, and, in fact, was not long interrupted by the war. In 1770 the export of masts, boards, staves, etc., from New England was valued at £45,000; ships, about 70 sail, at £49,000; and potash to the amount of 8000 barrels, at £20,000. The trade in lumber was largely with the West Indies, Madeira, and the Canaries.

The first use of the word "lumber" in its present sense apparently dates back to the early colonial times when the wharves of Boston were "lumbered" over with boards, logs, etc.

Practically the last act looking toward the preservation of the forest was an act passed by Massachusetts in 1784, providing a fine of \$100 for cutting a white pine tree on the public lands. Two years later the Commonwealth abandoned this policy of protection in favor of immediate realization of its resources. Both by royal and local authority restrictions on the cutting of timber had been severe, but now within twelve years after the close of the Revolutionary War, Massachusetts disposed of three and one-half million acres, much of it through lottery, in the region now Maine. Undoubtedly she was sadly in need of revenue after the heavy drain of the war, but the disposal of much of this public nonagricultural land in Massachusetts then and later throughout the United States was one of the greatest

mistakes made by a people just beginning to govern themselves. Canada has been fortunate in escaping a policy which, until the administration of President Cleveland, was followed by our state and national governments.

Naturally the lumber business grew rapidly with the removal of the old restrictions and the passing of these great tracts into private hands. The French traveler Michaux¹ says, that when he was at Windsor, Maine, in 1806, "the river was covered with thousands of logs of which the diameter of the greater part was fifteen or sixteen inches, and that of the remainder (perhaps one-fiftieth of the whole) twenty inches. The blue ash and red pine were the only species mingled with them (white pine) and these in not the proportion of one to a hundred." He adds elsewhere: "For a space of 600 miles from Philadelphia to a distance beyond Boston, I did not observe a single stock of the white pine large enough for the mast of a vessel of 600 tons." In 1807 the importations of timber to Great Britain from the United States amounted to \$1,302,980, of which white pine formed about one-fifth. This sold in Liverpool at that time at about \$20 per M.

Probably the greatest transfer of lands ever made in New England was that known as the "Bingham Purchase," by which, in 1793, William Bingham, of Philadelphia, secured 2,107,396 acres in Maine at twelve and a half cents an acre. Much of the land disposed of by the state in these early days went to pay soldiers of the Revolution and the War of 1812. Perhaps the best disposition of public land was to the various colleges which were established about this time. According to an early history of New England, about 80,000 acres were originally granted to Dartmouth College, and it was estimated that the income from this in 1805 would be the munificent sum of \$2000, a little over two cents an acre. The Legislature of Vermont granted about 33,000 acres in 1791 for the support of the University at Burlington. Unfortunately this was scattered through every section of the state, and an economical management of it was

¹ See "History of American Lumber Industry," Defebaugh.

impossible. Most of it was rented under permanent leases. Bowdoin College received a grant of six townships from the Legislature of Maine.

During the first half of the nineteenth century the white pine lumber industry grew to immense proportions. Before this time the rural parts of southern New England had begun to be depopulated, and gradually lands on the hillsides of Vermont and New Hampshire were abandoned for farm purposes. When the country districts had been well inhabited a great amount of wood was used as fuel by the farmers. Many of the early manufacturing industries also used large quantities of charcoal. For the production of these fuel supplies great forest regions such as the whole western part of Connecticut and Massachusetts were cut over again and again. President Dwight of Yale, who traveled extensively throughout New England in the early part of the nineteenth century, describes a system common in Connecticut at that time of allowing the sprouts of chestnut and oak to grow for fifteen or twenty years and then cutting them off for wood. Unquestionably the more accessible regions were cut again and again in this way. But when the farm population had fallen off greatly, much of this demand for wood ceased. About the same time railroads were built and coal was introduced for fuel for manufacturing purposes. Wood lots which had been cut close were allowed to grow up, and the increased area given up to brush resulting in an oversupply of fuel, a drop in the price followed, so that fuel wood is now not worth cutting in many sections of New England, where formerly it was worth from \$1 to \$2 a cord standing. Gradually a demand grew for larger materials, as railroad ties, telephone, telegraph, and electric-light poles, and these are now among the chief products of the chestnut and oak forests of southern New England.

The first steam engines burned wood, and many a hillside of Vermont and New Hampshire was stripped of its forest to meet this demand. The original settlers of the more remote localities got no other returns from their forests, which were destroyed to make room for agriculture, than that furnished by the potash

and pearl ash which they sold in Montreal and Boston. After the admission of Vermont to the Union a great industry grew up which Robinson in his entertaining history of the state described thus: "The great pines that fifty years before had been reserved for the 'masting of His Majesty's navy,' were felled now by hardy yeomen who owed allegiance to no earthly king, and gathered into enormous rafts, voyaged slowly down the lake, impelled by sail and sweep. They bore as their burden barrels of potash that had been condensed from the ashes of their brethren whose giant trunks had burned away in grand conflagration that made midnight hills and vales and skies bright with lurid flame. The crew of the raft lived on board, and the voyage (down Lake Champlain and the Richelieu to Canada) though always slow was pleasant and easy when the south wind filled the bellying sail, wafting the ponderous craft past the shifting scene of level shore, rocky headland, and green islands." For years these great rafts of timber went north to Montreal where they were exported, but with the completion of the canal joining the Lake with the Hudson, the current of traffic was turned in the other direction. Finally the timber of the Champlain valley was gone and the products of Canadian forests now supply the trade of Burlington, still one of the busiest lumber markets of New England.

There is no better picture of the condition of the Maine forests and the industries dependent upon them in the middle of the last century than in Thoreau's "Maine Woods." "Think how stood the white pine tree on the shore of Chesuncook, its branches souging with the four winds, and every individual needle trembling in the sunlight — think how it stands with it now, sold, perchance to the New England Friction-Match Company. There were in 1837, as I read, two hundred and fifty saw-mills on the Penobscot and its tributaries above Bangor and they sawed two hundred millions of feet of boards annually. To this is to be added the lumber of the Kennebec, Androscoggin, Saco, Passamaquoddy, and other streams. No wonder that we hear so often of vessels which are becalmed off our coast, being sur-

rounded a week at a time by floating lumber from the Maine woods."

Thoreau's first trip up the Penobscot was in 1846. Just above the mouth of the east branch, he says: "The woods hereabouts abounded in beech and yellow birch, of which last there were some very large specimens; also spruce, cedar, fir, and hemlock; but we saw only the stumps of the white pine here, some of them of great size, these having been already culled out, being the only tree much sought after, even as low down as this. Only a little spruce and hemlock beside had been logged here. The eastern wood which is sold for fuel in Massachusetts all comes from below Bangor. It was the pine alone that had tempted any but the hunter to precede us on this route." Even in those days Maine was famous for its forest fires, for he says: "The lumberers rarely trouble themselves to put out their fires, and this is one cause, no doubt, of the frequent fires in Maine, of which we hear so much on smoky days in Massachusetts." Thus interestingly he describes the Bangor of that day: "There stands the city of Bangor, fifty miles up the Penobscot, at the head of navigation for vessels of the largest class, the principal lumber depot on this continent, with a population of twelve thousand, like a star on the edge of night, still hewing at the forests of which it is built, already overflowing with the luxuries of Europe, and sending its vessels to Spain, to England, and to the West Indies."

At this time little was used from the great forests but pine, but gradually as this became scarce and had to be sought in the west the lumbermen of northern New England began to saw the better specimens of spruce. Later the great pulp industry grew up to use an ever-increasing quantity of that species for the production of paper. Tracts which long ago had been culled of their pine and later of their large spruce were now gone over for a third and a fourth time for smaller spruce trees for pulp. The rivers of Maine, the Merrimac, the Connecticut and its branches still bear their great drives of logs in the spring. A goodly proportion of these now go to the pulp mills. With the extension of

railroads throughout the territory many veneer mills and other concerns using hardwoods have sprung up and the proportion of birch and maple lumber used is constantly increasing.

A generation ago another important change came in the lumber industry — the introduction of the portable steam saw-mill. Up to this time many small tracts back in the mountains had escaped cutting. Now it was possible to take a mill into the farthest of these lots and transport only the finished lumber. Hundreds of these little mills have been at work throughout the region and virgin tracts are now rare. While they have in the past done much damage there is no reason why in the future they should not be an instrument for the improvement of our forests.

From the foregoing brief sketch of the early industries of New England it will be realized how intimately the life of the people was connected with the forest. It is interesting to note the change of feeling toward the forest which has taken place during the three centuries of our history. As has been said, the earliest settlers from England showed an appreciation of the forest wealth of their new country. But the difficulty of clearing away the woods and making the land tillable, the loneliness of the long forest trails, and, more than all, the dread of the forest as a hiding place of Indian war parties, gradually changed the feeling of respect to one of enmity if not actual hate. To children reared on the New England frontier the forest was probably as dark and foreboding as were those of the early German legends. Not until well into the nineteenth century was the forest visited by pleasure seekers. Thoreau wrote much about the forests and their ways and was bitter against their destruction. Other writers took up the part of the forest in a more or less sentimental way, and this gave rise to the woodman-spare-that-tree type of conservationist who was long the laughing stock of the lumberman, and with whom the forester was at first confused to the detriment of the forestry cause. After the railroads had reached into Maine and New Hampshire, big hotels were built which were more or less dependent on the forest for their patronage, and during the last generation most of the large forested watercourses have become

more or less bordered with summer cottages. Now, with improved roads and automobiles, a new movement is rapidly gaining throughout New England. Business men are making their permanent homes in the country and are acquiring large tracts of cheap land much of which is covered with second-growth forest.

Everyone is coming to see that the original forests of the United States will soon be exhausted, and the enthusiasm for forestry and conservation in general, which has swept the country in the past decade, is strong in New England. Nowhere in the country are the opportunities for the practice of forestry better than here, and nowhere has greater or finer progress in private forestry been made than in this old region which has been lumbered over and burned over for nearly three centuries.

CHAPTER XII.

PRESENT FOREST CONDITIONS.

As emphasized in the preceding pages, the New England forest in its virgin condition, although often uniform over broad areas, yet showed important differences in character; especially as the observer traveled in a general north and south direction across the whole territory. The differences in character were expressed mainly by changes in composition (*i.e.*, in the species of trees making up the forest) brought about by variations in climatic conditions and in soil and amount of moisture in the ground, as explained in the chapter on Silvics.

With the advent of settlement, which is always accompanied by lumbering, forest fires, and the clearing of land for farms, conditions which had for centuries governed the growth and development of the New England forest were changed, and as a result of this interference with the natural conditions forests now prevail which often differ widely from the original growth. Settlement has not only occasionally changed the original character of the forest, but it has everywhere emphasized its variations in character throughout the region.

New England now is naturally divided into four forest regions within each of which the forest has a distinctive character of its own. The chief species of trees are not the same in any of the four regions; and, what is even more significant, the density of settlement and the available markets for forest products vary immensely from region to region. From the standpoint of forest management these two factors (density of population and available markets for forest products) are of much more importance than the character of the forest. For without suitable opportunities for the sale of wood no forestry can be practiced.

Opposite this page is given a map showing the location of the four forest regions into which New England is divided. Actually, on the ground, no such fixed boundaries can exist as are traced on the map. In reality for several miles along the border line between two regions it may be hard to distinguish within which of the two a particular tract lies.

Thus the map is intended to indicate only the general location and relative area occupied by each region, rather than to furnish definite boundary lines between regions.

The total area of the New England States is 42,537,600 acres.¹ Included in this is 2,874,880 acres of water surface, the remainder, 39,662,720 acres being land surface. In giving the areas for the four forest regions water surfaces have been left out, and the figures given in the table are the approximate areas of land surface in the different regions. The area and per cent forested are given for each region as well as the per cent of New England occupied by the region.

TABLE SHOWING FORESTED AREAS OF NEW ENGLAND.

Region.	Total area of region (land surface), acres.	Per cent of region forested. ²	Area forested, acres.	Per cent of New England occupied by region.
Spruce.....	17,341,600	90	15,607,440	43 $\frac{1}{2}$
Northern hardwoods..	7,025,700	50	3,512,850	17 $\frac{1}{2}$
White pine.....	11,889,640	40	4,755,856	30
Sprout hardwoods.....	3,405,780	40	1,362,312	9
All New England.....	39,662,720	64	25,238,458	100

² Forested area includes waste land and brush land.

The spruce region lies to the north in Maine, New Hampshire, and Vermont, a large share of its area being in Maine. It is largely a region of conifers. The chief trees here are the red spruce, the balsam, and the northern white cedar (*Thuja occidentalis*).

¹ Based on the figures given in the United States Census for 1900.

Among the hardwoods paper and yellow birch, the aspens,¹ hard maple, and beech are most important. The country is still wild and rugged, as yet untouched by settlement, and with soils so thin, steep, or stony as to be useless for agriculture.

The northern hardwoods region extends through Maine, New Hampshire, and Vermont, into western Massachusetts, having its greatest area in Vermont.

The forest is composed chiefly of hard maple, yellow birch, and beech — trees commonly spoken of as “northern hardwoods.” Conifers such as red spruce and hemlock play a subordinate part. Owing to the greater depth and fertility of the soils a considerable part of the region is farmed and, as a whole, it is much better settled than the spruce region.

Next comes the white pine region, found in all six of the New England States, but centering in Massachusetts, New Hampshire, and Maine. White pine rules here, although other species occur commercially. In this region settlement is thickest. Numerous towns and cities furnish excellent markets, while a large variety of manufacturing plants create a demand for wood in various forms.

The sprout hardwoods region lies at the south in Connecticut, Rhode Island, and Massachusetts, occupying nearly the entire State of Connecticut. Like the white pine region it is a well-settled section, with many manufacturing industries; but the main species of trees are different. Chestnut and the oaks predominate, while conifers in commercial quantities are conspicuous by their absence.

The precipitation is fairly uniform throughout all New England, ranging between forty and fifty inches annually. In the White Mountain region of New Hampshire it rises to over fifty inches.

This brief description will serve roughly to distinguish the four regions. In the succeeding chapters may be found a de-

¹ The aspens, in spite of the softness of their wood, are classed among the hardwoods on account of their similarity in mode of growth and because they are all broad-leaved, deciduous trees.

tailed discussion of each region and the possibilities for forest work which it presents.

HOW TO FIND INFORMATION APPLICABLE TO A PARTICULAR TRACT.

If it is desired to secure definite information that may aid in the management of a particular tract, the forest region in which the tract is located should first be ascertained, which can be done by consulting the regional map. With the proper forest region determined, the next step will be to consult the chapters treating of this region and to select the forest types to which the forest of the tract in question most closely approaches.

The forest types determined on this tract may not coincide exactly with those described in the book, since the innumerable variations of tree associations which actually occur in a forest region render it impracticable to describe more than the few most important and typical ones. But the types in the field will correspond closely enough with those in the book so that their relationship can be easily recognized. Methods of treating each of the chief types of a region will be found and the treatment for the desired type should be studied.

It is believed that by following this procedure an owner of woodlands can not only avail himself of the general information in regard to forestry and its application in New England, but can also secure assistance in the detailed treatment of his own local forest problem.

CHAPTER XIII.

THE SPRUCE REGION.

GENERAL CONSIDERATIONS.

THE spruce region occupies the most elevated portions of New England; and within its borders lie the headwaters of nearly all its principal rivers. The White Mountains of New Hampshire furnish the most striking topographic feature of the region.

Fig. 66. — A general view of the topography in the Vermont portion of the spruce region.

They include seventy-four peaks over 3000 feet in height, with Mount Washington the highest, 6290 feet. The peaks of the White Mountains do not form a single range, but are grouped in an irregular manner; and with their steep, often precipitous slopes and deep, narrow valleys make an extremely rugged country.

North of the White Mountains in New Hampshire the country is not so rough. Many lakes occur. The mountains are lower, less precipitous, and have between one another fairly broad valleys.

The spruce region in Vermont lies in a long, narrow belt, running north and south through the center of the state, on the Green Mountain range. The extreme northeastern corner of the state is also in the spruce region. The Vermont section must be considered a rough country, although it is not nearly so rugged as the White Mountains.

In Maine the country is less rugged than in New Hampshire and Vermont. A broad plateau runs northeast from the western side across the Rangeley and Moosehead Lake districts. It gradually slopes eastward toward the Penobscot River basin, while to the north the gentle slope of the St. John River system is reached. In southeastern Maine the plateau runs down to sea level.

On this plateau, especially in central Maine, occasional mountains rise to relatively high altitudes, such, for example, as Mount Katahdin, elevation 5385 feet. A feature of the Maine section is the large number of lakes and ponds and the abundant waterways, navigable at least for small craft such as canoes. The comparatively level nature of central and eastern Maine, with its intricate network of small streams and ponds, makes an ideal country for transporting timber; while the White Mountains offer many obstacles to cheap and easy logging.

Granites and gneisses form the bedrock of the spruce region; and from them is derived a soil rich in the elements essential to plant life.

The soils, however, are not generally suitable for agriculture. In earlier times glaciers passed over the country, often carrying away the soil and leaving the rock bare. Usually, however, a covering of soil and rock *débris*, varying in thickness from scarcely an inch to many feet, was deposited.

So many rocks are found in these glacial deposits that from this cause alone many soils are rendered unfit for farm purposes. When to this is added the fact that many soils are extremely shallow, that many sites have steep slopes, and that large areas of bog and swamp occur, it will be readily understood that but a small proportion of the soils in the region are suitable for farm-

ing, even though it is true that its soils are chemically rich enough for agricultural use. The soils of the spruce region are largely true forest soils; that is, soils which for all time should be devoted to the production of wood crops.

No accurate surveys for classifying the kinds of land have been made; but from the best available data it has been estimated that not more than ten to fifteen per cent of the land has agricultural value; and less than ten per cent is at present used for such purposes. The farm land lies in belts along the principal valleys; or in isolated clearings near railroad stations, around which small towns have arisen. Fully ninety per cent of the area is now forested, in which is included cut-over and burned areas.

The forest as a whole is composed of trees of all ages, intermixed on the same area; it is thus an "uneven-aged" or an "all-aged" forest. Exceptions to this character occur; for sometimes a part of the forest is found where the trees are all of one age over considerable areas; *i.e.*, an "even-aged" forest. But such cases are in the minority. Mixed stands made up of several species, both conifers and broad-leaved trees, prevail rather than pure stands. The principal species are all shade-bearing (tolerant) trees, several of them possessing the power to endure shade for many years, such as spruce and hard maple.

Red spruce is the characteristic and predominant tree of the region. Here it finds climatic conditions suited to its best growth and development. Nowhere else in the United States does spruce do so well as in this region. It is at its optimum in the White Mountains and in the upper drainage of the Androscoggin River in New Hampshire and Maine. There are three species of spruce found: red, black, and white or Canadian spruce. The latter two are of much less frequent occurrence than the red; the black spruce occurring mainly in bogs as a small tree of little commercial value, while the white spruce grows in small numbers in stream valleys on moist ground.

Balsam (*Abies balsamea*) appears everywhere, sometimes associating with the spruce and occasionally forming pure stands.

Two species of pine, the white pine and the red or Norway pine,

occur, but not as important commercial trees. The red pine is apt to grow on sandy areas which are sometimes found along the main river valleys forming pure groves or mixed with white pine. The white pine likes similar sites though it is more widely scattered through the spruce forest.

Hemlock occurs through the region singly or in groups, but is not by any means an abundant tree.

In the swamps tamarack or larch and the northern white cedar (*Thuja occidentalis*) are frequent trees. The larch is mostly of small size and not commercially important. The cedar occurs both in mixture with other species and also in pure stands. It is a valuable tree, especially in Maine, while in the mountainous sections of New Hampshire and Vermont it is not so common.

Hard maple, beech, and yellow birch are important trees. They are apt to grow together, forming on certain good soils the bulk of the stand with a small amount of spruce in the mixture. The beech and hard maple are of comparatively poor quality and thrive better in regions further south.

Yellow birch, however, finds here optimum conditions for its development.

Paper birch in some parts of Maine and New Hampshire is a tree of considerable commercial value. It is scattered generally over the entire region.

The aspens (*Populus balsamea*, *Populus tremuloides*, and *Populus grandidentata*) occur on burned-over and cut-over lands in mixture with other trees or in pure stands. Where abundant, aspen is valuable for pulpwood.

FOREST TYPES.

Within the spruce region the forest is not the same throughout, for the different species found do not all occur in the same proportions in all places. Indeed, there may be an endless variety and a wide range in the combinations of the different species; so much so, that no two spots in a forest can be said to be alike in every detail. Over considerable areas, however, the forest may for all practical purposes be the same. This gives

rise to "forest types" or associations of forest trees, each association having a distinctive character which usually is readily recognized even by persons not technically trained. To the forester, these forest types are helpful in a practical way in managing the forest, because for each type the same general method of treatment holds good. For this reason the main forest types in a region are always determined and studied in order to ascertain the way in which each can best be treated.

Fig. 67. — Logging camp. Pure spruce in the background.

The forest of the spruce region can be classified with advantage into six forest types. These six grade one into the other with innumerable variations which might be considered as separate subtypes, so that it may often be difficult to identify the main forest type.

Of these six types, two are of a transitory nature and owe their existence to the action of fire or to the clearing of land. In other words, they have come in as a result of interference with natural conditions. If left undisturbed, these two types (temporary

forest types) revert to some one of the other four forest types (permanent forest types).

The six types are:

Permanent Forest Types:

1. Swamp.
2. Spruce Flat.
3. Hardwood.
4. Spruce Slope.

Temporary Forest Types:

5. Birch and Poplar.
6. Old Field.

1. *Swamp*. — Forests of the swamp type, as the name would imply, occur on the low, wet ground near lakes and streams, and are most abundant in the Maine section of the region. In Vermont and the White Mountain section of New Hampshire relatively little swamp land is found.

The soil is apt to be wet throughout the year and is covered with a dense bed of sphagnum moss often of considerable depth. In certain times of the year the swamps are nearly impassable on account of the water present.

Spruce forms from thirty to fifty per cent of the number of trees, both red and black spruce occurring. Other conifers which thrive here are balsam, northern white cedar, and tamarack.

Among the hardwoods, black ash, soft maple, and yellow birch are the most common.

The character of the growth is poor; this is well shown in the spruce which, on the average, is small when compared with spruce timber on the other types. Two causes are assigned as contributing to this small size. First, the growth is slow and it takes the individual trees much longer to attain a given diameter than on less swampy sites. Second, due to the great danger from windfall on the soft, wet land of this type, the chances are very much against individual trees attaining any considerable

size. Old trees are usually blown over before they reach large diameters. The timber of merchantable size is apt to be unsound. A yield of 5000 feet, board measure, per acre, over a whole swamp would be high.

The forest of the swamp land is decidedly uneven-aged. Trees of all ages are intermingled singly or in groups. Wherever openings are made by the death or decay of older trees, there small patches of seedlings start up on the wet, mossy floor. The reproduction secured in this manner is sufficient to keep the type thoroughly stocked.

While the typical swamp forest contains a mixture of several species with spruce predominant, yet in exceptional cases pure stands of other trees occur in the swamps. Sometimes the northern white cedar takes possession, forming a dense valuable growth. Sometimes tamarack grows pure, always in a rather open stand and on the wet ground near the shores of lakes. The balsam may form pure stands in the swamps and grows in almost impenetrable thickets.

On newly-formed ground close to lakes the black spruce may grow alone in a park-like stand, reaching a maximum size scarcely large enough for pulp.

2. *Spruce Flat*. — The spruce flat type occurs on low rolling ground above the watercourses. It is an abundant type in the leveler portions of the region, such as parts of northern New Hampshire and in Maine.

The soils are moist but not wet as in the swamps. They may be deep or shallow and are characteristically strewn with rocks. The drainage is fairly good.

Spruce forms about fifty per cent or more of the stand. The spruce here is practically all red spruce, black spruce being entirely absent and white spruce of only occasional occurrence. Originally, white pine was an important tree in this type, but it was largely cut out in the early lumbering operations. Balsam is abundant, sometimes covering twenty to thirty per cent of the area. Hemlock grows sparingly in this type, and the maples and birches also occur.

The best individual specimens of cedar are found in this type, but it is not a common tree.

The timber is of much better quality than in the swamp forest. Still it is often unsound and does not average so good as

Fig. 68. — Spruce flat running 6000 feet, B.M., per acre. Chief species are, from left to right, yellow birch, balsam, arborvitæ, spruce.

on the better-drained ground. Considerable windfall takes place as the soil is always moist; although on account of its location the type is sheltered from excessive wind damage. Yields of 15,000 feet, board measure, per acre are not uncommon.

Spruce and balsam, especially the latter, reproduce exceedingly well on lands of this type. They take advantage of the least

opening in the forest canopy, appearing wherever light reaches the forest floor.

3. *Hardwood*. — The sites characteristic of this type have well-drained soils of considerable depth, and usually the most fertile in the region. In the mountainous section of Vermont and New Hampshire this type occurs on the lower slopes. In the White Mountains it does not run above elevations of 2400 to 2500 feet. It occupies the low hills and broad, rolling valleys in northern New Hampshire and Maine. The type, in proportion to the forest area, is most abundant in the Vermont section.

Spruce is still present in this type forming on the average twenty to thirty per cent of the stand. But it has yielded the foremost place to three hardwoods: the hard maple, the yellow birch, and the beech. These three species make up sixty per cent or more of the composition. Other species, varying with the locality, mingle with these four trees.

On the fertile soils of the hardwood land the spruce reaches its best individual development, although numerically less important than in other types. The hardwoods with their thick foliage assist the spruce in clearing its trunk of branches and make clear boles. Being sturdy, deep-rooted species, they support the shallow-rooted spruce, preventing windfall, and allow the latter to reach great size and age uninjured.

The hardwood timber is much of it overmature and deteriorating. It has not been lumbered extensively throughout the region, though in a few places heavy cuttings have taken place. To-day in the accessible regions it is rapidly being cut. 12,000 to 15,000 feet, board measure, per acre is a fair maximum yield, while the average stand yields much less.

Most of the best spruce has been removed by loggers and the percentage of hardwoods is on the increase.

Logging operations have attacked the spruce first and more heavily than the hardwoods, and this, coupled with the fact that the situation is best adapted for hardwood reproduction, prevents the spruce from maintaining its position in the type. The reproduction is good, but almost wholly of hardwoods.

The thick litter of hardwood leaves, which covers the ground, furnishes a germinating bed far more favorable for the development of hardwood seeds than for those of spruce or balsam. The latter like a cover of moss, rotten wood, or coniferous duff for germination.

A thick undergrowth of witchhobble and mountain maple is characteristic of the hardwood type. Indeed, once seen it will serve to identify this type of forest.

Fig. 69. — Spruce slope type. Stand about 40,000 feet per acre.

4. *Spruce Slope*. — The spruce slope type occupies steep, rocky slopes with thin soils. Often the soil is practically lacking, thick deposits of moss and duff here taking the function of soil. When a forest fire passes over such lands the moss and duff are consumed together with the wood and nothing is left but the bare rock. The roughest sites and the shallowest soils of the region fall in the type. It is well distributed through the entire region, but is most important in the more mountainous parts, such, for example, as the White Mountains of New Hampshire, where occur many slopes of extreme steepness.

Spruce is the most prominent tree, composing fifty to seventy-five per cent of the growth. With the spruce, balsam is usually associated, and two hardwoods may be found, the yellow birch and the paper birch. Hemlock occasionally occurs.

The timber is not of such poor character as might be inferred from the quality of the site, as spruce thrives in amazingly poor

By permission of the U. S. Forest Service.

Fig. 70. — The upper slope type. Here the forest changes into stands of unmerchantable material growing smaller as the slope is ascended. Notice moss covered bark indicating great age.

situations. Usually the timber grows in thick stands with long, clear boles of smaller diameter than on the hardwood land, but still of good quality.

The heaviest stands of spruce in the region are found in the spruce slope type. Exceptional single acres sometimes run as high as 40,000 feet, board measure, but for a tract of any size a yield of 10,000 feet, board measure, per acre is excellent. On good sites it is the most productive of the four permanent types.

As the slopes are ascended the timber naturally becomes smaller, due both to the absolute elevation and because the soil and moisture decrease with increasing height. Finally, on a few of the higher mountains, timber line is reached, above which no tree growth is found. This line is between 4500 and 5000 feet above sea level.

On the upper slopes, from 3500 feet in elevation up to timber line, the slope type does not contain trees of merchantable size. They are scrubby and twisted and often only a few feet high. Balsam usually predominates in these stands at high elevations, and may form the entire growth. Black spruce also occurs at these high elevations. These unmerchantable stands perform a most important function as protection forests where such forests are badly needed.

Excellent reproduction takes place in the spruce slope type. Even in the virgin stands plenty of seedlings and young growth ordinarily are found. Balsam seedlings are apt to exceed the spruce in such stands, though the latter is well represented.

5. *Birch and Poplar*. — This is one of the temporary types occurring on no particular kind of soil or site. It is confined, however, to lands of differing qualities of soil which have been burned over.

On such land the leaf litter and moss have been destroyed and the mineral soil is left bare and exposed. Such a seed bed is preferred by yellow and paper birch and poplar. The light seeds of these species are blown in by the wind, often for several thousand feet, and germinate on the bare soil of the burned lands, creating the type.

Yellow and paper birch and poplar (*Populus tremuloides* and *grandidentata* and a little *balsamea*) are the chief species. Other light-seeded species, such as red maple and mountain maple, are often abundant. One fairly heavy-seeded species may be present in considerable quantities. This is the bird cherry, the seeds of which are brought in by birds and scattered over the burned areas.

This composition is but temporary, as under the light shade

of these hardwood trees various conifers spring up. The conifers gradually enter, usually five to ten years after the hardwoods have started, and form an understory. The conifers are the more persistent growers and longer-lived trees, so that finally they outlive the hardwoods and gain possession of the land, causing the

By permission of the U. S. Forest Service.

Fig. 71. — The birch and poplar type, starting after fire on lumbered land.

type to revert to one of the four permanent types previously described.

On extensive burns where conifers have failed to seed in, owing to the absence of seed trees, the birch and poplar type may hold the land for several generations. Unless the type is burned over after cutting, the conditions are not especially favorable for seedling reproduction of birch and poplar, but paper birch frequently sprouts prolifically from the cut stumps, while poplar sends up large numbers of root suckers. These root suckers persist, and will reach merchantable size.

The type is found all through the region, being most abundant in sections where there have been many and large burns in previous years. Within the last ten years better fire protection has been the rule. This prevents the formation of seed-bed conditions favorable to the start of birch and poplar stands.

Fig. 72. — Birch and poplar type. A 40 year old stand on an old burn, chiefly yellow birch and pin cherry. Beneath the hardwoods conifers are coming in.

Thus the area of that type cannot be increasing. Instead of being stationary it is decreasing, because reversion to other types is continually lessening the present area.

The birch and poplar type is an example of an even-aged forest. The majority of the trees in a given stand started at practically the same time and are more nearly of the same

diameter and height than is the case in any of the four permanent types. The latter are examples of uneven-aged forests.

Figures secured recently by the United States Forest Service¹ in this region indicate that stands of paper birch on first-quality soil will yield, at sixty years, forty cords of wood per acre, and on second quality soil nearly thirty cords of wood per acre. Definite data for poplar stands are not available, but the

Fig. 73. — A stand of the birch and poplar type 10 to 15 years old.

growth should equal or slightly exceed that made by paper birch stands. The general impression has been that the birch and poplar type was the fastest growing one in the region. This, however, is not the case, although it is a fast growing one. For the first twenty to thirty years it may exceed all others, but after that age the growth falls off.

The old field type has a much higher average growth when stands of merchantable size are considered and must be classed as the fastest growing one in the spruce region, with the birch and poplar type second. Nevertheless the latter is of great

¹ Forest Service Circular, No. 163.

importance because of its moderately fast growth and high yield, and because the two principal species are of value: the poplar for pulpwood and excelsior, the birch for spools and other uses.

The fact that relatively small-sized trees are merchantable and that the type can, therefore, be grown on a short rotation adds to its value.

6. *Old Field*. — Scattered around the borders of the region and in the main valleys which penetrate the interior are occa-

Fig. 74. — The old field spruce type, showing a young fully stocked stand.

sional areas which were cleared and used for farms and pastures. Many of these lands are now unused and have seeded up to forest.

Lands in this condition are classed in the old field type because their forest growth differs widely from that found elsewhere. The stands are usually even-aged like those of the birch and poplar type, and contain trees which are usually exceedingly limby. Some stands have already reached merchantable size, but the majority contain young timber.

A variety of species is found; red and white spruce, white pine, balsam, white cedar (in northern Vermont), hard maple,

birch, and poplar may all be found on this class of land, usually in pure or nearly pure stands. Red spruce is the most common tree. The soils here are of medium to good quality and the growth correspondingly rapid. Where spruce forms the stand the growth will often average a cord of pulpwood per acre per year. For example, one acre of spruce of the old field type, measured in New Hampshire, gave the following figures:

Age of the stand.....	65 years
Height of the stand.....	60 to 65 feet
Number of trees 5 inches or over in diameter.....	627
Cutting to a 4-inch top the yield was 69 cords of stacked pulpwood.	
Growth per year $69 \div 65 = 1.06$ cords.	

Stands yielding 40,000 to 50,000 feet, board measure, per acre are sometimes found.

The type has the smallest area of any in the region, and is relatively more abundant in Vermont than elsewhere.

METHODS OF HANDLING THE FOREST.

In forestry work throughout New England and especially in the spruce region, measures best for the forest from the theoretical standpoint often cannot be undertaken, owing to obstacles of a practical nature. The forester directs his efforts to securing continuous crops of timber on the land and to increasing the productive power of the forest, but frequently the distance from markets and poor facilities for the sale of timber force him to employ some method not altogether the best for the good of the forest. His work is often a compromise between an ideal system and methods the lumberman has found practicable. The intention in these pages is to advise measures which are practicable, and at the same time improve the condition of the forest.

The object of forest management in the spruce region is in general the production of spruce. This is the tree to favor over all others. Occasionally in special types of forest other trees should be favored, but such cases are in the minority.

Intensive methods of management are here usually out of the question owing to the unsettled state of the region.

Since the management for the different types is often dissimilar it will be best to consider the types separately.

Spruce Slope. — The forest of this type, it will be remembered, lies on steep slopes with shallow soil, where it is exposed to great danger from the wind. The situation often would make it advisable to hold these stands untouched, or at most culled only of a very few of the largest trees, as protection forests for the upper watersheds of New England's important streams. But the spruce slope contains a great deal of valuable timber, which, when conservatively cut, can be harvested without destroying the protective power of the forest.¹

How shall this be done? For two reasons the use of the selection system in the spruce slope type appears to be out of the question. First, because the stands are comparatively even-aged, and of such density that the culling out of the bigger trees here and there results in heavy damage through windfall of trees standing next to those cut. Second, because the cost of logging timber on steep slopes far from the lower valleys is high and a considerable quantity of timber *per acre* (more than would be secured under the system of selection) must be cut in order to make a paying operation.

Some system of clear cutting must be used. But it must radically differ from the ruthless slashing and complete clearing of timber, now being made on steep slopes by many lumber companies. The clear-cutting system when skillfully applied is of great use and the disastrous results which have followed its use in northern New England, especially in the White Mountains, are due to its wrongful application and lack of protection from fire after the cutting.

In applying the clear-cutting method to the spruce slope type, clumps of seed trees can often be selected on spots which are comparatively safe from windfall. (Clear-cutting system

¹ There are many scrubby and unmerchantable stands at high elevations which should be retained always uncut as protection forests.

reserving groups of trees. See chapter on silvicultural systems.) On a slope intersected with small gullies and ravines, the seed trees should be located on the higher ground where the seed can be scattered over the ground below. The greater part of the stand is cut clear, leaving these clumps of trees to scatter seed over the clear-cut area. An ideal arrangement would be to have two or three trees in a clump on each acre, but frequently the

By permission of the U. S. Forest Service.

Fig. 75. — The result of leaving scattered trees in exposed positions is seen in these wind-falls. Spruce slope type.

groups must be bigger than this, for their own protection, and are accordingly farther apart. Great care must be exercised to have the groups large enough to withstand wind, as they will frequently have to be left on top of knolls and ridges. Usually a few firmly-rooted trees can be found if time is taken to look for them.

It is often unnecessary to leave large merchantable trees as seed trees, because clumps of middle-aged trees capable of bear-

ing seed can be found here and there, which make excellent seed trees. Where such a clump is left there should be no cutting within the group, not even the removal of a single tree; as any breaks in the cover expose the other trees to wind throw.

Groups of young growth often contain a few old trees, and where the young growth is left the old trees among them also should be uncut, unless they are dead or dying.

Where the spruce slope type occupies but a small space among other types, seed trees can sometimes be left on the edge of the slope.

The timber left in the clumps of seed trees may range from almost nothing of commercial value to, in rare cases, twenty or twenty-five per cent of the merchantable stand. Whatever is left as seed trees remains for a forest generation, until the new reproduction is mature.

Another form of the clear-cutting system can sometimes be applied, described as follows: about one-third of the forest is left uncut, in the form of large, irregular-shaped patches, or in strips, running usually up and down the slope. These patches or strips furnish seed which is blown over the cut area. The reserve groups are an investment to be left for future cutting. The bodies of uncut timber should be located either above or to the windward of cut-over areas and near enough for the seed to reach all parts of the area.

Spruce seed often falls on the snow and may slide along the crust for a considerable distance. The distances between the patches of standing timber should never exceed five hundred feet and much better reproduction will be secured with half this distance. When reproduction has been secured the remaining timber is cut in a separate operation. This would take place about ten to fifteen years after the first cutting. To obtain reproduction on the strips it will be necessary to leave scattered clumps of seed trees in safe positions. The advantage of this strip system over that of leaving clumps of seed trees is that greater protection from the wind is secured, and reproduction is made more certain. But it requires two logging operations,

which, in the very steepest regions and farther from markets, often may be impracticable.

Some stands in the spruce slope type have a full reproduction already on the ground when cut. This reproduction may be either spruce or balsam, but is apt to contain more balsam than spruce. Usually there is some spruce with the balsam. In such

By permission of the U. S. Forest Service.

Fig. 76. — Pure stand of conifers cut over twice in twenty years and still in good growing condition. On the right is a stump of the first cutting and in left center one of the second cutting.

stands, where reproduction is already present, the cutting can remove all the trees of merchantable size and allow the reproduction to develop.

Spruce Flat. — The forest of the spruce flat type is apt to be more uneven-aged and to contain a greater number of species than that of the spruce slope. In places where the soil is rocky and shallow, there may be considerable danger of windfall; and

in such portions of the type the method of clear cutting carried out as in the slope type is advisable.

Much of the spruce flat country, however, is not in great danger of windfall. Here the selection system of cutting works admirably. The forest is suited to such a system by its uneven-aged character, and the location of the type relatively near the main streams, together with its comparatively gentle topography, makes it possible to take out scattered timber at a profit.

Fig. 77. — A carefully made cutting in which a number of large hardwoods were removed without injury to the understory of young conifers.

Under the selection system as applied here a cutting is to be made at intervals, which takes out the larger and less thrifty trees. The cutting can most easily be controlled by establishing a diameter limit below which size (theoretically) no trees are to be cut, and above which all trees are to be cut. For spruce a diameter limit lying between ten and fourteen inches at breast height is the best. An arbitrary limit must not be strictly adhered to. Where the timber is all of large size for several acres, cutting exactly to a limit might strip the land, and therefore a clump of trees should be selected and left to furnish seed,

even though they may be above the limit in diameter. On the other hand, injured or suppressed trees frequently are seen, below the limit in size, which are unthrifty and growing very slowly if at all. Such unproductive trees ought to be cut, whatever their size, unless needed to scatter seed.

The diameter limit is thus "elastic," permitting the cutting of some trees above and some below the limit.

Where the forest is of the typical uneven-aged form it will be possible to return to the same areas and cut again after an interval of ten to thirty years; the interval depending on the amount of the first cut.

A difficulty often met with in handling this type, as well as the other spruce types, is the presence of balsam. This tree reproduces so well that it may become a strong competitor with the spruce. On account of its lower value for lumber and pulpwood it should be discriminated against in favor of the spruce.¹ Where the cutting is made on the selection system this discrimination may be effected by cutting balsam to a lower diameter limit than spruce. This limit should be as low as the market conditions on any given tract allow.

Swamp. — The method of handling this type is the same as for the spruce flats. Wherever danger from windfall is great (as is the case over a great part of the swamp type), or occasionally where a dense, nearly even-aged growth occurs, the stand must be cut nearly clear, making provision for clumps of seed trees, and where the stand is comparatively safe from wind the selection system may be used. In a great many instances reproduction will be found already started before the cutting is made. Here, even if the stand is cut clear, a good second crop will be insured without leaving trees for seed.

From one hundred to two hundred years, depending on the quality of the site, are needed to produce yields of saw timber on the swamp, spruce slope and flat types.

¹ The rapid growth of the balsam in part compensates for its lower value. Eventually, as the market for balsam becomes better, it may merit the same or even greater attention than spruce.

Hardwood. — Here a condition exists radically different from that in the other three permanent types. The large number of hardwood trees makes it difficult for the spruce to reproduce abundantly, because the leaves of the hardwoods form a thick cover on the ground which is very unfavorable for the germination of spruce seed.

In past lumbering operations the merchantable spruce has been cut and most of the hardwoods left standing. Under such treatment the reproduction following cutting is of hardwood species, and spruce may entirely disappear.

Just the opposite policy must be pursued to secure an increased amount of spruce in the second crop: that is to say, the hardwoods must be heavily cut and numerous spruce seed trees allowed to remain. This cutting should be in the nature of a selection cutting, taking out the hardwood trees down to the smallest merchantable size, and cutting only the spruce above a certain large diameter, such as fourteen inches, breast-high (four and a half feet from the ground). This must be supplemented by leaving spruce trees above this limit where cutting exactly to the limit would remove all seed trees. Provision must in this way be made to leave at least two seed trees per acre.

As yet the hardwoods are not salable throughout the entire region, owing to the expense of transporting the heavy hardwood logs to market. Near railroads they can be profitably handled, but in the remote sections it is often impossible to cut the hardwoods. On such lands it may be impossible to secure spruce reproduction, and hardwood will take the place of the spruce as it is cut. To prevent this change in the type it sometimes is advisable to defer cutting of the spruce a few years, until transportation facilities improve sufficiently to make possible the close utilization of the hardwoods. Sometimes a plant utilizing hardwoods may be established and solve the problem.

The treatment so far suggested for the hardwood type is based on the assumption that an increased amount of spruce at once is wanted in the type; and such is silviculturally the best policy. But from the financial standpoint it may be best to give

up for the present the idea of getting more spruce on these lands and to work for the hardwoods. The following facts lead to this conclusion: prices for hardwood logs have not risen proportionately with the advance in coniferous logs; the latter now command prices which are about maximum and in which relatively little advance may be anticipated within the coming decade. The prices of hardwood logs, on the other hand, have been

Fig. 78. — A combined selection cutting and thinning in an old field spruce stand.

relatively low, but are now advancing, and within ten years should rise to a much higher level.

In expectation of such an advance it may often be advisable to refrain from cutting hardwoods for the next ten years. This would apply even to overmature trees, which are not putting on growth in volume, because the growth in value per unit of their present lumber content will more than pay for their lack of volume increase.

Badly diseased and deteriorating hardwood trees, together with the biggest and most unthrifty of the spruce, might have to be removed in a light cutting, leaving the remainder of the stand

for at least a decade. Undoubtedly hardwood reproduction would stock the gaps made in this cutting; but the question of whether or not to try for spruce reproduction in the type would be deferred for ten or more years.

In cuttings in the hardwood type there need be no loss from windfall due to leaving scattered spruce trees for seed. On the deep, fertile soil of the hardwood land the spruce itself develops

Fig. 79. — A selection cutting taking out the most limby trees combined with a thinning, removing the spindling and badly crowded individuals. This is another portion of the old field spruce stand shown in Fig. 78.

a more secure root system than on other sites, and, more important still, one or two hardwood trees can be left close to the spruce seed trees and will support the latter against the wind.

From one hundred to one hundred and fifty years are needed to produce saw timber. The most profitable treatment of the type in the long run would be to cut clear and plant to conifers. But it is usually impracticable, owing to the impossibility of disposing of the poorer hardwoods. Where the markets are sufficiently good to allow cutting the stand clear and putting the poor hardwoods into cordwood, clear cutting and planting are advisable.

Old Field Spruce. — The stands in this type are extremely dense with closely interlocked crowns, and fairly even-aged. Since these stands, as already stated, occur chiefly on the borders of the region and near settlements, they can be handled more intensively than those of the other types.

One of the best systems of treatment will be the clear-cutting system with replanting. Under this system the stand would be allowed to grow until fifty to seventy-five years of age, when it would be cut clear, the brush burned, and the area replanted.¹ The greater part of the material can be sold for pulpwood, as straight sticks can be taken down to a three-inch top. For pulpwood a lower rotation can be used than for saw timber, which requires at least seventy-five years. Such treatment is especially adapted to tracts of small size, where comparatively little timber is found and it is desirable to harvest this at one time. Reproduction of spruce is absolutely assured by this system.

On tracts of some size the strip method of clear cutting can be used, with strips not over one hundred feet in width. Seeding is secured from the adjoining stands. The last strip to be cut must be restocked by some other method. The danger in this method is that other species may seed in ahead of the spruce, and where this is especially to be feared the land should be cut and artificially restocked.

Still another method, an adaptation of the shelterwood system, can be used to advantage, when it is desired to insure the natural reproduction of spruce. Under this method a heavy cutting, removing about one-third of the volume, is made throughout the forest. Theoretically this should remove the poorer individuals, single trees, scattered here and there through the stand. An old-field spruce stand, however, is not adapted for such a system of cutting because of the thickly interlacing crowns, which make the felling of single trees a laborious and expensive operation. Instead, then, of cutting scattered trees, narrow alleyways, possibly ten feet in width, are cut through the stand, leaving

¹ The Norway spruce, a European variety, should be planted rather than the native red spruce. The former grows much faster and yields excellent pulpwood.

belts approximately twenty feet wide, uncut. This removes one-third of the timber and has the effect of admitting light to the forest floor. The result of this increased light is that spruce seedlings spring up in the alleyways and under the standing trees.

Fig. 80. — Reproduction on a small cutting in the old field spruce type.

Within ten years a good reproduction should have started, and the old timber can then be cut clear.

In cutting the trees in the strips they can all be easily felled into and hauled out along the alleyways. A good yield of pulpwood results, which makes the operation profitable financially as well as silviculturally.

This system was devised and first tried in 1903, by T. S. Woolsey, Jr., on a New Hampshire tract, with satisfactory results;

spruce and balsam seedlings stocking the ground thoroughly at the end of five years. The cutting in this particular instance was tried as a method of thinning old-field spruce stands to secure increased growth of the remaining trees. So far no increased growth has resulted, and, as a method of thinning, therefore, the system is apt to be a failure, as spruce of this character fails to respond appreciably to the increased light. This may reasonably be explained as due to the severe crowding which the individual trees in the stand underwent for a long period of years previous to the thinning. If the strip cutting is made comparatively early, — before the thirtieth year, and before the trees have suffered serious crowding, — increased growth might be expected to follow.

The age of this stand was fifty-two years. Thirty-eight per cent of the volume was removed in the first cutting, or thirteen stacked cords of pulpwood per acre. This was disposed of at a net profit of about \$2.00 per cord, making a handsome return per acre on the operation.

Birch and Poplar. — The treatment advisable for this type depends on whether the object is to keep the type as it is or to transform it to one of the four permanent types. It has been already stated that where coniferous seed trees are in the vicinity the stands of birch and poplar become stocked with coniferous seedlings, which develop and finally dominate the type. If birch and poplar are considered more profitable than spruce and balsam, an effort should be made to maintain the temporary type. Otherwise the change into one of the spruce types would be preferable.

It should be wholly a financial question and conifers or poplar and birch favored accordingly. In case spruce and balsam are to be favored, the birch and poplar should be cut clear, taking care to spare all coniferous seedlings which may have started. The mature conifers should be left uncut to serve as seed trees, to seed up such areas as are still unstocked. Such treatment will often turn the type at once into a good coniferous stand.

Where it is desired to have birch and poplar reproduce, a clear-

cutting method must be used and, if seedling reproduction is desired, special provision must be made to have the seed bed in best condition for the germination of these two species. They both need exposed mineral soil and plenty of light for satisfactory reproduction. To secure such a condition on the clear-cut areas it will be best to burn the brush and ground cover. This can be done by allowing fire to run over the whole area. In burning over the area great care must be taken to prevent the spread of fire to adjoining stands. Lines fifteen to twenty-five feet wide should be cleared of all inflammable material on the edges, and, if the tract to be burned is a large one, at intervals across it. Then the burning should be done against the wind on a still day in damp weather, with a sufficient force of men at hand to control its spread.

The seedling reproduction on these burned-over areas must be secured from belts or patches of uncut timber along the sides of the cutting, or an occasional seed tree left on the cut-over area. All conifers to the lowest merchantable size should be removed. What seedlings and saplings remain will be destroyed in burning, and the site left free for birch and poplar.

Instead of depending on seedlings for reproduction it may be secured by sprouts in the case of the birch and by root suckers in the case of the poplar. This is really the coppice system, which consists of cutting the stand clear and allowing the sprouts from the old stumps to make the second crop. The stand must be cut when not over fifty to sixty years of age for birch, as above that age birch sprouts poorly (see Forest Service Circular, No. 163); for poplar, when fifty to seventy years of age. This system could not be used without burning where a dense coniferous undergrowth was present, as the conifers would suppress a majority of the sprouts or root suckers.

A light fire will not completely destroy the power of the birch stumps to sprout, although it weakens them. Poplar root suckers will start even when the stump has been quite badly burned. A fire in the summertime injures the sprouting capacity of both species.

As it is absolutely necessary to get rid of the other species, in order to secure pure or nearly pure stands of birch and poplar, burning must be used. This should be done preferably in the late spring or early fall and never in the summer. Winter,

By permission of the U. S. Forest Service.

Fig. 81. — Old field spruce type. Stand just after a strip thinning.

theoretically, would be the safest time to burn, but snow prevents clean burning at that time. Where a mixture of seedlings is wanted with the root suckers, the fire must be set when the ground is free from snow and the litter is not too dry to burn.

Such a fire will necessarily be hotter than a spring or fall fire and do more damage to the stumps.

The rotation for the birch and poplar type should lie between forty and seventy-five years. If left longer than eighty years, stands containing much poplar will rapidly decrease in merchantable content, because poplar matures usually before that time. Paper birch also is a short-lived tree, though a little longer lived than poplar, and like poplar deteriorates rapidly after maturity. If the stands are composed of sprouts and root suckers the age of maturity comes a few years earlier and rotations of sixty years or under are advisable.

Planting. — Planting as yet is not an important branch of management in the spruce region of New England, nor will it ever take the position which it holds in some other forest regions. The reason for this is that natural reproduction of the valuable species is so abundant that the necessity for artificial restocking of cut-over lands does not ordinarily arise. Lands once cleared for agriculture and then later left idle and requiring planting to become productive are insignificant in area.

Occasionally very heavily cut lands and burns which have failed to reproduce or have become stocked with worthless species offer opportunities for planting.¹ Very little planting of such lands has been done up to the present time. When the advisability of making all lands productive and replacing poor with valuable species is better realized planting will be adopted. As yet the sentiment in favor of planting, except on old fields in the Vermont section, is little developed.

The best species to plant for general purposes is the Norway spruce, on account of its rapid growth (more rapid than red spruce) and ease with which it is raised in a nursery. Its wood is also valuable for pulp or timber. White spruce should also be used and white pine and Norway pine in the lower elevations of the type. The latter is nearly as rapid in growth as white pine, will endure poorer soils, and is a tree immune from danger-

¹ Earlier in the chapter planting has been recommended for use in reproducing stands of the old field spruce type.

ous insect and fungous enemies. For information in regard to the silvical habits of these species see Chapter III.

Avoiding Waste in the Woods. — Ten to fifteen years ago there was a large amount of waste in the logging operations of the spruce region—waste of timber, not only according to the possibilities of utilization to-day but also of material which was then merchantable, and of young trees in thrifty growing condition.

Conditions have greatly improved in recent years, due to the increased use of spruce and balsam in smaller sizes for pulp, and also to the fact that operators are more careful to avoid unnecessary waste in the material cut and to young standing timber. However, on many operations there is still abundant opportunity for further improvement along this line.

The principal ways in which material is wasted in the woods are:

1. In cutting high stumps. (Stumps should be cut down to where the swelling of the roots begins.)
2. In not cutting trees to smallest possible diameter in the tops.
3. In failure to utilize windfalls, and dead and dying trees containing merchantable material.
4. In destroying promising young growth either to make the work of logging easier or for use in construction of skidways, bridges, etc.

In considering the subject of waste great weight must be given to the logging and market problem of each particular tract. For example, on one tract it may be possible to utilize trees to a three-inch top, while on another tract six inches is the lowest possible limit. Hence, if seven inches is the present average cutting limit in the tops on both tracts, the amount wasted in the tops is vastly different in the two cases.

Thus, in studying the amount of waste no standard for the region should be taken. For each particular operation there should be an investigation made of what there constitutes

“waste in the woods,” and then attention given to improving the woods work so that this waste is eliminated.

The terms “avoidable” and “unavoidable” waste might be employed to advantage; their use being illustrated by the following example: On very steep slopes it is often necessary in removing the big trees to cut all the young growth, so that the logs may be rolled down to the log road. Here the difficulties of

By permission of the U. S. Forest Service.

Fig. 82.—Old field spruce type, just after a strip thinning. Looking obliquely across the strips. The trees have not been trimmed as yet nor the logs taken out.

logging prevent the saving of the young growth, and its destruction cannot be charged as avoidable waste. On level land the big trees could be felled and snaked out without serious injury to the surrounding young growth, and there destruction of the young growth is plainly avoidable waste.

Of course, every timber owner desires to prevent all “avoidable” waste. If he is not now doing so it is largely through ignorance of the loss, so far as merchantable material is con-

cerned. This applies to the three first classes of waste in the woods. Their prevention is nothing more nor less than the best practicable utilization, and should be obtained by every lumberman and demanded by every timberland owner who sells timber.

The fourth class of waste covers the destruction of young growth. Unless an owner is practicing forestry or has interest in the future timber value of his holdings he may not care to avoid this class of waste. While comparatively few owners are now practicing forestry, the great majority are interested in the future timber value of their lands, at least from the standpoint of sale value.

The "avoidable" waste in the destruction of young growth on a logging job is often large. Frequently choppers cut down saplings in felling a big tree, where bending them aside or lopping off an interfering limb would be sufficient. By felling trees away from groups of young growth waste may be avoided. Oftentimes several young trees are felled to facilitate the removal of the logs, where, by a little care or by sending in one horse instead of two for the log, the young trees could be saved.

Probably the greatest "avoidable" waste of young growth occurs in the use of young trees for skids, corduroying roads, and the construction of skidways and bridges. Of course quantities of material are needed for these purposes, and this must come from the neighboring forest. But it is in many cases unnecessary to use thrifty growing trees of valuable species for such purposes, since an inferior species will do as well. In some cases this may involve no extra cost or inconvenience. In most cases it is likely that the inferior species will not answer the purpose quite as well as the tree customarily used, but the owner should remember that the young growth of the valuable species like spruce represents his future profits. Rather than to seriously injure the selling value of the land and these future returns it is advisable to substitute, even at a little added expense, inferior species for valuable young growth, for use as skids, etc.

To secure complete utilization and the saving of young growth in logging operations inspection is necessary. The man doing

the marking and inspecting the cutting should also inspect for all classes of waste. Frequent inspection with regular reports to headquarters will serve to keep the logging foremen up to the mark.

Fig. 83. — Old field spruce type. Stand 5 years after a strip thinning. Looking down strip. Note that crowns have not closed. Spruce and balsam seedlings on the ground.

LOGGING METHODS, MARKET CONDITIONS, INDUSTRIES, OWNERSHIP OF WOODLANDS.

Logging Methods. — In each forest region distinctive methods of logging have been developed, suited to the character of the forest and the nature of the country. These methods of logging

have been tried and improved upon until in old lumbered regions, such as the different sections of New England, it is probable that the most economical system has been developed. To make any radical change in methods so developed and long used would be

Fig. 84. — Old field spruce type. Stand 5 years after a strip thinning. Looking across the strips. The fallen trees are all tops or dead trees too small for pulp. Note absence of brush.

difficult; and as the method of logging usually has a vital bearing on the possible silvicultural treatment of the forest it becomes of the highest importance to know these methods and their effect either as helping or making more difficult conservative cutting. The object here is to outline the logging methods, especially as

they have a direct silvicultural bearing. No detailed description or comparative discussion of the methods is given.

In the spruce region there is an abundant cover of snow from November until late spring. As will be seen, the logging is so arranged as to make use of the snow to the fullest extent. It is a very favorable thing from the forestry standpoint, since logging with snow on the ground hurts the forest far less than logging on bare ground.

The beginning of a logging operation is made in the woods by the felling crew. The trees are cut down, trimmed, and left full length, or (in some cases) they are sawn into logs. These logs or trees are then dragged out by single horses or double teams. Where the trees are large and left full length two horses are needed to haul them. Usually several logs are bunched together, and then the front ends placed on a rough sled with the rear ends dragging. The logs are thus taken down ("snaked") to skidways placed beside the main hauling road. This is often called "yarding" the logs. Where near a drivable stream they may be dragged directly to its bank and piled or rolled in.

From the silvicultural standpoint it is better to use but one horse for yarding, as the single horse does not need so wide a road and therefore does less damage. On account of the weight of the longer sticks it is not always possible to use one horse. In any case, to enable the team to reach the log, a lane must be cut through the underbrush and young growth. When carefully selected these lanes can avoid the best groups of young growth. The lanes or skidding trails from the individual trees converge, running into one another, until finally one or two main trails lead down to the skidway. This network of skidding trails, while thoroughly gridironing the land, is so scattered, and each trail is in itself so narrow, that the destruction of the young growth on the trails is not a serious injury. This applies to cutting on the selection system. Where the cutting is very heavy approaching a clear cutting, the damage may be considerable but cannot well be avoided.

On very steep slopes it may be impossible to drive a horse to

each tree and the logs must be rolled down short distances to main skidding trails. This results in the destruction of young growth between the tree and the skidding trail.

Fig. 85. — Old field spruce type. Stand 5 years after thinning. In wet soil windfall is apt to occur. All the thrown trees in this picture are dead ones except 1 live 7-inch tree.

Under the most adverse conditions, however, the use of horses and hand labor is far superior from a silvicultural standpoint to the use of machinery such as steam skidders and cable systems, in removing the logs from the stump to the yards.

Where the yarding is done with machinery the logs have to be

hauled in by wire ropes or cables, and the hauling must be done in practically straight lines from the stump to the yard. This results inevitably in the breakage of much young growth, especially near the yard, where everything may be destroyed.

Oftentimes the cutting and yarding of the timber are done only after snowfall. When this is the case, seedlings growing on the smaller skidding trails may escape entirely uninjured and the loss to saplings is less. At the present time the tendency is to do the cutting and yarding in the fall before there is much snow on the ground.¹

The yarding of the logs onto skidways still leaves the timber in the woods. It does not pay to drag the timber great distances, and it is desirable that the haul to a skidway should not exceed one-quarter of a mile.

The next step is to take the timber from the yards to the mills. Ordinarily, the mills are comparatively large, stationary, well-equipped plants, located on railroad lines, on rivers navigable for ocean-going vessels, or at falls on drivable streams. Many of the mills are outside the boundaries of the spruce region, a hundred miles or more away from the forest. The factor which makes possible this location of the mills distant from their source of supply is the comprehensive network of lakes, ponds, and drivable streams, covering the spruce region, especially the Maine section of the region, as will be seen by a glance at a large scale map of northern New England. The Connecticut in New Hampshire and Vermont, the Aroostook in New Hampshire and Maine, the Kennebec, Penobscot, and St. John in Maine are the important outlets for this water system; and on these streams, at falls and railroad intersections, the principal mills are located.

Owing to their natural advantages and to the thoroughness and system with which these waterways have been developed for log driving, it is far cheaper to locate the mills well outside the

¹ In logging poplar for pulpwood the trees are cut in the spring and early summer, when they peel easiest. As the logs do not drive well they are transported on sleds or railroads to the mills wherever this is possible.

forest and drive the logs to them than to have the mills within the forest and ship out the manufactured product.

In portions of the forest close to a drivable stream it is possible to yard the logs directly to the stream bank, but on the land further back it is necessary to haul from the various skidways to the stream. These skidways are always located on the main hauling roads, which are laid out very carefully, so as to give a continuous level or down-grade haul to the stream. They

Fig. 86. — Old field spruce type. Stand 5 years after thinning. Where the cutting was heavy a thick growth of berry bushes sprang up preventing the reproduction of softwoods.

are carefully cleared and graded, but not surfaced, as the hauling is to be done on the snow. When the winter's snow comes, these roads are broken out and iced (sprinkled with water, which freezes), giving a smooth, hard surface on which large loads of logs can be hauled by a single team of horses. The hauling is done on double-truck sleds, and is known as "two-sledding."

The logs are landed on the bank or the icy floor of the stream, to remain until the ice breaks up in the spring, when they are "driven" down to the mills. Out of every little drivable stream

and pond may come a few logs. These small additions accumulate and when the "drive" reaches the main river it may total millions of feet.

As many owners of logs are represented in the drive on a single large stream it is manifestly impossible to keep the logs owned by each man separate. To save expense, log-driving associations have been incorporated, whose function it is to handle all logs on a drive over a given route, and charge the individual owner *pro rata* on the amount of timber driven. Each owner stamps his logs with a distinctive mark, so that a given lot of logs can be sorted out from the others whenever desired. The establishment of these associations has been instrumental in lessening the cost of driving.

Another method of taking logs from the skidways to the mill is by rail, where a tract is conveniently situated with reference to an established railroad line. There has been no general introduction of logging railroads, built especially for logging purposes, as is frequently the case in other parts of the country. There are, however, a few examples of logging railroads mainly in places where river driving is unusually expensive, or impossible. This method of transportation for softwood logs will never, under ordinary conditions, take the place of river driving.

The natural advantages favoring cheap river driving are one factor but not the only one against construction of logging railroads. Another reason is that the stands of timber do not average high enough per acre over large tracts to justify railroad building. Were there extensive areas to be stripped clean the stand of timber might be heavy enough to justify such an investment, but with the selection type of forest prevailing, the timber is too light for railroad logging. In some sections of the United States an incentive to the construction of a logging railroad is found in the fact that after the timber is cut the land may be used for agriculture and the railroad may develop into an ordinary common carrier. In the spruce region this is not true, because the soil is essentially forest soil, with no possibility of extensive, permanent agriculture.

One silvicultural advantage of the presence of a railroad is that it enables the owner to market his hardwoods. These cannot be driven on account of their weight, and are, therefore, unmarketable where driving is the only method of transportation. On the other hand, a railroad nearby tends to encourage heavy cutting and even the stripping of the land, and increases the danger of fire. Heavy cutting is not desirable as a whole in the spruce forest. The cheapness of the logging, where river driving is used, makes it possible, even in the case of a small cut per acre, to leave the small trees standing for further growth.

In the Vermont section there are more permanent railroads at present and hence the opportunities for rail transportation of logs are relatively better than in the New Hampshire or Maine sections.

In summary it may be said that the presence of a railroad as a common carrier is desirable, but the presence of special logging railroads with their demand for an exceptionally heavy cutting is a disadvantage from a forestry standpoint. A railroad of the first type offers the owner a chance to sell his hardwoods, but as he is not financially interested in the railroad, and as the railroad will be there permanently and does not depend on log carrying for its main revenue, there is no insistent pressure to strip the land.

Market Conditions. — The spruce region is essentially a timber-exporting region. The lack of agricultural land and the scarcity of its permanent population prevent any large internal demand for forest products, but it is excellently located for exporting purposes. The market lies naturally to the south, for on the north is the Canadian boundary, with a rather sparsely-settled country, with an abundant supply of spruce. To the south are the numerous manufacturing cities of New England, and the district surrounding New York City — distant only one hundred to three hundred miles from the mills of the spruce region. This southern territory is not only very thickly settled, but it also is an important manufacturing section, calling for all sorts of forest products.

The effective network of waterways bringing the logs from the

forest to the mills advantageously located on railroads or navigable streams, has already been mentioned. The favorable location of the mills needs further emphasis, however. Throughout the Maine section of the region the mills are many of them so situated that they can ship directly by vessel to Atlantic coast points, and also to foreign countries. The railway system of New England provides quick transportation from the mills to inland points.

The demand for spruce, the principal forest product, whether in the form of lumber or as pulp, is in excess of the supply. The area in the United States capable of producing spruce to best advantage is comparatively limited, and as the timber has high technical value, both for lumber and pulp, there is no doubt that a constant demand for the wood will continue.

The forest products shipped from the spruce region are lumber and pulpwood, and special products used in various manufacturing plants, such, for example, as bolts of yellow and paper birch for spools and bobbins. The region is too far from markets to make possible the sale of cordwood on any extensive scale.

Industries. — Usually each forest region has some one or several industries dealing with forest products. These industries may be found only in that particular forest region, or may be best developed there, though occurring in other regions.

As a forest region is separated from adjacent territory mainly on its differences in forest growth, and as different timber species are best suited for various different uses, the development of an industry, typical of a forest region is simply the logical commercial expression of the forest.

Pulpwood. — In the spruce region the production of pulpwood is the typical industry, and it is the leading region for the production of spruce and poplar pulpwood.¹

¹ In this connection it should be noted that the Adirondack section of New York state which is a great pulpwood producing region is naturally a part of the spruce region. The figures given here are given for the New England portion of the spruce region, with the recognition, however, that the Adirondack section is naturally a part of the same forest region and should be included to show the true place of the region in relation to this industry.

The only other sections of the United States producing spruce pulpwood in large quantities are the Lake States and the Virginia, West Virginia, and North Carolina portions of the southern Appalachians.¹ Neither of these sections approaches the spruce region in importance, either in the production of spruce or poplar pulpwood. The figures in the following table serve to show the importance of the pulpwood industry in the spruce region.²

PULPWOOD CONSUMPTION IN THE UNITED STATES FOR
THE YEAR 1909.

	Num-ber of mills.	Cords of pulpwood consumed.				All other woods.	Total.
		Spruce.		Poplar.			
		Domestic.	Im-ported.	Domestic.	Im-ported.		
New England States ³	64	756,088	286,654	121,824	5,050	130,242	1,299,858
New York State	90	384,883	408,719	52,797	17,547	57,936	921,882
All other states	99	512,278	72,959	128,255	3,025	1,063,350	1,779,867
Grand totals.	253	1,653,249	768,332	302,876	25,622	1,251,528	4,001,607

³ The amount consumed in Vermont by species is not included here as it is in the census figure included under "all other states." For *all species* the consumption in Vermont is 70,977 cords.

In the table above the United States has been divided into three portions, the New England States, New York, and all other states. The first two divisions taken together represent the spruce region. It will be noted that the figures relate to the pulpwood consumed in the mills rather than to the amount cut in a state. Figures to show the latter are not available. For our purposes it is of little importance whether the pulpwood consumed in a given state was cut there or not, so long as it was cut in the same forest region. It may safely be assumed that practically the entire amount of domestic spruce and poplar pulpwood

¹ Oregon produces a small quantity of western spruce pulpwood.

² The figures in this table are compiled from the publication issued under date of May 19, 1911, by the U. S. Bureau of the Census, entitled "Forest Products of the United States, 1909."

consumed in the New England States (as well as in New York State) was cut in the spruce region. The imported spruce and poplar pulpwood consumed in the New England mills of course cannot be credited to the cut of the spruce region, coming, as it does, largely from Canada.

Omitting the imported pulpwood from the table leaves a total consumption of 3,278,630 cords of pulpwood cut in the United States. The New England States produced 1,079,131 cords, and New York State 495,616, making a total of 1,574,747 cords for the spruce region. This is nearly 47 per cent of the total production in the country. When only spruce and poplar are considered there is a total consumption of 1,956,125 cords. Of this amount, 877,912 cords were consumed (presumably also produced) in the New England States, and 437,680 cords in New York State, giving a total of 1,315,592 cords for the spruce region, or over 67 per cent of the total production.

Lumber Industry. — While the production of pulpwood may be considered as the typical forest industry, the cutting of wood for use in the form of lumber holds first place in the annual amount of product. This is the leading forest region of the country for the production of eastern spruce and balsam fir lumber. The following table gives the amount of these timbers cut in 1909:

PRODUCTION IN THE UNITED STATES OF SPRUCE AND
BALSAM FIR FOR LUMBER — 1909. (See note 2 on page 244.)

	Feet, board measure.	
	Spruce (Eastern). ¹	Balsam.
New England States.....	834,479,000	72,781,000
New York State.....	127,864,000	
All other states.....	536,204,000	35,921,000 ²
	1,498,547,000	108,702,000

¹ Approximately 286,045,000 feet, board measure, of western spruce were cut in the Rocky Mountain and Pacific coast states.

² The cut of balsam in New York is included in this total.

The New England States furnish nearly 56 per cent of the eastern spruce and 67 per cent of the balsam fir cut for lumber. A little of this timber undoubtedly came from the northern hardwoods region. Besides spruce and balsam, such species as beech, maple, birch, basswood, and hemlock are cut for lumber; but as all occur commercially in some of the other New England regions it is difficult to give definite figures for the amounts cut. The census figures are for whole states, and where a species is important in two or more forest regions in the same state it is difficult to distinguish between them. Approximately, 466,000,000 feet, board measure, of the above-listed species were cut in Maine, New Hampshire, Vermont, and Massachusetts in 1909, of which possibly half, or 233,000,000 feet, board measure, came from the spruce region. For none of these species was the spruce region a large producer, as the output in other forest regions greatly exceeded this amount in the case of each species. Besides these species Maine furnished 15,140,000 feet, board measure, of cedar, and various other species are estimated to add at least 3,000,000 feet, board measure, more.

The total amount of all species cut in 1909 for the portion of the spruce region in New England, was 1,158,400,000 feet, board measure, but to obtain the total for the whole region the New York cut must be added. This amounts to a round 300,000,000 feet, board measure, for all species, giving a total for the region of 1,458,400,000 feet, board measure, or a little over three per cent of the whole lumber cut of the United States.

It is interesting to compare the amounts used for lumber and pulpwood. This can best be done by converting the cords of pulpwood into terms of feet, board measure. A commonly used allowance for a cord of pulpwood is 600 feet, board measure. Using this figure the cut of pulpwood in the spruce region equals 902,262,000 feet, board measure, or a little more than 60 per cent of the volume of the lumber cut. If spruce and balsam lumber only are considered an amount equal to 66 per cent of the lumber cut for these species is cut as pulpwood.

The comparative desirability, from the standpoint of forestry,

of the two industries (pulpwood production and lumber production) should be noted. The lumber industry, preferring the larger sized, clearer material, and seeing little or no profit in small knotty logs, tends to leave lands lightly cut. This is not always so; but usually lands cut for lumber are left in better condition than lands logged for pulpwood. The pulpwood operator can profitably use smaller, defective, and more knotty trees than can the lumber operator. As a result of this fact a winter's cut is sometimes disposed of partly to the pulp mills and partly to the sawmills, the former taking the smaller, defective logs, the latter the butt logs and better portions of the trees. The pulp concerns, however, do not aim to accept culls in this way.

Thus the pulpwood operator is encouraged to cut his lands more closely than the lumberman. Owing to the small-sized trees which can be used, there is all the more need for conservative and scientific handling of lands by the pulp men. Emphasis has already been placed on the fact that, in the selection forest of the spruce region, heavy cutting as a whole is undesirable, so that from this standpoint, the lumberman is to be preferred to the pulpwood operator. However, there are other points to be considered. The ability of the pulp man to utilize small, rough, and defective sticks may be silviculturally an advantage. The pulpwood operation may be utilized to remove undesirable defective trees, to make thinnings in too thick groups of young trees, and in disposing of material in the tops of felled trees, which would not be merchantable for lumber, thus reducing the fire danger. Again, the pulpwood concern, owning its own lands, usually has a heavy investment in a pulp mill which can be made profitable only by a long period of use. Thus the continued production of pulpwood on its lands may cause it to handle the lands more conservatively than a neighboring lumberman, who, having a relatively small investment in equipment and plant, is apt to think more of immediate profits and less of continued production.

Where both operators desire to handle their lands on forestry

principles the pulpwood operator should have an advantage owing to his ability to utilize small and poor material. Where neither are thinking of conservative treatment the lumberman is apt to leave the lands in best growing condition.

Special Woodworking Industries.—A record of the industries using forest products which are characteristic of the spruce region would not be complete without mention of those using paper birch. This tree has a restricted commercial range, extending through the southern portion of this region in Maine, and the eastern side of the White Mountains in New Hampshire.¹ Within this range it is a commercially important species, being used for the manufacture of spools, shoe pegs and shanks, toothpicks, toys, and novelties of various sorts. For many of these articles no other wood so far tried has given as good results as paper birch, owing to its clean white color, relative softness, ease of turning, and even texture. The amount used annually is not large, but practically the entire cut of the species occurs here, and the industries using the wood have not as yet developed extensively elsewhere. The annual cut of the species has been estimated at 80,000 cords, or 32,000,000 feet, board measure. The location of the belt of paper birch near the southern limit of the spruce region brings it into a more settled country, with better transportation facilities than the average. As a result, partly of this condition and also of the scattered nature of the paper birch timber with a low average stand per acre (see map),¹ the mills handling the wood have a small average capacity.

There are four chief products into which the paper birch is manufactured, named here in order of size of annual output: spools; novelties, toys, etc.; shoe pegs and shanks; and, of least importance, toothpicks. The manufacture of toothpicks, shoe pegs and shanks, and spools requires wood of high grade, the highest quality being needed for the former and the poorest for the latter. Even for spools, however, the wood must be white (which excludes the reddish heartwood), sound, free from rot

¹ In Circular No. 163 of the United States Forest Service can be found a map showing the commercial distribution of paper birch.

and large knots. For toothpicks absolutely clear, straight wood is needed. The quality of the wood needed for these products causes considerable waste in the logging and makes the wood expensive. Besides the paper birch a little yellow birch is used for these products, and in other regions the gray birch, though with less satisfactory results.

A decidedly lower grade of paper birch may be employed in the manufacture of various novelties¹ and toys. Sometimes a novelty mill can utilize a large part of the waste left in manufacturing one of the other products, thus utilizing the knotty wood and the red heartwood. Inasmuch as low-grade wood is often permitted in the manufacture of novelties other species, as yellow birch, beech, and maple, of a lower technical value than paper birch are employed.

These minor industries all aid in utilizing the hardwood species, and, where (as in the manufacture of novelties) they can use wood other than that of the highest grade or best species, are a valuable aid in forest management. The use of poplar for excelsior is another small industry which can be of assistance in forest management. The amount of wood cut for this purpose in New England is not large. Spruce and balsam are used to a small extent for slack cooperage staves.

Summer Resort Business. — The summer resort industry which may so strongly affect forestry, and be affected by it, deserves consideration. Such interrelation between forestry and this business may not exist in every section of the country, but in this territory it is certainly important.

The fact that the spruce region throughout its entire extent, from the Adirondacks on the west, through northern Vermont and New Hampshire into northern and eastern Maine, is a well-developed and popular resort for summer tourists, hunters, and fishermen, is too well understood to need elaboration. It is a business which brings in large amounts of money annually to the local communities, and is a chief source of livelihood to many of the inhabitants.

¹ Under the name of novelties are included all sorts of small wooden knickknacks.

The region owes its attractiveness for the tourist to its climate, its rough and varied topography, its water, the fish and game inhabiting the forest, and its forest cover. Of these five the one most easily and visibly affected is the forest cover, and it certainly is not the least important of the five attractions. From the standpoint of the tourist this forest cover should suffer no injury, but should be kept in an untouched virgin condition, preserving all of its original beauty. Since, however, the forests of the spruce region constitute one of its chief natural resources, they cannot be allowed to lie unproductive. It is here that forestry can arrange a compromise between simple exploitation, which, in the long run, would decrease the possible value of, if not entirely destroy, this natural resource — and preservation for æsthetic purposes, which also would keep the forest unproductive. Through conservative cutting and especially through proper protection from fire, the forest can be made to produce timber crops and at the same time be kept æsthetically attractive. Thus forestry will enable both lumbering and the summer resort business to utilize the forest for their widely different purposes.

On certain situations, such as the tops of high mountains or on the slopes of picturesque ravines, it may be advisable to keep the forest untouched, simply from the æsthetic standpoint, since the value of the forest here as an addition to the scenery may far outweigh its lumber value. The slopes of the Crawford Notch, to be acquired by the State of New Hampshire, furnish an illustration. This forest should either be kept untouched or culled of the dying and defective trees in the lightest possible manner.

Undoubtedly the desire to cater to the summer tourists has created a strong sentiment in the region for fire protection. Fire damages the appearance of the forest even more than the worst lumbering. Throughout the White Mountain section of New Hampshire, the sentiment is especially strong to prevent fire injury to forest scenery, for it is in this section that the summer resort business has been most highly developed.

Wherever men directly interested in the business own forest

lands they have been influenced to cut more conservatively and to secure adequate protection.

Character of the Land and Timber Ownership. — The character of the ownership of the land and timber in a forest region is always of interest from the forestry standpoint, since it often has a bearing on the methods of management which may be employed. Usually conditions of ownership differ widely in the several forest regions and in a way serve as a distinctive characteristic of a region.

The region under discussion is characterized by the large size of the individual holdings as compared to the other portions of New England. There are a number of holdings comprising several hundred thousand acres apiece, and holdings of from 20,000 to 100,000 acres are numerous. A large part of the land, however, is owned in small holdings of less than 1000 acres in extent. The proportion of large to small holdings is greatest in the Maine section and smallest in the Vermont section. Figures showing the character of the ownership are not available for the entire region. For the New Hampshire portion, however, data secured in 1903-4 by the United States Forest Service,¹ are available, and are here given to show the approximate areas owned by different classes of landowners in northern New Hampshire in that year.

Lumber companies.....	400,000 acres
Pulp and paper mills.....	500,000 acres
Agricultural land.....	244,000 acres
Hotel companies.....	28,000 acres
Small holders of forest land.....	756,000 acres
Total.....	1,928,000 acres

These figures cover approximately the New Hampshire area in the spruce region. It will be seen that small holdings form the largest single class, but that lumber companies combined with pulp and paper mills own a larger acreage. New Hampshire stands midway between the Vermont and Maine sections in per cent of small holders, and undoubtedly for the whole

¹ See Bulletin 55, Forest Service, United States Department of Agriculture.

region the ratio of acreage of small holdings to large ones is much below that indicated in the figures given.

Besides such large owners of land as lumber companies, pulp and paper concerns, should be added in Maine another class of large owners, namely, individuals or companies owning timber land, but not themselves operating the lands. They are owners who sell stumpage and in the Maine section are an important class of owners. Formerly the number and relative importance of this class was greater than it is to-day. In fact, the trend of ownership is away from individuals who hold stumpage toward corporations who conduct their own logging operations. As a rule the timberland owner selling stumpage should be inclined favorably toward conservative cutting. He desires to secure a steady income (received often periodically) from his timberlands and to do this must cut conservatively. He does this in ordinary practice by specifying in the logging contract a diameter limit below which size trees may not be cut. This is, of course, a crude method of securing proper cutting, but it serves as an indication of the right attitude. As knowledge of the proper and practicable methods spreads it is to be expected that owners selling stumpage will improve their selling contracts. The difference in attitude between the ordinary lumberman and the pulp and paper mill has been discussed already under "Industries." The tendency is for the holdings of pulp and paper mills to increase, by the absorption of lands belonging to lumber companies.

The area of 28,000 acres listed as owned by hotel companies in northern New Hampshire is worthy of mention, because this class of owners is increasing. Their control means either reserving the forest for its scenic value without any cutting or an extremely light and conservative culling. In the latter case they become an extremely desirable class of owners.

Another thing characteristic of land and timber ownership in the spruce region is that the ownership of the land and of the timber usually lie with the same person or company. Ownership of the land by one party and of the timber by another is an

uncommon arrangement in the region, although of frequent occurrence in some other forest regions. It is true that a timberland owner will frequently make a sale of a certain amount of stumpage or the stumpage on a given tract. This sale ordinarily is for immediate cutting, usually the same year as made, and is not comparable with the condition where for a long series of years the ownership of the land and of the timber is vested in two different parties.

There is practically no reversion of land to the state for non-payment of taxes, which is so common in certain parts of the country. This condition occurs usually on lands which are heavily lumbered and stripped of all valuable growth. It is uncommon in a forest of a selection type. In the forests of the spruce region, unless repeatedly burned, there is either something of value left on the land, or reproduction will start there. Thus the productive power of the land remains even after heavy lumbering, lessened, to be sure, by improper methods of cutting, but still there.

Another reason that no land is abandoned is that taxation on cut-over lands and timberlands is not so excessive as, for example, in the Lake States, and the owner is therefore not forced to strip his land.

The individual states own an insignificant amount of land in the spruce region as is shown in a later chapter. As a result of the passage, in 1911, of the law permitting the creation of National Forests in the Appalachians and White Mountains, it is probable that the Federal Government will become an owner of land here.

These national forests will be largely in the White Mountains and presumably will be handled so as to produce timber, but with special care to maintain the protective function and æsthetic value of the forest.

FOREST PROTECTION.

The principal agencies damaging forests and against which protective measures are often necessary are forest fires, grazing animals, insects, and fungi. Each of the four will be discussed here in their relation to the forest of the spruce region.

Forest Fires. — The general effects of forest fires have been stated in the chapter on that subject. All classes of fire injury as there described may be found in this region. Owing to the nature of the soil on many sites (usually slopes), consisting of a thick layer of duff immediately underlaid with loose rocks or a thin layer of mineral soil, injury to the soil is especially marked.

By permission of the U. S. Forest Service.

Fig. 87. — A steep slope once clothed with merchantable timber, but now stripped of humus and soil by forest fires.

Undoubtedly the greatest damage is done on such situations where a fire entirely consumes the duff and soil, leaving the bare rocks, which may lie unproductive for centuries.

The three kinds of fire, ground, surface, and crown fires, all occur; ground fires being the most typical, because common here and not ordinarily found in other New England forest regions, where the accumulations of duff are much thinner. The dangerous season is in two periods, beginning in the spring as

soon as the snow disappears and lasting until the green foliage is well out. In ordinary seasons this is from the latter part of April until well into June. The second danger season is the early fall after the leaves have dropped from the trees and before snow comes, usually from early in September until well into October. The distribution of the rainfall controls the season of fire damage. An early spring with little rainfall may cause the fire season to open early, and if the rain continues scanty may make dangerous conditions all summer. The season of 1908 furnishes a good example of this. In the report of the Forest Commissioner of Maine for 1907 and 1908, he says, speaking of the season of 1908: "The dry season began early in May and extended until October 27th, during which period there were not more than three weeks when forest fires would not run." Such a condition is unusual and does not occur on the average once a decade.

The following table illustrates the effect of drouth in increasing forest fires:

FOREST FIRES IN THE SPRUCE REGION OF MAINE FOR THE YEARS 1907-1910.¹

Year.	Number of fires.	Acres burned over.	Average area burned over per fire, acres.
1907.....	16	2,124	133
1908.....	126	98,691	783
1909.....	68	27,083	398
1910.....	18	267	15
Total.....	228	128,165	
Annual average.....	57	32,041	562

¹ This table is compiled from the seventh and eighth reports of the Forest Commissioner of Maine. The unincorporated towns of Maine have been taken as making up the spruce region of Maine.

What is most significant in bringing out the relative increase of damage done in a dry season is the large area burned over by the average fire in 1908 as compared with 1907, 1909, and 1910. In 1908 the area burned over averaged 783 acres per fire, as

against 398 in 1909 (which was second to 1908 in dryness), 133 in 1907, and only 15 acres per fire in 1910.

The number of fires annually reported is remarkably small, but the numerous small fires just starting, which have been extinguished by patrolmen are not included.

As a matter of fact the spruce region is by nature better protected from forest fires than many others. The rainfall is ample and normally so distributed that long, severe droughts are exceptional. This rainfall and the cover of moss and duff keep the forest floor in a moist condition unfavorable to the spread of fire. It is only in times of drouth, or when the forest floor is aided artificially in drying out, that severe fire danger threatens, as when lumbering has opened up the forest and let in added light and heat. Even in a season with abundant and well-distributed rainfall, land heavily cut over may be dried out sufficiently to burn easily. Of course the slash left by the lumberman increases the amount of inflammable material on which a fire may feed.

In ordinary years the forest fires all arise on cut-over lands, stands of uncut timber being practically immune, since they are too moist to allow a fire to start. A crown fire, however, may run through a virgin forest if it secures a good start on cut-over land and there is a strong wind. The damage to merchantable standing timber is ordinarily small, the chief injury (beside damage to the soil) being to young growth. Cut-over lands in the spruce region usually have at least a fair stocking of young conifers from seedlings up to trees just under merchantable size. The fires destroy all these, and change the condition of the forest floor so that it no longer offers a favorable germination bed for the seed of spruce and balsam, but is best for the reproduction of bird cherry, mountain maple, and berry bushes among worthless species, and the valuable aspen and birch. If these latter could always be counted on to thoroughly seed up burned lands without delay, the damage done by the fires would be greatly reduced, but unfortunately they do not.

The principal known causes of forest fires are in the order of

their importance: first, carelessness in burning brush in clearing land; second, sportsmen of various sorts, such as campers, fishermen, and hunters; and third, railroad locomotives. In the Vermont section, railroad locomotives are the cause of only a small percentage of the fires, owing to the fact that the railroads traversing this portion of the region are not adjacent to extensive wooded areas — a narrow belt of agricultural land along the valleys intervening between the railroad and the forest. This is true to a lesser extent in the New Hampshire section, but in Maine many railroads run for considerable distances through woodland.

At the present time, methods of securing data on forest fires lack the highest efficiency, and a large per cent of the fires reported are attributed to "unknown" causes. As the state organizations for reporting fires become thoroughly organized and trained this class of fires should be reduced to a small per cent of the total. If the unknown causes were discovered the number of fires set by sportsmen would undoubtedly be greatly increased, and it is believed would take first place in the region.

Statistics on fires in the spruce region will be found in the Appendix under "Forest Fire Statistics."

Methods of Fire Protection. — The best method of fire protection for the spruce region consists in a combined system of mountain lookout stations and patrolmen, maintained by the coöperation of the states involved, individual timberland owners, and the federal government.¹ A network of telephone lines to all parts of the territory is necessary. The forests of the spruce region have been lumbered for so long a period, and the selection character of the forest allows so many and frequent returns to previously cut-over lands, that old roads, camps, and telephone lines cover the whole area. On many tracts all the telephone lines needed for protection have existed for years. Elsewhere new construction or repair of old lines is made easy by the improvements already existing.

¹ The coöperative arrangement between the states and the federal government is described in Chapter XVII.

The coöperative system of lookout stations and patrolmen is already established over the greater part of the region and is each year becoming more thoroughly organized and efficient. The details of the organization differ for each of the three states involved, Maine, New Hampshire, and Vermont, and are described in Chapter XVII.

Supplementing this system the use of oil or electricity for fuel on railroads running through timberlands is advisable; and the lopping of coniferous tops so that they lie in contact with the ground is often best.

The object of the lopping-off of branches from the tops of felled conifers, so that the top lies in close contact with the ground, is not only to prevent the danger of fires starting, but to lessen their severity when once started. A spruce or balsam top with the branches left on decays very slowly and is liable to burn readily for many years after cutting. If lopped it decays with comparative rapidity, due to its contact with the moist ground. In ten years after cutting all but the largest tops should have entirely disappeared. The danger of their burning is over in three or four years after the cutting.

Lopping is advised wherever the danger from fire is great, near railroads for example, where the cutting has been heavy and there are many tops on the ground, and where an owner is willing to spend something to secure the fullest protection.

The operators in the New York portion of the region are now required by a law passed in 1909 to lop tops. The law is enforced through the fire rangers, who are under the control of the Forest, Fish and Game Commission.¹ That the lopping has so far proved successful can be seen from the following quotation.²

“More recent operations also show results favorable to lopping. The brush is more closely packed upon the ground. This is true, even when it is found in piles as the result of many tops lying

¹ This is now placed under the New York State Conservation Commission.

² See article by John W. Stephen, State Forester, and published in the Fifteenth Annual Report of the Forest, Fish and Game Commission.

By permission of the U. S. Forest Service.

Fig. 88. — A spruce top improperly lopped. The top is still a fire trap.

By permission of the U. S. Forest Service.

Fig. 89. — The same top properly lopped, with all the branches taken off so that all portions are close to the ground in a position to decay rapidly.

together or when collected into piles in order to clear roadways for hauling to skidways, the piles are lower and occupy less room. They will come in contact with the ground more readily, retain the moisture more persistently and decay more rapidly. This shortens the time necessary to guard against fire and in case a fire gets started, the brush being lower, the fire is nearer the ground, men can approach it more closely, and it is less liable to communicate with the crowns of the trees and start a crown fire than it is when the piles are higher."

The lopping should be done at the same time as the logging in order to secure the cheapest results. Where done at this time the average cost should not exceed ten cents per cord of pulpwood cut, or fifteen cents per thousand feet of lumber. Oftentimes lopping results in an additional profit instead of an expense, because when lopping is done the loggers are apt to take a longer total length out of the tree and thus secure more timber for a comparatively small outlay. Pulpwood especially might be taken to smaller sizes than at present. With the ordinary mechanical process of rossing (removing) the bark to prepare the wood for the manufacture of pulp, sticks much less than four inches in diameter are wasted. If, however, newer processes of removing the bark, with the aid of water or steam, are employed, it should be possible to use sticks considerably under three inches in diameter. Cutting to a diameter limit of one inch less in the tops would mean that the tops left in the woods would be much smaller.

In a heavy cutting where the tops have to be thrown aside for roadways, the lopping may make the tops so much easier to handle that a saving is effected.

Lopping is not recommended for hardwoods, since hardwood tops rot much sooner than those of conifers.

The piling and burning of brush is often recommended as the best way to dispose of inflammable debris. This method is, however, wholly unsuited for use in the spruce region. There is too much young growth and reproduction on the ground which will be injured in burning the piles of brush. The ground actu-

ally burned over by the piles is usually left with the mineral soil exposed and is apt to seed up to poplar, birch, or inferior species instead of to conifers.

Fighting Fires. — In fighting fires in this region the most effective tools are shovels, axes, and pails. Practically the only way to stop a ground fire is to dig through the duff down to mineral soil, and as almost all surface fires here are apt to be accompanied by ground fires this is one of the commonest methods of fighting. A trench a foot or more wide cut through to bare soil will serve to stop a ground fire and the smaller surface fires. The fire should be entirely surrounded by the trench before it is left. If the fire fighters patrol along this line they can stop even a hot surface fire by throwing shovelfuls of dirt onto the fire where it threatens to cross. Beating the fire out with green branches or wet "gunny" sacks when it crosses the line is also effective.

Axes are needed to cut out roots or logs which cross the ditch and occasionally to fell a dead stub which might blaze up and scatter sparks. The pails are valuable wherever water is available and the application of water is always very effective. However, even when water is used a ground fire should be trenched, as it is almost impossible to be sure that such a fire has been completely extinguished.

A shovel or a tool of similar nature and an axe are essential for controlling a ground fire. If these tools are at hand or can be quickly secured much valuable time will be saved in putting out the fire.

From what has been said it is evident that the system of fire protection for an individual tract in the New England portion of the spruce region will have its basis in state or coöperative patrol and lookout stations, made effective by a complete telephone system. The individual owner should strengthen his protection by lopping tops on his holdings and may, if he wishes, add extra patrolmen to those employed by the central authority. He should develop the telephone system on his tract so as to thoroughly cover his territory, and should distribute supplies of

fire-fighting tools which can quickly be reached from any portion of the area.

Protection against Grazing Animals. — The spruce region is fortunate in being free from serious damage from grazing animals. Such animals are one of the commonest agencies working injury to the forests of the United States, but conditions here are not favorable for them. The forest is too unbroken in its extent and too dense in its character to afford good grazing. The settlers may turn out to pasture their few cows and horses but the injury done the forest by these animals is immaterial.

Protection against Insects. — The most destructive insect to standing timber is the spruce-destroying beetle (*Dendroctonus picaperda*). The habits of this insect, the injuries which it causes and the general methods of control have been discussed in the Chapter on Insects. Ten to fifteen years ago, the last serious attack made by this insect, of which there is a record, occurred in the upper Androscoggin valley in extreme north-western Maine. Through the efforts of Mr. Austin Cary, at that time forester for the Berlin Mills Company, the work of the insect was discovered and finally checked. Many fine bodies of timber had been killed, others were infested, and the beetle, left uncontrolled, might have destroyed all the merchantable timber in that section. By directing the logging operations into the areas containing the most dead and infected timber the beetle was finally checked and although by no means exterminated was so reduced in numbers as to be held in control subsequently by natural enemies.

The larch sawfly (*Nematus erichsonii*)¹ about thirty years ago destroyed practically all the large tamarack timber. This tree is now of secondary commercial importance and does not occur in large enough bodies to justify special efforts for its protection. On tracts situated close to markets it might be possible to remove the dead and infested trees and utilize them, but away from markets no special cuttings can be made.

The spruce-bud worm (*Tortrix fumiferana*)¹ is another

¹ See Chapter on Insects.

dangerous insect, although recently it has been more abundant in Canada than in New England.

Protection against Fungi. — Both *Trametes pini* and *Polyporus schweinitzii* attack various conifers in the spruce region. There is practically nothing that can be done here in the way of protection except to remove as much of the diseased timber as possible.

Watershed Protection. — In considering the subject of forest protection, watershed protection quite naturally has a place, as it is one of the most important functions of the forest. The fact is unquestioned, that a forest cover exerts a powerful protective influence in checking the rapid run-off of precipitation, in steadying the flow of springs and streams, and in preventing erosion.

The necessity for the forest cover as a watershed protector undoubtedly varies in the different districts, depending on such factors as climate, topography, soil, general location, and whether a substitute for the forest exists. In the region under consideration the need of a forest cover for watershed protection is not so urgent as in certain other parts of the country in spite of the fact that the region comprises the upper watersheds of all New England's chief rivers, which are largely used for power purposes and in their lower reaches are navigable. The effect of a forest cover in lessening the volume of floods and in equalizing the run-off through the year is here secured through the great areas of swamp and flat country on the upper reaches of the streams and by the large number of lakes. Many of these lakes act as reservoirs, their flow being controlled by gates. This lessens the effect of floods in the lower portions of the streams and assists in making the flow regular. In Vermont and in the White Mountain section of New Hampshire especially, the steep topography and lack of swamp land makes a forest cover of great importance in regulating run-off.

The soil, due to its texture and to the cover of moss and duff so commonly found, is not one which erodes badly, even after lumbering.

It is only on lands which have been lumbered and then *burned over* that the protecting soil cover is removed and danger of erosion caused. On such lands no serious damage need be feared unless the land slopes sharply, for it is on the steep cut-over and *burned-over* slopes of the mountains that the serious danger occurs. Such lands comprise only a small per cent of the total area and it is believed that the natural soil cover of moss, herbs, and shrubs, which will persist on lands cut clear but *unburned*, is a sufficient preventative.

In regulating run-off the forest is more satisfactory than a good soil cover of moss, assisted by herbs and shrubs.

There is no intention to minimize the high value of a forest cover in protecting watersheds as a general proposition, but it is important to emphasize the point that for the spruce region as a whole the forest, owing to existing conditions, is not a vital necessity for watershed protection.

SUMMARY.

1. This is primarily a forest region with an exceedingly high percentage of true forest soil, a timber producing and exporting region, now and for all time.

2. It is characterized by coniferous forests and possesses, due to the silvicultural character and adaptability to the region of its principal species, great growing and reproductive power which it is difficult to entirely destroy by careless treatment.

3. The land is chiefly owned in large holdings by concerns whose interests are leading them to hold the land indefinitely, to protect them and to cut conservatively.

4. It is a famous summer resort section, its fame being largely due, directly and indirectly, to the forest cover.

CHAPTER XIV.

THE NORTHERN HARDWOODS REGION.

GENERAL CONSIDERATIONS.

THIS region is a transition belt varying in width from a few miles to over forty, but with an average of less than twenty,

Fig. 90. — A general view of the country in the northern hardwoods region.

between the forests of the spruce region in the higher elevation and those of the New England white pine region in the lower elevations. On consulting the map on page 197, it will be seen that the region is in two sections, the larger extending through Maine, New Hampshire, Vermont, and Massachusetts, the smaller being a small area in northeastern Maine, in the famous

potato-growing section of Aroostook County. The underlying rock is limestone, which explains its separation from the surrounding spruce region with its rock of granite and gneiss.

Owing to the narrowness of the northern hardwoods region and to the fact that its principal species occur frequently in the two bordering regions, it is extremely difficult to locate the boundaries definitely in the field. Persons using the map should bear this in mind, remembering that the location is only approximately correct.

The topography is not rugged in nature but is usually hilly and presents relatively only a small per cent of level surface. In Vermont there is much steeply sloping land but in going northeast across the region into Maine the topography becomes much less hilly. Many of the hilltops, especially in parts of Vermont, have gently rounded summits. There are few large swamps in the region but small ones occasionally occur, often on the tops of the hills as a result of glacial deposits, which have dammed natural drainage lines.

From its location bordering the spruce region, it follows that none of New England's most important streams find their sources within its boundaries, but many of them cross the region from their upper sources in the other region.

There are comparatively few slow, gently flowing streams here. Most of them fall rapidly to the main rivers, but in the central portion of Maine and in Aroostook County there are a good many lakes and more sluggish streams. This is in the leveler portion of the region, where the topography and drainage conditions differ from the rest of the territory.

Elevations range up to 2500 feet above sea level. There are also a number of mountains of considerably higher elevation, but their summits support forests typical of the spruce region and should be classed as in that region. Minimum elevations of about 100 feet are found in Maine, but most of the region lies above 500 feet.

A considerable area is underlaid with rocks of a limestone nature, the marble quarries of New England being located in the

region. Granites and gneisses are, however, the chief kinds of bedrock.

The soils are mainly rich, sandy, or clayey loams, with alluvial deposits in the main valleys. They average deeper, have a higher fertility, and contain less loose surface rock than the soils in the spruce region. The soils are not, however, free from stones. In a large majority of cases the soils could be used for sheep grazing, if for no other form of agriculture, a fairly low per cent being true forest soil. The distinction between farm and true forest soil here depends chiefly upon the location of the site. Almost all the soils are fertile enough for agricultural use and the distinction can often be made correctly by considering the very steep slopes as forest soils and other lands as farm soil. The quantity of loose stone in the surface soil is another point to be considered in assigning land to its best use.

There is no data available for accurately giving the per cent of true forest soil. It is estimated that less than twenty-five per cent of the area can be so classified. At the present time the estimated area forested is fifty per cent of the total. In the rougher and higher portions, oftentimes, only ten per cent is cleared, while in the stream valleys seventy-five or eighty per cent may be cleared. Although much land of agricultural value is still forested, the per cent now forested is not likely to decrease until agricultural conditions change decidedly.

The forest is more broken in its distribution and is in less extensive bodies than that of the spruce region. The main stream valleys are almost always cleared, while the secondary streams on their lower reaches, where descending precipitately into the main streams, are apt to be forested. On the upper courses of these secondary streams a large per cent of the agricultural land is located, this being especially true of the Vermont section where frequently the rounded summits of the lower hills are cleared and furnish excellent farm land. Such a distribution of the cleared land may make the region appear to a traveler on the railroad as a very densely forested section, whereas if he could pass up one of the heavily wooded ravines and climb a

hill he would see a country dotted with cleared land and wooded areas.

The forest may be characterized as a mixed hardwood growth of tolerant trees. Conifers occur in small proportion only, usually as scattered individuals or on swampy lands, or abandoned fields. The greater part of the land now forested

Fig. 91. — The higher hills are wooded, while the upper portions of the valleys usually are cleared. Mt. Equinox, Vermont, in background.

has never been entirely cleared of its growth, but has usually been culled of the larger and better trees. This style of cutting assisted by the natural tolerance of the chief species has resulted in forming stands of uneven age, which is the characteristic form of the forest. Small bodies of virgin timber still remain.

Sugar maple is the predominant tree and finds here its optimum range in the United States,¹ alone forming from twenty-five to seventy-five per cent of the forest growth over considerable areas with a steadily increasing proportion. Beech and yellow birch are the two species next in importance; these three

¹ The optimum range for sugar maple occurs in Canada in the Province of Ontario.

trees together forming approximately sixty per cent of the forest. Spruce, hemlock, and white pine are the leading conifers. There is also some balsam and arborvitæ. Pure coniferous stands are of infrequent occurrence.

In the original forest some areas bore more spruce than at present, while other portions were originally all hardwood growth. The amount of spruce in mixture with the hardwoods has been decreased by cutting out the former.

Other common hardwoods are poplar, paper birch, basswood, and white ash. Red oak becomes of commercial importance in the Vermont, New Hampshire, and Massachusetts sections of the region. Black cherry and black birch occur mainly in the southern portions. Chestnut extends up from the regions to the south a little way into the northern hardwoods region in sufficient quantity to be a commercial species in the Massachusetts section.

FOREST TYPES.

As in the spruce region both permanent and temporary forest types are found. Of the five types recognized two are permanent and three temporary.

Permanent forest types.

1. Hardwood.
2. Swamp.
 - a. Hardwood swamps.
 - b. Softwood swamps.

Temporary forest types.

3. Birch and poplar.
4. Old-field hardwoods.
5. Old-field conifers.

1. *Hardwood.* — This is the prominent type, far exceeding in area all others combined, and being well distributed throughout the region. It occurs on a variety of soil situations, but is never found on swampy sites. The soils are usually of good depth and fairly rich and in many cases could be used for farming.

Indeed, the lands now cleared for farming, with few exceptions, were formerly occupied by forests of the hardwood type. In other cases the sites now occupied by the type are too rocky or steep to warrant their use for agricultural purposes.

Fig. 92. — The hardwood type in the Berkshires. A mature stand of yellow and paper birch, oak and a little chestnut. Excellent reproduction of white ash, birch and oak is already on the ground. The stand should be cut clear.

The hardwood type is almost identical with the same type of the spruce region, having much the same composition and occupying the same kind of site. But from being a type of secondary importance it becomes, in the northern hardwoods region, the

leading type. A similar relation can often be observed between types of two adjacent forest regions, one or more types being the same in each of the two regions, but their relative importance being vastly different from region to region.

Sugar maple, beech, and yellow birch are the chief trees, averaging together at least sixty per cent of the type (sugar maple, thirty per cent, beech and yellow birch together, thirty per cent), while beech and sugar maple in individual stands often greatly exceed the percentages given, sometimes occurring nearly pure. Other hardwoods constitute about thirty per cent, while conifers do not exceed ten per cent, sometimes being entirely absent, especially in the heavily lumbered stands. Hemlock is the most common conifer.

On account of the deep fertile soil an excellent quality of timber can be produced. In many cases, however, the best trees have been removed, leaving the defective individuals; thus, at present, there are many poorly stocked stands in the type, which are not producing the quantity nor the quality of timber of which they are capable.

Excellent reproduction occurs wherever any opening admits light to the forest floor, sugar maple, yellow birch, and beech all being prolific seeders. The maple excels the others, and is gradually increasing in proportion as a result of cutting and subsequent reproduction. White ash reproduces well after cuttings and like the maple is increasing in proportion. In second-growth stands after heavy cuttings some of the reproduction is of sprout origin, but the old hardwoods do not sprout satisfactorily when cut, and the younger trees are only average sprouters in this region.

The soil cover of deciduous leaves presents an unfavorable condition for the reproduction of conifers, hemlock being the most successful. This is the main reason why the proportion of conifers in the type decreases after a cutting. Both the even-aged and the uneven-aged forms of forest occur in the hardwood type. The virgin stands and those which have been culled over one or more times approach the uneven-aged form. Areas on

which clear cutting or a very heavy cutting has been practiced are now stocked with approximately even-aged stands. In some cases such stands are extremely regular and even-aged in form.

2. *Swamp*. — This is not a type of large area and is of only minor commercial importance. The name indicates the character of the site on which the type occurs, the most unfavorable for tree growth to be found in the region. The type may be divided into two sub-types: (a) hardwood swamp, and (b) softwood swamp.

(a) The hardwood swamp is the more important of the two. Originally there were some conifers in most of the swamps, but cutting has excluded them from many stands. Black ash and soft maple are the most abundant and important hardwoods though neither of them can be classed as high-grade timber trees; and the excessive water supply prevents the best growth. Reproduction is poor and confined largely to sprouts.

(b) The softwood swamp is similar to that of the spruce region, except that it contains a greater per cent of hardwoods. Spruce, balsam, and tamarack are the chief conifers. *Arborvitæ* is not a common tree in this type. With the softwoods there is a mixture of black ash, soft maple, and other hardwoods. The conifers here originally furnished considerable merchantable material, but they have been largely removed and hardwood reproduction rather than softwood has followed. It is much harder for softwoods to reproduce in the swamp type here than in the spruce region, because of the large percentage of hardwoods in the stand, resulting in unfavorable seed-bed conditions for the conifers.

3. *Birch and Poplar*. — This temporary type is similar to the type of the same name in the spruce region, but is relatively of much less importance in this region. Its distribution does not depend on any particular kind of soil or situation, but on the location of burned-over areas. A recent burn with the mineral soil exposed and plenty of light admitted is apt to reproduce to stands of this type, which are composed chiefly of paper and yellow birch and poplar. Under these intolerant

species with their light shade reproduction of sugar maple and often of hemlock and spruce, if seed trees are present, soon takes place. Finally with the maturity of the paper birch and poplar the sugar maple comes into control, though usually the yellow birch in the stand persists with the maple. The reversion from the birch and poplar type to the original hardwood type is then complete. The sugar maple and hemlock play a part identical in principle with that played by spruce and balsam in the spruce region. There it will be remembered the birch and poplar type was slowly reproduced to spruce and balsam and finally reverted to one of the original and permanent types. In the northern hardwoods region, sugar maple and, to a limited extent, hemlock accomplish the same end. The birch and poplar type is even-aged in form.

4. *Old-Field Hardwoods*. — This type occurs on lands once used for agriculture and now abandoned. It is important since there are large areas in the aggregate of land formerly cultivated.

The composition is of mixed hardwoods, particularly hard maple, yellow and paper birch and white ash. Oftentimes pure stands of maple or birch are seen, and the species do not differ materially from those in the hardwood type, except for the absence of the heavy-seeded beech, whose seed is not easily scattered over the open fields. The proportion of white ash is often greater than in the hardwood type. The stands of old-field hardwoods are all young or middle-aged, for two reasons; first, because most of the so-called abandoned farm land was abandoned within the last fifty years, and second, because stands of this type, as they pass middle-age resemble more and more the original hardwood type, and often cannot be distinguished from it. They are more even-aged in form than a repeatedly culled stand of the hardwood type, but this distinction may not serve to separate them from stands of the hardwood type which have been heavily cut. Indeed, an old field may seed up very irregularly and present from the beginning the appearance of an uneven-aged stand. In most cases there is little if any practical advantage in keeping the two types separate except

for the first forty to fifty years of the rotation. Older stands should be considered as belonging to the hardwood type.

Fig. 93. — An old field which seeded up to hardwood and now contains an irregular stand of yellow birch, cherry and maple. The larger trees should be cut. (Liberation cutting.)

5. *Old-Field Conifers*. — This is another old-field type, not so important in area as the previous one, but of considerable value, due to the coniferous timber which it furnishes. This type is found only in the higher portions of the region where the soil is apt to be less thoroughly drained than is that on which the old-field hardwoods occur. Spruce is the principal conifer in the type, often forming pure stands and occupying most of the

acreage. Tamarack, hemlock, and, in northern Vermont, arborvitæ and white spruce occasionally seed up the old fields; and stands of white pine also rarely occur. It may seem strange that, in a region so dominated by hardwoods as this one is,

Fig. 94. — Old highway and field seeding up to spruce.

pure stands of conifers should occur on the old fields, but their presence is made possible by the change in seed-bed conditions. In the absence of the thick layer of hardwood leaves, favorable conditions for coniferous reproduction often exist on the old fields.

The type is only temporary for no pure stand of conifers can maintain its existence in the region if the natural forces are left undisturbed. As soon as openings appear in the stand, and

sometimes even before, seedlings of sugar maple and other tolerant hardwoods spring up. They prevent softwood reproduction and will finally cause the type to revert to the hardwood type.

METHODS OF HANDLING THE FOREST.

Both intensive and extensive management can be practiced in the northern hardwoods region. There are more opportunities for intensive methods than in the spruce region, owing to the broken distribution of the forest, interspersed by farms, and the greater local population. Much of the territory, however, is so situated that only rough methods are yet applicable.

In management a few of the more valuable hardwoods and those best adapted to the site should be favored. An effort should be made to increase their representation as compared with the inferior species.

The trees to favor are sugar maple, white ash, yellow birch, basswood, and red oak where it occurs. Beech is a less desirable tree.

The greater part of the territory will have to be kept under hardwood forest for the present generation at least. In the sections where intensive methods are possible it may be advisable to gradually change the most poorly stocked portions of the forest from hardwood into coniferous stands. This can only be done by planting. While the hardwood species now dominating the forest (sugar maple, yellow birch, and beech) are well adapted to the site and reproduce excellently, they are not rapidly growing trees and do not furnish timber of such high average value, nor as large yield per acre, as such species as white pine and spruce, which could be planted.¹ White ash and basswood are rapid growing species and their lumber is in demand for certain industries, hence special care should be taken to encourage them in preference to all other hardwoods. They are recommended for extensive planting. White pine, Norway spruce, and European larch are the conifers relied on for general planting. There will

¹ See Chapter on Planting, where a fuller explanation of the advantages of conifers over hardwood trees is given.

be a comparatively small demand for species adapted to sterile, sandy sites, as little of such land occurs in this region. Norway pine can be advantageously mixed in the plantations of white pine as a precaution against the various enemies of the latter. European larch is another good tree for planting on the well-drained, fertile soils of the hardwood type.

Naturally the first sites planted will be the vacant fields not now used for agriculture. When this class of land is stocked the

Fig. 95. — A field in Vermont on which shifting sand is encroaching. The sandy lands from which the sand comes should be fixed by planting.

planting of poorly stocked hardwood land, where handled intensively, can be started. The method of planting this class of land, using only a few hundred plants per acre, is described in the Chapter on Planting.

1. *Hardwood*. — In handling stands of this type the selection system will give satisfactory results. The species to be favored (ash, sugar maple, yellow birch, basswood, and red oak) are easily managed under this method, as they are either very tolerant or fairly so. Ash is the least tolerant of those men-

tioned. Moreover, they all reproduce well in small openings such as would be made by a selection cutting. The cutting can be based on a diameter limit of, say, twelve inches breast high, but the trees to come out should be carefully selected and marked without strict adherence to this limit.

Such a system can be used in the most remote sections of the region. Where markets are better a thinning among dense, even-aged clumps of middle-aged growth should accompany the

Fig. 96. — Open land too ledgy for pasture in the northern hardwoods region; should be planted.

selection cutting. All large trees so defective as to be of no timber value should be cut and put into cordwood. Under present methods of cutting, these trees are ordinarily left where they take up much of the crown space and greatly reduce the growing power of the tract. Too many examples can be found of stands half stocked because of the presence of such trees. Trees of this class are hard to cut and work up into cordwood, and oftentimes it requires considerable effort to get the work done, for the average lumberman would rather claim that it is impossible than make a trial to learn the cost.

Many of the second-growth stands in the type are even-aged in nature. Where such stands are well situated with reference to markets they can be handled on the shelterwood system, and thinned at regular intervals during the rotation. An excellent grade of cordwood can be secured from these thinnings.

The length of rotation for the hardwood type must be at least seventy to one hundred years. It is only with the faster growing species such as white ash, basswood, and red oak that a seventy-year rotation can be used. The slower growing hardwoods require one hundred years or more to reach maturity.

Where the stand is pure sugar maple, or contains a considerable per cent of this species, it may often be desirable to handle the type as a sugar orchard for the production of maple sugar and syrup. To accomplish this somewhat different treatment is required from that given the type when timber production is the aim. Pure stands of maple are wanted in this case and in all the cuttings other species should be removed, favoring the maple and encouraging it to seed all openings. The amount of sap secured from a maple tree is proportional to the size of the crown, *i.e.*, to the leaf surface. Bearing this in mind, it might appear as though the aim should be to encourage the development of a very few broad spreading trees, possibly three or four to the acre. This would be going to an extreme. For what is really wanted is the greatest amount of sap production from a given area. This will not necessarily be secured from a very few large trees, but rather from a number of moderate sized trees so spaced that the greatest amount of leaf surface is developed. Tall trees, fairly slender for their height, but with dense crowns which nearly reach the ground, represent the ideal, which calls for a sacrifice of the clear length of the bole, so desirable in a timber tree.

The chief difference in handling for sap production as against lumber production is that in the former a tree with the longest possible crown is wanted, while for the latter a tree with the longest possible clear length is desired.

Wherever the stand approaches an even-aged form thinnings

should be made. In these thinnings gaps of from ten to twelve feet should be left between trees in young and middle-aged stands. In older stands somewhat wider gaps have to be made, owing to the crown development of the individual trees. This calls for a heavier thinning than would be used for the production of lumber. It makes possible the development of a good crown nearly to the base of the tree. In a sugar orchard so much depends on the size of the crown, that thinnings to develop good

Fig. 97. — A maple sugar orchard.

crowns are advisable even in stands so young as to yield no merchantable material in the cutting. A method advocated by the United States Forest Service,¹ is to make the first thinning in a dense thicket of young maples when the trees are only six to eight feet high. It is done by selecting the more promising individuals, spaced about 10 feet apart, and cutting off the tops of all the other trees. This can be done quickly with a bush hook or other tool. Cutting back the tops a couple of feet frees the selected trees sufficiently to enable them to forge ahead of the

¹ See Bulletin No. 59, "The Sugar Maple Industry."

others. Of course only a very young stand can be economically thinned in this way.

Frequently the owner of a sugar grove considers it desirable to keep down reproduction and undergrowth with the idea of making the interior of the stand as open as possible, — because then men and teams can get around and collect the sap more easily. Grazing animals are sometimes turned in to accomplish

Fig. 98. — A pure stand of young hard maple in which a first thinning has been made, reducing the number of trees per acre from 4000 to 2000. The product of the thinning was too small to be merchantable.

this purpose. Such an opening up of the stand is a mistake and true forest conditions should be maintained for two reasons, first, because sugar maple needs forest conditions, especially a thick, moist leaf litter underneath, for thrifty development, and second, because for the longest and largest yield of sap the ground should be protected from sudden thaws and kept frozen as long as possible and this is best accomplished by the thick leaf litter and heavy undergrowth. Reproduction should be encouraged in all openings and allowed to develop. Later on it may be needed to replace some older trees which have been injured.

Another way in which the silvicultural conditions of sugar-maple groves may be improved, is by leaving the edges of the stand (when making a thinning), very dense, wherever it is

Fig. 99. — The hardwood type. A middle-aged stand of even-age marked for a heavy thinning.

bordered by open fields. Often these groves, and in fact stands of all types, occur as small patches surrounded by open land. If a thinning made in such a stand is carried out to the very edge, the stand is opened up on the sides to the entrance of sun and wind. The moisture conditions of the soil cover, so favorable

for the best production of sap and indeed for the growth of the sugar maple are then disturbed.

2. *Swamp*. — The swamps furnish the most difficult silvicultural problem of all the types. This is because it is hard to get good natural reproduction on these sites. Under present methods of cutting the softwoods are removed as well as the good hardwoods. Soft maple, to which species the wet land is no great hindrance, and other inferior species are then apt to get possession of the cut-over land. To keep the poorer species out greater care must be taken in the cuttings to leave plenty of seed trees, softwoods preferably.

The swamp land is the site which can best be devoted to softwoods, for they will reproduce better here and produce a better quality of timber than the hardwood species. Trees like sugar maple and beech will not grow in poorly-drained swamp soil, but the competition of inferior species like soft maple combined with close cutting is driving, or has driven, the softwoods from many swamps.

The best way to bring the swamps into productive condition is to plant softwoods like spruce after cutting clear. Often this may appear too intensive an operation for the present, in which case the best method is to remove only the largest softwoods leaving several trees of seed-bearing age to an acre, at the same time cutting out all hardwoods to the smallest size the markets allow, either for cordwood or charcoal.

Where no softwoods remain and the ground is already stocked with such trees as soft maple the simple coppice system may be employed, by which the stand is cut clear and a new stand secured by sprouts from the stumps. For profitable use this requires good markets, as the product secured is nearly all cordwood.

3. *Birch and Poplar*. — The treatment for this type has been fully described under a similar heading in the spruce region, which should be consulted for details. The question will arise whether it is more advisable to maintain the birch and poplar permanently or to allow it to take the natural course and revert

to the original hardwood type. Either may be done. The same treatment which will keep softwoods from encroaching on the type in the spruce region will prevent sugar maple, hemlock, and various hardwoods from taking possession in the northern hardwoods region.

Where there is a ready market for poplar pulpwood and excelsior, and for paper birch as spoolwood, etc., as was the case in the spruce region, it will be profitable to maintain the type. Otherwise it should be allowed to revert to the hardwood type.

Fig. 100. — An example of the use of a final cutting under the shelterwood system. A pure even-aged stand of young hard maple with a few old trees. These large trees should be removed.

4. *Old-Field Hardwoods.* — This type may be handled in the same manner as the hardwood type. It will be remembered that the two types differ more in their origin and form than in composition. The old-field hardwoods type is in most instances even-aged while the hardwood type in the majority of cases approaches an uneven-aged form.

Its even-aged character makes the type well adapted for treatment under the shelterwood system. Since these lands were once cleared, it may be taken for granted that they are not in the most inaccessible portions of the region. Hence it may

often be possible to handle the type intensively enough to warrant the use of this system.

5. *Old-Field Conifers*. — Here again the treatment advised for a similar type in the spruce region applies. The old-field conifers type is mainly composed of stands of spruce, which can

Fig. 101. — The hardwood type. An irregular stand marked for a selection cutting and thinning combined. Ash and maple are favored. Most of the trees removed are beech.

be handled in the manner described for the old-field spruce type in the spruce region.

Clear cutting and replanting is especially advised, whether the stands are spruce, pine, larch, or hemlock, as being the simplest and in reality the cheapest method of reproduction.

LOGGING METHODS — MARKET CONDITIONS — INDUSTRIES — OWNERSHIP OF WOODLANDS.

Logging Methods. — Logging is conducted in small operations, and often is carried on by farmers. The forest is too broken up by cleared lands, and too little virgin timber remains to permit operations on a large scale. Owing to their weight it is necessary to cut the hardwood trees into short logs, rather than to remove

the tree in one log, as is done with the conifers in the spruce region.

The logs are cut in the fall and winter and hauled out on sleds to the mills. No expensive roads are constructed for this work, ordinary woods roads and the regular highways furnishing satisfactory facilities. The tendency of the hardwoods to sink when driven prevents the use of this method of transportation, even if

Photograph by J. P. Reed.

Fig. 102. — One of the many small water powers, furnishing power to a stationary sawmill.

drivable streams were available. Occasionally the logs are shipped by rail considerable distances to a mill, but usually are delivered on sleds to mills near the place of cutting.

Many small mills, both portable and stationary, are distributed throughout the region, and there are very few large sawmills. In the early days of settlement, stationary mills were installed, and run by the little water powers which are here so abundant. With the development of the country and general utilization of the virgin timber larger mills were occasionally built. These finally were crowded out by the exhaustion of extensive bodies

of timber and then were succeeded by many portable mills, which could be transported to the numerous isolated bodies of virgin timber. As this timber is being exhausted and the bodies of remaining timber are each year averaging smaller in size the trend is again toward the development of stationary mills. When timber lies in comparatively large bodies, with many such patches, it is more economical to employ a portable mill and take it into the timber. When the timber remaining is in scattered small patches it is better economy to have a stationary mill and bring the timber to it. The stationary mills where run by water power are cheaper to maintain, and do a better grade of work where the machinery rests on a permanent foundation. Moreover, they can be equipped with additional machinery, such as planers, small resaws, and machines for sawing special products. Thus the stationary mill should utilize more fully and more profitably the entire log than can the portable mill.

Market Conditions. — Transportation facilities are reasonably well developed. No point is twenty miles distant from a railroad in a direct line, while fifteen miles is an exceptionally long haul. County and state roads penetrate all portions of the territory and make it possible to haul timber or logs by team to a railroad usually in less than a day's time. While the region has a fairly good transportation system, yet with the disappearance of most of the virgin timber and the great inroads on the forest lands for agricultural use, it cannot be counted on to furnish export timber in large amounts. Agriculture has moderately populated the region, so that there is a good local demand for forest products and the cut is seldom in excess of the local demand. However, the higher grades of timber are shipped to outside markets and some timber is imported.

The local inhabitants furnish a good market for cordwood, as well as for timber. This is especially true of the people scattered through the country at a distance from railroad lines, because coal is expensive, while cordwood is relatively cheap and of a high grade,¹ and also because the winters are long and

¹ Beech and sugar maple are two of the best species in the country for fuel wood.

cold, requiring much fuel. Where maple sugar is made a large amount of poor-grade wood is used for boiling sap and as a result the average family in the northern hardwoods region burns more wood than does a similar family in the white pine region and nearly twice as much as in the southern hardwoods region. This is a great help in utilizing small-sized material, and in making intensive methods possible.

Industries. Lumber Industry. — This is the principal forest industry for the timber cut goes on the market mainly as lum-

Fig. 103. — These hardwood logs have been hauled in by farmers to the mill pond, where they will be sawed by a stationary water power mill.

ber. There is nothing like the pulpwood industry in the spruce region to compete on a large scale for the unsawn logs. The principal species cut are hemlock, birch (chiefly yellow), maple, beech, spruce, basswood, and ash. It is even more difficult than in the spruce region to get exact figures for the cut, owing to the irregular form of the northern hardwoods region and the way in which it cuts across state and county lines.

Moreover, there are no species cut for lumber in this region

which are not cut in far greater amounts elsewhere in the United States. In fact, they are all cut on a commercial scale in one or more of the other New England forest districts. However, an estimate of the annual cut (based on census figures for the year 1909), would place it in the neighborhood of 250,000,000 feet, board measure.

Much of the better grade of hardwoods, such as the red birch (as the red heartwood of the yellow birch is called) are made into high-class flooring. Many mills that specialize in this trade are also equipped with machinery for utilizing the poorer grades, which are not fit for flooring, in the manufacture of such small articles as clothespins, novelties, toys, etc.

Small wood-working plants, manufacturing various articles such as bobbins, novelties, staves, and heading for slack cooperage, caskets, tool handles, excelsior, veneer for baskets, etc., are abundantly scattered throughout the region. They buy rough lumber or cut small quantities of wood especially for their own use. None of them especially characterizes the region. The wood used in these plants would largely be included in the figure of the annual lumber cut already given.

Maple Sugar Industry. — This industry gathers and manufactures a forest product and is therefore a forest industry. It characterizes the region, although extending beyond its bounds, following the commercial distribution of the sugar maple. The spruce region of New England, and portions of New York and Ohio are the only competitors in this industry with the northern hardwoods region.¹

The northern hardwoods region is the most important one for the production of the two products, maple sugar and syrup. There is so little margin of profit in these industries that they cannot be financially profitable except when carried on in connection with farming.

The summer-resort business is one which brings considerable

¹ The sugar and syrup produced in New York State is largely produced in the extension of the New England northern hardwoods region, which surrounds the spruce region in New York State.

income to the inhabitants of the region, but it is of less volume and does not assume the relative importance which it holds in parts of the spruce region where many people are dependent upon tourists for their summer work. Agriculture is the leading industry of this section and furnishes abundant work during the tourist season. The importance of the forest cover in attracting and holding summer trade is, therefore, much less than in the spruce region.

Strictly forest industries are seen to occupy a place secondary in this region to agriculture. There is also considerable development of water powers for manufacturing purposes, and in the Vermont section large quarries of marble and granite are located. The relative place in value of output held by manufacturing interests with respect to agriculture and the lumber industry is difficult to determine, but it is probable that manufacturing exceeds the lumber industry in value of annual output. To summarize, it may be said that the northern hardwoods region is an agricultural section with important manufacturing and lumber interests.

Character of the Land and Timber Ownership. — Ownership of the land and timber in small holdings is the rule. It is a forest region characterized by so-called woodlot ownership, *i.e.*, the forest areas are owned mainly in connection with the farms. Each farmer has his woodlot but these lots are considerably larger than those of the sprout hardwoods region, often comprising several hundred acres of forest. There are, of course, many forest tracts held by other persons than farmers. The larger holdings are among this latter class, being owned principally by lumbermen or by sporting clubs or private estates. There are still comparatively few such club or estate owners, but the number is increasing, — there being a decided tendency for wealthy men to buy up rundown farms with their accompanying woodlots.

Lumbermen as a class of permanent land owners are not prominent; their holdings are changing continually, through the sale of cut-over lands and the purchase of timbered lands.

Holdings of between 5000 and 10,000 acres are considered large, while one containing more than 10,000 acres is only occasionally found.

Title to the land and timber goes together in practically all cases, except where stumpage is bought for immediate cutting.

FOREST PROTECTION.

Forest Fires. — Surface fires characterize this region. The litter of the northern hardwoods forest does not afford opportunity for a ground fire, as did the accumulations of coniferous duff and moss in the spruce region, and crown fires are of rare occurrence and then run only in the few coniferous stands.

The fires are worse on cut-over lands with heavy slash, but are by no means confined to such lands. In dry times surface fires can easily run through virgin stands, feeding on the leaf litter. The rapidity with which hardwood reproduction springs up on cut-over lands, shading and keeping the ground moist, soon lessens the fire danger. The most dangerous season is ordinarily considered to be in the spring and fall, but a little earlier in the spring and a little later in the fall than is the case in the spruce region. In reality the occurrence of drouths during spring, summer, or fall determines the dangerous season, for a drouth in midsummer will make this the most dangerous season. The hardwood leaves furnish the chief fuel for the fires, and these are dried out easily by even a short drought.

The chief known cause of forest fires,¹ at the present time, is carelessness in burning brush while clearing land. The railroads are the principal cause of fires where they pass directly through woodlands, but fortunately their location in most cases does not bring them in close contact with such lands. What is true of the Vermont portion of the spruce region is true quite largely for the whole northern hardwoods district, namely, that the railroads lying in the main valleys have belts of cleared land adjacent to their rights of way and are therefore responsible for

¹ Forest Fire Statistics for the northern hardwoods region will be found in the Appendix.

only a small percentage of the fires of this region. The fires started by sportsmen are the second largest in number.

Methods of Fire Protection. — Fire protection in this region should lie with the town and state authorities. A central authority is needed, inasmuch as the forest holdings are of small extent. In most cases an organization for the protection of a single tract only would be very expensive, and the owners are too many in a given section to make practicable co-operative fire-protective associations. It devolves, then, in this as in all woodlot regions, upon the towns and state to furnish protection. This can be best accomplished with one central authority (the state forestry department), in charge and working through local representatives (the forest-fire wardens), in every town. The forest-fire wardens should have the authority to *patrol* in dangerous fire seasons, as well as to attend to the putting out of fires. Unless the right to patrol is given the wardens the system must lack the highest efficiency, because not directed to preventing the start of fires.

The maintenance of lookout stations on mountains, while often giving excellent results, is not an essential part of the system in this region, since the country is well settled and mountains with extended views over the neighboring country are relatively few. The farmers with short views over their immediate neighborhood take the place of mountain lookouts. Telephones are already well distributed over the territory, but it may often be advisable to extend the system by connecting lines with farm-houses having good views over wooded territory.

Special measures for the disposal of logging débris are not considered necessary. Coniferous forests, with the bad slash left after logging, are notable by their absence. The hardwood tops decay rapidly and do not make a bad fire trap. Cordwood should be taken out of the tops of trees felled for lumber wherever it can be done without financial loss, thus leaving the stand in excellent condition so far as brush is concerned.

In fighting fires the same tools are useful in this as in the spruce region. There is, however, less need for shovels, as

ground fires are rarely met with and hence deep trenching is not often needed, and unless there is plenty of dirt available a hoe or rake is more useful. Surface fires are principally encountered and in stopping them a narrow fire line raked or hoed clear of leaves is often all that is necessary, if men are at hand to beat out fires which may be started by sparks blown across the fire line. The methods of fighting ground and crown fires have been previously described.

Fig. 104. — An abandoned schoolhouse, which indicates more strongly than the abandonment of a single house, the decrease in New England's rural population in the last 50 years.

Protection against Grazing Animals. — Damage by grazing animals is quite prevalent in this region. Nearly every farmer has a few cows and horses which are turned out part of the year. With a large majority of the farmers dairying or, in a few cases, the raising of horses and sheep, is the chief business.

The injury done the forest is not well recognized by the land owners. Cattle are especially fond of browsing on sugar maple seedlings and will prevent good reproduction of this important species on grazed-over lands. A great deal of the land now for-

ested is suitable for grazing purposes and once the soil cover of leaves is opened up will produce a growth of grass even under quite a stand of trees. The custom too often is to allow stock to roam over open pastures and through woodland, which results in gradually opening up even a dense stand and helping the advance of grass throughout the wooded area to the exclusion of reproduction.

It should not be inferred that a reduction of the number of grazing animals is advised in order to prevent damage to the forest. Such a course is wholly unnecessary since in most cases excluding the stock from the forested areas will not make necessary any reduction in numbers. The feed secured under forest trees is not equal to that obtained on a well-kept pasture, and its loss is often not felt at all. However, should the feed outside the forest be insufficient to support the stock, the best site now forested should be cleared and put into pasture. Better economic results will be secured by not using the same piece of land for the two purposes. Inferior timber production in both quantity and quality is the result of grazing in woodlands. Poorer forage is the result of keeping pasture forested.¹ The owner should determine for which purpose the site is most needed and then devote it to that purpose unreservedly.

The influence of grazing animals is felt especially on fields not cultivated but still used for pasture. A few animals pastured in such a field may not be able to wholly keep down the hardwood reproduction which is striving to come in, but they will be able to hinder the process of reseeding, and to make the new forest patchy and composed of limby, big-crowned trees of inferior lumber value. Under such circumstances a portion of the field just large enough for their needs should be fenced off for the cattle, and the rest of the field allowed to come up to a thick stand of trees.

In this way a good pasture and a good forest will result,

¹ As a matter of fact the pastures as well as the woodlands are not scientifically handled in the region. That, however, is outside the present discussion. The reader is referred to Circular No. 49, of the U. S. Bureau of Plant Industry.

instead of a combination of second-rate pasture and open forest. Most of the partially stocked stands at present in the old-field hardwood type owe their poor stocking to the influence of grazing during the period of reproduction.

Protection against Insects and Fungi. — The destructive insects and fungi common to this region are few in number. The forest tent caterpillar attacks the sugar maple and is now the most dangerous enemy of the kind in the region from the forestry standpoint, but its ravages have not recently been widespread nor does it give indications of becoming a serious insect pest in the forest. The work of the forest tent caterpillar is described in the chapter on Insects.

Watershed Protection. — The location of the region with respect to the headwaters of New England's main rivers has already been shown. As a result of its location below the headwaters of these rivers, and of the character of its topography and other natural features the region does not require a forest cover primarily for protection.

SUMMARY.

1. The Northern Hardwoods region is an agricultural region with important lumber interests.

2. It is a hardwood region, characterized by northern species and stands of seedling origin, with the forest mainly in woodlot holdings of a larger size than in the other two New England woodlot regions.

3. Much land now forested is of agricultural value. However, the best lands have been cleared and the farm area will not increase appreciably in the near future, or until a decided change in agricultural conditions takes place.

4. Markets for forest products are fairly good, better than in the spruce region, but poorer than in the other two regions.

CHAPTER XV.

THE WHITE PINE REGION.

GENERAL CONSIDERATIONS.

Two separate sections of the white pine region are recognized, one of small extent, lying along the eastern shore of Lake Champlain; the other, and larger portion, extending from Connecticut and Rhode Island through Massachusetts into southern Vermont, New Hampshire, and Maine.

In comparison with the two previously discussed, the white pine region occupies a lower elevation. A glance at the map on page 197 will show that the white pine region in a rough way borders the seacoast, with the northern hardwoods and spruce regions occupying the territory behind, which is of a more elevated character. Only where elevations are low, as in the Champlain valley of Vermont and in the upper Connecticut River valley does the region extend any distance inland.¹ A northern latitude reacts in the same way as elevation in limiting the white pine region. In eastern Maine, even along the coast, although the elevations are low the species of the spruce region prevail rather than that of the white pine. The region is largely below the 500-foot contour, there being very few peaks where it exceeds 2000 feet in elevation, and it also lies below the torrential portions of the main rivers. These streams have descended from the mountains and high plateaus of the spruce region through the hilly and broken country of the northern hardwoods into a land of gentler topography, where their courses are often meandering and their currents sluggish. There are numerous lakes and ponds, especially in the Maine and Central New Hampshire sections. Many extended river bottoms occur with

¹ The limits of the region are formed not so much by the proximity to the sea as they are by the lower elevation and soil conditions.

sandy plains and terraces. Between these valleys are areas of low rolling hills. The hills are highest and roughest in New Hampshire and Massachusetts in a belt east of and paralleling the Connecticut River. A larger portion of swamp land is found than in the northern hardwoods region.

Granites form the predominant underlying rock, but the bed-rock is not so noticeable as in the spruce region. This is because glacial and river deposits in enormous quantities have been left, obscuring the bedrock. All through the region are found glacial soils and formations, while drumlins and moraines of gravel and sand are characteristic features. The soils are sandy and gravelly in nature, although all classes are found. Sandy loam is the most common soil, but many areas of pure sand occur, as, for example, in extreme southeastern Massachusetts, on Cape Cod, and in Plymouth County. Here rolling hills of sand deposited by glacial action cover nearly the entire country. These sandy soils are free from surface rock, but the stiffer soils are in many cases thickly strewn with loose stones. On the whole the soils are less stony than those of any of the other three New England forest regions.

It may easily be inferred that a region characterized by such sandy soils will, if forested, be stocked with pines, and this occurs here. White pine is the chief tree, the region being an optimum one for it. It is, however, not the only forest region in the United States which affords conditions for the best development of white pine. There are two others, one in the northern part of the Lake States, the other in portions of New York and Pennsylvania.

Much of the better land has been cleared so that the forest is broken up into small areas, much smaller than was the case in the northern hardwoods region. Over small areas in the higher and more hilly portions, or on the worst sandy soils, as much as eighty to ninety per cent may be in forest or waste land. The average, however, is in all probability about forty per cent. The forested per cent may be expected to remain about the same or to increase slightly rather than to decrease during the next genera-

tion. There are to-day large areas of abandoned farm land which will be reforested by natural or artificial means within the next few decades. This land, although useful for agricultural purposes, is not as yet needed. The opening up of more fertile western lands threw it out of cultivation forty to eighty years ago, and until a very decided agricultural development takes place it will be best kept in forest. The very sandy and gravelly soils should always be kept forested, and this class of land, together with swamps, steep slopes, and the tops of the higher hills, constitute the true forest soils of the region.

While white pine is the chief tree it is far from forming the entire forest, as there is often a mixture of hardwoods and conifers. The pine occurs both in pure stands and in mixture with the hardwoods, and the latter often form pure stands with no mixture of conifers. Hemlock and pitch pine occur as important conifers, and the southern white cedar (*chamaecyparis thyoides*) is present in commercial quantities in the swamps of southeastern Massachusetts.

The principal hardwoods are red oak, chestnut, soft maple, gray birch, white oak, and white ash. The red oak found commercially in portions of the northern hardwoods region and the chestnut, an infrequent tree there, become in the white pine region two of the most important hardwood trees. As a general rule the pine is most abundant on the poorer sandy and gravelly soils, the hardwoods taking the lead on the better soils. An exception to this is found on abandoned farm lands, which often seed up to pure stands of pine, and these lands, while not the best in the region, cannot usually be classed with the poor sandy lands.

The inferior species, gray birch and soft maple, are two of the hardwoods most abundantly found. Indeed, this region is the optimum one for the development of gray birch, and very favorable for soft maple. Sugar maple and yellow birch are numerically important on some of the cooler sites, but do not figure as trees of general commercial importance. The white oak is most abundant in the eastern half of the Massachusetts portion of the

region. Hemlock occurs on the cooler slopes and in ravines, while pitch pine is confined to the most sterile sandy soils. In some localities black cherry grows and when present is a valuable species.

The virgin forest is a thing of the past in the white pine region, many areas having been heavily cut over, not only once but two or three times. Clear cutting is usually practiced and has resulted in producing stands of even age, which give the forest its characteristic even-aged form. The original forest was of seedling origin. In the present second-growth forests the conifers are of seedling origin, but among the hardwoods sprout growth has quite largely replaced the original seedling growth. Almost all the hardwoods sprout freely in this region.

FOREST TYPES.

The original and permanent forest types are less prominent than in either of the regions already considered. Cutting and forest fires have caused the formation of many temporary types. The former has been heavier and both have been repeated a greater number of times than in the two regions previously considered. In other words, the original types have been cut off and burned over, and under the continued action of these agencies have so little chance to reappear permanently that temporary types occupy the greater portion of the area.

There are eight types in all, classified as follows:

Permanent Forest Types.

1. Hemlock.
2. Pitch pine.
3. White cedar swamp.

Temporary Forest Types.

4. Pure white pine.
5. Pine and inferior hardwoods.
6. Mixed hardwoods.
7. Soft-maple swamp.
8. Waste land.

1. *Hemlock*. — While this is an original and permanent type it is now found as second growth rather than in virgin stands. It is distributed on cool slopes and ravines, and occurs chiefly in the less-settled portions of the territory, for example, in the New Hampshire portion west of the Merrimac River. The soils on which the type occurs are medium to fairly good in quality, but from their location are undesirable for farm purposes. None of the sandy, gravelly soils are occupied by the hemlock type.

By permission of F. F. Moon.

Fig. 105. — A remnant of the original forest in the white pine region. This is a mixed stand of white pine, hemlock, and hardwoods. Heights range up to 110 feet, diameters to 38 inches.

The stand is a mixed one, composed of hemlock, white pine, chestnut, red oak, maples, white ash, basswood, and white oak. Hemlock, while oftentimes forming only a small per cent, is always present, and may compose as high as fifty per cent of the stand. In other stands, chestnut and red oak may make up fifty per cent of the stand, and occasionally white pine is similarly represented. Hemlock, however, is always the key tree, serving to distinguish the type. A stand containing several age classes is the most common forest form. The undergrowth is

usually not dense, but is of witchhobble, mountain, and striped maple, and has much the same character as the hardwood type of the northern hardwoods region, to which it bears some resemblance.

The type is not an important one from the standpoint of area covered, as this is relatively small. The timber produced is, however, of good quality. A maximum yield of from 25,000 to 40,000 feet, board measure, is sometimes secured from well-stocked stands. Such stands are at least eighty to one hundred years of age.

In stands which have not been opened up no reproduction occurs, owing to the density, but in all openings a good reproduction of the various species represented in the stand springs up.

2. *Pitch Pine*. — This is another type which covers only a limited area. It is restricted to the poorest and driest sandy soils, and is most prevalent in the Saco River region of Maine, in parts of New Hampshire, and in southeastern Massachusetts. In these sections quite large areas of the type exist; elsewhere in the region only an occasional small patch is found.

Pure pitch pine stands are typical. Frequently scrub oak (*quercus pumila*) accompanies the pitch pine. This is especially noticeable on areas which are repeatedly burned over. Fires on the sandy soils of the type are altogether too common, and have made the present stands very open and poorly stocked.

The pitch pine reproduces abundantly in all the openings, and when spared from fires soon fills them with seedlings.

The value of the type as a timber producer is small, owing both to the slow growth which results from the poor, dry soil, and to the poor quality of the lumber produced.

3. *White Cedar Swamp*. — Lying in small isolated patches or as narrow belts along streams and ponds are swamps in southeastern Massachusetts stocked with the southern white cedar (*chamaecyparis thyoides*).¹ The type is an intrusion from the southern coastal region, and is of extremely limited area and, in

¹ The type extends in bodies of commercial size as far north as the outskirts of Boston.

this region, of small commercial importance. The soils are very wet and covered with thick deposits of sphagnum moss.

Sometimes the stands contain only the white cedar, but usually have a mixture of soft maple growing with the cedar. Even-aged seedling stands, containing a remarkably large number of trees per acre, are characteristic of the white cedar swamps. The growth of stands in this region has not been thoroughly studied, but figures taken by Pinchot,¹ in stands of the same type in

By permission of the Massachusetts State Forester.

Fig. 106. — Pitch pine type on a poor site, Cape Cod, Massachusetts.

New Jersey, showed as many as 3,500,000 young seedlings per acre, at twenty years over 10,000 trees, at forty years 3500 trees, and at eighty years 1000 trees per acre. A stand of pure white pine has at sixty years only 250 to 300 trees per acre. White cedar is a slow grower even in the regions suitable for its best development, while in the white pine region it must be classed as an extremely slow-growing conifer. Of course, the wet site has an important influence on the rate of growth.

Referring again to figures secured by Pinchot in New Jersey

¹ See Annual Reports of the State Geologist of New Jersey.

cedar swamps, the following yields for fully stocked stands are recorded:

Sixty years, 10,000 feet, board measure, and 500 fence rails.

Eighty years, 20,000 to 25,000 feet, board measure, and 1500 fence rails.

This may be taken as a maximum yield for the type in the white pine region.

Fig. 107. — An open stand of white pine in good condition. Many of the trees, as seen on the left, are two-forked and branchy. The yield is not so good in quantity or quality as can be produced.

4. *Pure White Pine*. — Commercially this type is the most important. In area it is exceeded by the mixed hardwoods type and probably also by the pine and inferior hardwoods type.

Two classes of land may be occupied by the type: abandoned fields and lands once cut clear. Usually the type is confined to small scattered patches. While classed as a temporary type on some situations it is really permanent. This is true on some of the poorer soils which in the original forest bore stands of pure pine. The most suitable soils are sandy or gravelly in nature,

but often soils of a better grade are seeded to stands of the type. This is especially the case on old-field situations. Well-drained soil is an essential.

White pine composes eighty per cent or more of the stand, while mixed with it in small numbers may be found occasionally almost any of the hardwoods in the region. Soft maple and gray birch are perhaps the commonest associates of the pine.

The pure white pine type furnishes a fine example of a regular even-aged stand, which is the usual form. The stands are generally free from undergrowth, having a thick soil covering of pine needles. Any openings are stocked with reproduction, both hardwood and pine being represented. Sometimes hardwood reproduction appears in quite dense shade of pine.

More investigations have been carried on by the United States Forest Service and the various state forestry departments in regard to the pure white pine type than for any other type in New England. As a result, reliable figures are available for its growth and yield. All the figures given are for unmanaged stands which started from natural reproduction. Table LV given in the Appendix shows the total number of trees per acre, the number of merchantable trees, and the average height of the stand at different ages. The rapid lessening in numbers through suppression and death of the poorer individuals as the stand grows older is noteworthy.

Three yield tables have been made within recent years for different portions of the region. One made in coöperation between the United States Forest Service and the State of New Hampshire is for the New Hampshire section.¹ Another, for the Massachusetts section of the region, is based on measurements taken within that state.² The third, made by the United States Forest Service, is intended to apply to the whole region.³

¹ Published in the Report of the New Hampshire Forestry Commission for 1905-1906.

² It is issued by the State Forester of Massachusetts under the title of "Forest Mensuration of the White Pine in Massachusetts."

³ See Forest Service, Bulletin No. 63.

The yield tables secured by these three investigations do not agree exactly for reasons to be shown later. The following yield table has been compiled from all three sources and will bring out their differences. The figures most applicable to any particular case should be the ones used.

It will at once be seen that the Massachusetts figures for feet, board measure, are much higher throughout than the New Hampshire data. This is partly to be explained by closer

Fig. 108. — In the center is seen good reproduction of white pine on an old field bordering the Connecticut River. The seed comes from the neighboring seed woods at the left and right of picture.

utilization of the trees in the Massachusetts section as contrasted to the New Hampshire section. This, however, cannot explain the entire difference, which must be accounted for through variation in the character of the timber and lack of a sufficiently large amount of data. If a much larger number of trees and plots were secured in each of the two localities probably the results would be nearer alike.

In comparing the yield in cords secured in Massachusetts with that obtained by the United States Forest Service for the region

YIELD TABLE FOR THE PURE WHITE PINE TYPE AT DIFFERENT AGES AND ON DIFFERENT QUALITIES OF SOIL IN CORDS¹ AND FEET, BOARD MEASURE.

Years.	Quality I.			Quality II.			Quality III.			All qualities combined.
	New Hampshire, ² Feet, Board measure.	Massachusetts, ³		New Hampshire, ² Feet, Board measure.	Massachusetts, ³		New Hampshire, ² Feet, Board measure.	Massachusetts, ³		
		Feet, Board measure.	Cords.		Feet, Board measure.	Cords.		Feet, Board measure.	Cords.	
20	4,600	.....	.....	3,150	.....	.....	1,700	.....	.....	11
25	8,400	10,825	25.1	5,900	6,750	16.4	3,450	3,975	10.8	21
30	15,100	19,000	44.0	10,800	12,500	31.2	6,550	7,500	18.2	30
35	24,950	31,150	60.4	18,050	24,400	49.0	11,200	16,950	35.8	38
40	33,550	40,650	70.6	25,000	32,800	58.0	16,450	25,200	46.2	45
45	40,750	49,350	78.0	31,450	40,600	64.8	22,150	32,100	51.8	53
50	47,450	55,150	84.2	37,800	46,500	70.0	27,650	37,550	56.6	65
55	52,350	59,050	89.2	42,550	50,550	74.8	32,750	42,100	60.8	80
60	57,300	63,600	93.4	47,400	53,200	79.2	37,500	44,550	64.6	
65	61,850	67,050	97.2	51,850	56,600	83.0	41,850	46,150	68.4	
70	65,900	.....	.....	55,800	.....	.....	45,700	.....	.....	
75	69,750	.....	.....	59,500	.....	.....	49,250	.....	.....	
80	73,300	.....	.....	62,850	.....	.....	52,400	.....	.....	
85	76,700	.....	.....	66,000	.....	.....	55,300	.....	.....	
90	80,050	.....	.....	69,000	.....	.....	57,950	.....	.....	

¹ Cords are measured by the caliper rule.

² Taken from the N. H. Forestry Com. Report for 1905-1906.

³ Taken from "Measurement of the White Pine in Massachusetts."

⁴ Taken from U. S. Forest Service Bull., No. 63.

as a whole higher figures are shown for the Massachusetts section. Inasmuch as the government figures are average for the whole region they might be best compared with Quality II sites in Massachusetts. However, it is believed an average site for the pure white pine type throughout the region would be below Quality II (Massachusetts), so that the United States Forest Service figures should be lower than Quality II in Massachusetts. As a matter of fact the Forest Service figures start at twenty-five

By permission of the Massachusetts State Forester.

Fig. 109. — Pure white pine type. The portion seen between A and B is a plantation. Yield of the stand about 38,000 feet, board measure, per acre.

years, practically identical with Quality III stands as given for Massachusetts, then go above Quality III at thirty years, and later fall below Quality III from thirty-five years until after fifty years. At fifty-five years the Forest Service figures give a higher yield, and in five years more they have jumped up and are a little above those of Quality II. This indicates a growth tendency for the first sixty years entirely different from the New Hampshire and Massachusetts figures, which in relative rate of growth are alike, although differing in absolute figures. The government figures indicate a poor utilization in young stands and would seem to have been improperly distributed between

qualities, too many plots of Quality III being taken in young stands and too few in old stands to give average figures. These figures are too low for ordinary conditions and the New Hampshire or Massachusetts yields should be given the preference. Except for the closest utilization and best stands it will be safer to employ the New Hampshire figures or an average of the New

Fig. 110. — The pine and inferior hardwoods type, here composed of white pine, gray birch, poplar, soft maple, and alder. The pine is getting ahead of the hardwoods but has grown in too open a stand to make first quality lumber.

Hampshire and Massachusetts figures, rather than the latter figures alone.

An idea quite commonly held is that the dense even-aged stands of white pine for the first fifty to sixty years of their life yield only boxboard material. This, however, is a fallacy, as stands less than fifty years old yield much material better than the boxboard grade. There is little clear lumber, but it contains small sound knots, which do not unfit it for many purposes other than boxboards. The poorest boards only should be classed as boxboards.

5. *Pine and Inferior Hardwoods.* — In area this is the second or third in importance, but in commercial value it is subordinate

to the pure white pine type. Old fields or pine land which have been cut clear are the sites on which the type occurs. These are the same situations as those chosen by the pure white pine type. Sandy soils are preferred.

In composition the stand contains pine, gray birch, soft maple, and poplar, all light-seeded species and capable of seeding up open lands. Occasionally oak occurs in the type. Soft maple is most abundant where the soil is not very sandy. Occasionally on the poorest soil pitch pine takes the place of white pine. Pine may not be present at the time that the stand is starting, but may seed in underneath the hardwoods, as does red spruce in the spruce region. This is not a stable association, since the pine will finally kill out the gray birch and poplar, by passing them in height growth and suppressing them. Soft maple, however, due to its tolerance and rapid growth, is on the better and moister soils able to keep up with the pine. On poor soils, like the birch and poplar, it may be crowded out by the pine. The pure white pine type results from this reversion. The percentage of the different species shows great variation from nearly pure stands of any one of the four to complicated mixtures.

The type is even-aged or occasionally two storied in form. The question might arise as to whether this type is not an original and permanent type, being composed of pine and mixed hardwoods, which formed the bulk of the original forest. But the hardwoods found in this type are entirely different species from those prominent in the original mixed forest. The hardwoods in the pine and inferior hardwoods type are light-seeded species, all but soft maple being relatively short-lived, and all of low commercial importance. In the original forest such hardwoods as red and white oak, chestnut, and white ash were mixed with the pine, giving the stand quite a different character.

In the pine and inferior hardwoods type the character of the growth is poor. The pine develops slowly and is usually branchy and of inferior form. Its slow development is accounted for by the fact that the hardwoods, growing more rapidly when young, get ahead of the pine. This is true even when the pine and

hardwoods start at the same time, and since the pine often seeds in a few years after the hardwoods the latter secure a considerable start. Before the pine can work its way up through the hardwood tops its stem often becomes twisted and sometimes the leader is killed by the mechanical rubbing of the hardwood limbs. In fact the cover of hardwoods may be so dense or have such a start over the pine that the latter is unable to pass it and never amounts to anything. Another form of pine found in the type

By permission of the Massachusetts State Forester.

Fig. 111. — Sandy lands on Cape Cod in need of forest planting.

are trees with branchy crowns widely spreading and sometimes reaching to the ground. These trees are in poorly stocked stands where seeding of hardwood and pine was not sufficiently dense to insure proper natural pruning.

The hardwoods themselves do not furnish material of value except as cordwood. Occasionally there may be a small use locally for other purposes. Thus the value of the type depends on the amount of pine contained in the main stand, *i.e.*, which has been able to get ahead of the hardwoods. The yield can usually be figured as a certain per cent of what a stand of pure pine would give at that age, the per cent being identical with the

per cent of the area actually stocked with the pine. A forty-year old stand having ten per cent of its area in pine, the rest in birch, poplar, etc., would be estimated to have ten per cent of the yield of a pure pine stand at forty years. Usually the quality of the material is much poorer than in the pure pine stands, and must be classed chiefly as boxboards.

6. *Mixed Hardwoods*. — Without doubt the mixed hardwoods type occupies more area than any one of the other forest types. In commercial importance it ranks second to the pure white pine type.

It occurs chiefly on cut-over lands which originally bore hardwoods or a mixture of hardwoods and conifers. These lands have already been described as comprising the better soils. Hence the type will be found on the richest of the soils now forested. Occasionally stands of this type gain a foothold on old fields, though ordinarily such fields seed up to pure pine or pine and hardwood stands.

The proportion of sprout to seedling trees is high, and sprout growth may be said to characterize the type. This characteristic explains why the type is classed as a temporary one. The composition is the same as in portions of the original forest, and on the better soils this composition would not change greatly if the forest were left untouched, but seedling stands would replace sprout stands.

A great deal of the land now in this type originally had a mixture of conifers, which have disappeared under the influence of repeated cuttings and fires.

The leading species are chestnut, red and white oak, white ash, soft maple, and gray birch, while white pine, black cherry, and other trees occasionally occur. The stands are usually thrifty and even-aged. No comprehensive study has been made of the yield for the type, but sufficient figures have been secured to indicate that between a quarter of a cord and a cord of wood per acre per annum, varying with the site, can be expected.

At the present time the stands are cut rather young, and yield material suitable largely for the rougher grades of lumber and

for cordwood. Yields of good grade timber can, however, be secured from stands containing chestnut, oak, and white ash, if not cut too young.

7. *Soft Maple Swamp*. — The type is somewhat similar to the hardwood swamps of the northern hardwoods region, though apt to be more even-aged in form and to contain a greater per cent of soft maple sprouts. Wet, swampy land is, of course, the situation on which the type grows.

Pure stands of soft maple are often in evidence, and always soft maple is the chief tree. The associated species of importance are black ash, yellow birch, swamp white oak, and elm. A great difference in character of growth can be observed between individual stands. Where soft maple is purest the growth is often rapid and the stands present a thrifty appearance. In other instances the same poor and stunted growth of soft maple, black ash, and yellow birch in open stands apparent in so many swamps in the northern hardwoods region is seen. Variation in moisture and soil conditions of the swamp accounts for these differences in growth.

The best swamps of pure soft maple will produce a yield of at least one cord of fuelwood per acre per annum.

The type is classed as a temporary one because of its sprout origin.

8. *Waste Land*. — On the sandier soils, where the stands were pure conifers or nearly pure, cuttings, followed by fires, have often resulted in leaving the land bare of any forest growth. This has rarely been the case where hardwoods were in mixture, as these species continued to sprout even under severe treatment.

Enough of this kind of land exists to warrant it being listed as a separate type. The soils are among the poorer class and are true forest soils, although now bare.

The land is usually covered with such plants as scrub oak, grass, ferns, and various shrubs, but not with trees. In some cases, as, for example, in southeastern Massachusetts, areas of almost bare sand can be found.

The type is the most worthless of any in New England,

though in natural productive power it exceeds much of the land in the white cedar and soft maple swamp types. The land can often be bought for fifty cents per acre, or less.

By permission of the U. S. Forest Service.

Fig. 112. — The waste land type. Lands which have been repeatedly burned over.

METHODS OF HANDLING THE FOREST.

Intensive management is possible on the majority of tracts in the white pine region, and the white pine is the tree to be favored. The purpose of the management should be to replace the inferior species, and in fact many of the better hardwoods, with stands of nearly pure white pine. A small mixture of such hardwoods as red oak, white ash, chestnut, and black cherry in the stand with the pine is better than pure pine. Such a mixture produces a few hardwood logs of fine quality which can often be sold at higher prices than the pine. Improvement cuttings of various kinds are practicable and should be made where needed, as a regular part of the management, as explained in the special chapter on the subject.

By permission of the U. S. Forest Service.

Fig. 113. — Pine and inferior hardwoods type. The gray birch should be removed and the pine allowed to develop in a pure stand. See next picture.

Planting holds in this region an exceedingly important place in forest management. It will be needed mainly on waste lands and on recently cut-over pine lands, but also on cut-over hardwood lands, to replace the poorer hardwood species, and on portions of farms no longer needed for cultivation or pasture. White pine and red pine should be used most extensively.

1. *Hemlock*. — The object in this type should be to favor white pine, chestnut, red oak, white ash, and black cherry when present, at the expense of the hemlock. An even-aged mixed stand of white pine and hardwoods with a mixture of hemlock should result.

The clear-cutting system, with reserves of scattered seed trees should be used (see Chapter II for description). These seed trees can usually be taken out profitably in a separate operation when reproduction has started. Especial care must be used to remove all the hemlock, as otherwise it may seed in. The

By permission of the U. S. Forest Service.

Fig. 114. — The gray birch has been removed, freeing the pine. This cleaning yielded an immediate profit. See Fig. 113.

chances are that there is already scattered hemlock reproduction in the stand before cutting. This develops when released by the cutting, and keeps hemlock in the mixture although no seed trees are left. It will be very hard to completely eradicate the hemlock, but it can be kept in a subordinate position. The young hemlock will usually be outstripped by the pine and hardwoods in height growth, and finally take the place of a tolerant understory. As such it serves a good function in promoting natural pruning of the other trees. Windfirm trees of either white pine, oak, ash, or cherry should be selected for seed trees, and, if possible, the cutting should be made at the time of a pine seed year. The chestnut will maintain its representation in the stand by coppicing and through occasional seedlings which get a start in some opening, so that it will be unnecessary to leave seed trees of this species. A rotation of approximately eighty years should be used, as the hardwood species need a

period of that length to produce a high yield of good quality timber. The material grown should be saw timber, for use in various woodworking industries.

2. *White Cedar Swamp*. — This is a type which has not been sufficiently studied from the management standpoint. A system of clear cutting in strips seems best adapted to the type. Where windfirm individuals can be found clear cutting with scattered seed trees should give satisfactory results. In the swamp where white cedar is in pure stands these methods of cutting should insure cedar reproduction. Where soft maple is present it will be apt to compete with the cedar. It is still an open question whether stands of the slow-growing but more valuable cedar will give better financial returns than the much more rapid-growing soft maple, which, however, yields nothing but cordwood. The soft maple may prove upon further study an equally good or better tree to favor than the white cedar.

3. *Pitch Pine*. — The great need of lands in this type is for protection. From its situation on dry sandy soils it is exposed to frequent fires, but when these are stopped reproduction is easily secured. While the soils of the type are all poor sands there are two degrees of poverty which need recognition. One of these includes the very deepest and poorest sands, and are best suited for the production of pitch pine or some pine of similar soil and moisture requirements, as the Scotch pine; the other soil is not so poor naturally, but has been burned over so frequently that pitch pine has replaced better species like white pine, which could grow on these sites.

The first class of soils will have to be managed for pitch pine. It can be easily reproduced under any of the systems of clear cutting with natural reproduction. The scattered seed tree method is especially recommended. There seems to be no reason why red or Scotch pine would not thrive on the pitch pine soils. These would produce a much better grade of lumber and give a higher yield per acre. The extreme southeastern portion of the white pine region may be too different climatically from the commercial range of the red pine to war-

rant its introduction, but elsewhere in the region red pine is recommended for planting, to replace the pitch pine. Probably a clear cutting of the pitch pine before planting with red pine will be best, as the latter does not require shade of an older stand in youth.

On the second class of soils where white pine could grow, the management should work to replace the pitch pine by white

Fig. 115. — Reproduction following clear cutting with the leaving of seed trees. The clear cutting was done about 10 years ago and the seed trees (the stump of one being seen in the foreground) were recently removed.

pine. If seed trees of the latter are in the vicinity it can often be done by protection from fire together with a clear cutting of the pitch pine in a white pine seed year. Indeed, the white pine, under fire protection, will reproduce abundantly, directly under the pitch pine stand, which has a favorable influence as nurse trees on the growth of the white pine for a few years.

Where white pine seed trees are lacking the white pine should be underplanted and a few years later the pitch pine stand cut clear.

4. *Pure White Pine.* — Several systems of reproduction can be employed with this type, as white pine reproduces well after nearly all styles of cutting.

Regular even-aged stands are desired, hence some method of clear cutting or the shelterwood system should be employed.

The scattered seed tree method will give good results if the proper type of seed trees are left. Three seed trees per acre are usually sufficient to insure a full reproduction. These trees can be taken out when the reproduction has started. Some lumbermen laugh at the idea of leaving scattered white pine seed trees, stating that from their experience the trees are sure to blow down. On investigation the experience of such men with seed trees usually proves to have been the leaving of tall, slender unmerchantable trees with a sprig of foliage at the top. Naturally such a tree has a feeble root system and a weak stem, and is liable to be uprooted and blown down by the wind, and moreover, is incapable of bearing fertile seed. It is in no sense of the word a seed tree.

Even when a sufficient number of first-class seed trees have been left, satisfactory reproduction may not follow the cutting. The principal cause of this failure is apt to be that the cutting has been made in a year which was not a seed year, and that before a seed year occurs the seed-bed conditions have become unfavorable or other species have usurped the site. Periods of three to seven years intervene between good seed years of white pine. In New England the years 1897, 1904, 1907, 1908, 1910, and 1911 were good seed years for all or certain portions of the region. If the cutting is made when the crop of seed has just ripened much of the seed is worked into the ground and the following spring advantage is taken of favorable seed-bed conditions, before grass, herbs, and other trees secure a start.

It is often inconvenient to delay the cutting until a seed year arrives, and this is one objection to the method, an objection which holds also against another good method, clear cutting in strips. In applying this system the strips cut over should not exceed two hundred feet in width or about three times the height

of the surrounding seed woods. This method could be used on large tracts, but is not suitable for a pine woodlot which must be cut over in one operation. After reproduction is secured the seed woods are removed.

Clear cutting with artificial reproduction should also be given serious consideration in selecting the method of reproduction. It has the advantage of making the operator entirely

Fig. 116. — Clear cutting with artificial reproduction. This stand of the white pine type is being cut clear. The hardwoods in the foreground are temporarily left but will soon be cut for cordwood. Note the small amount of brush. This will, however, hinder planting. It should be piled and burned, and the stand reproduced artificially.

independent of seed years, and enables him to cut every merchantable tree at one cutting. It is a more expensive method, but not so much more expensive as is often thought. Natural reproduction under any of the other systems requires some sacrifice in leaving trees or in slightly raising the cost of harvesting the crop. Owing to its greater certainty and more regular reproduction a somewhat higher cost for planting is justifiable. On small woodlots where the total amount of timber is too small to justify two logging jobs the use of artificial reproduction is always advisable.

The shelterwood system has some advantages for handling white pine over the clear-cutting methods of natural reproduction. For one thing a shelter is afforded the reproduction during the first few years, and there is less danger of the soil running wild to grasses, herbs, etc., and becoming unfavorable for the germination of pine seed. Even when this system is used it is

By permission of the U. S. Forest Service.

Fig. 117. — A 50 year old stand of white pine before the cutting shown in the next picture.

advisable to make the cuttings in a pine seed year, as otherwise undesirable species such as soft maple may reproduce.

In applying the shelterwood system the removal of the stand in two cuttings is recommended. The first takes out forty to sixty per cent of the volume, and the second, a final cutting, removes the remainder when reproduction is well established. Should the reproduction be patchy it may be best to make two, instead of one, final cuttings.

If an uneven-aged white pine forest is wanted for some special purpose, such for example as the æsthetic effect, it can be secured by use of the selection system. White pine responds well to this method of treatment. The timber secured is apt to be larger in diameter for the same age, but more knotty than that grown in even-aged stands.

Thinnings at regular intervals should be made where the stand is handled as an even-aged one. The thinnings can often be started as early as the twentieth year and be repeated at intervals of ten years or less. These thinnings, while having as their primary object the better development of the trees left standing, will yield substantial returns. The following table, showing yields from thinnings, has been compiled from figures secured in New Hampshire and Massachusetts, and published in the "Report of the New Hampshire Forestry Commission for 1905-1906," and in "Forest Mensuration of the White Pine in Massachusetts."

YIELD PER ACRE FROM THINNINGS IN THE PURE WHITE PINE TYPE IN STANDS NEVER THINNED BEFORE.

Age in years.	Trees over 5 inches in diameter.		Trees less than 5 inches in diameter.
	Massachusetts.	New Hampshire.	New Hampshire.
	Feet, board measure.		Cubic feet.
25.....	1,400	750	750
30.....	3,700	3,300	600
35.....	4,950	5,600	450
40.....	6,000	7,500	300
45.....	6,800	8,900	150
50.....	7,400	9,900	
55.....	7,900		

It is believed that for stands under thirty-five years the Massachusetts figures are best, and for stands over thirty-five years the New Hampshire figures are more desirable. The severity of the thinning has of course much to do with its yield.

The figures of yield given above are true only for the first thinning in stands not previously thinned. They do not show

what could be secured in a stand repeatedly thinned, for example, thinned in the twenty-fifth year and then at intervals of ten years, but the total amount obtained from repeated thinnings, say at the ages of twenty-five, thirty-five, forty-five, and fifty-five years, would exceed that secured by a single thinning at fifty-five years. If the age at which the last thinning is to

By permission of the U. S. Forest Service.

Fig. 118. — A cutting which removed about 50 per cent of the stand, and should result in securing reproduction. See Fig. 117.

be made is known, the yield given for a thinning at that age may be accepted as a very conservative estimate of what can be secured from a stand by the thinnings during the rotation.

The yield from thinnings, as explained in Chapter V, is secured without decreasing the final yield of the stand. The thinnings in the latter half of the rotation often result in the bringing in of pine reproduction and sometimes may result in fully stocking the ground. In such a case the entire stand

can be cut clear at the end of the rotation and the reproduction allowed to develop. The last thinning has then really been a first cutting under the shelterwood method.

The most profitable rotation for the pure white pine type is about fifty or fifty-five years. This is shown by the yield tables given in the New Hampshire Forestry Report for 1905-1906, and in "Forest Mensuration of the White Pine," issued by the State Forester of Massachusetts. These two tables

By permission of F. F. Moon.

Fig. 119. — A thinning in the white pine type showing the character of logs secured and the brush piled. This operation was carried on under the direction of the State Forester of Massachusetts.

differ in the exact financial returns to be secured, but agree in showing that the best returns are obtained by rotations of fifty to fifty-five years.¹ Using their figures it seems safe to assume a return of from five to six per cent compound interest on the investment for stands of the pure white pine type.

5. *Pine and Inferior Hardwoods.* — The object here is to get rid of the hardwoods, and to transform the type into a pure

¹ It may often be desirable to allow white pine stands to grow until seventy or seventy-five years of age, in order to obtain the large yields of high-grade timber, which can be produced on such a rotation, although a smaller return on the investment is secured than when using a lower rotation.

pine stand. (It will be remembered that the hardwoods in the type are gray birch, soft maple, and poplar, and are of little value except for cordwood.) The treatment to accomplish this transformation consists mainly in cutting out all hardwoods and leaving the pine. It can best be started as an improvement cutting (strictly a cleaning) in young stands, freeing the pine from crowding and overtopping hardwoods. In very young stands, too small to furnish cordwood, the hardwoods can be lopped back sufficiently so that their tops are lower than those of the pine. This provides for the proper development of the white pine in the stand, though it may not result in any further seeding. Where areas of more than a quarter of an acre are stocked with the hardwoods and there is no pine in the mixture, it is necessary either to cut clear and plant or else to secure pine reproduction naturally from adjacent seed trees. Planting is the quickest and surest, but natural reproduction can be secured by cutting clear the hardwoods when seed trees nearby have a full crop of seed. Whether artificial or natural reproduction is used it will be necessary to protect the pine seedlings from the growth of hardwood sprouts, which is almost certain to follow the cutting. This can be accomplished by means of cleanings.

When the type changes into the pure white pine type its treatment becomes the same as that described for the latter.

6. *Mixed Hardwoods*. — This is another type best handled as an even-aged forest, as that is its present form and the reproduction is quite largely by sprouts, making it desirable to maintain a regular even-aged character.

The shelterwood system or the modified form of this system, known as the polewood coppice system is advised. As the mixed hardwoods type of this region occurs in greater abundance and is the chief commercial type in the adjacent forest region to the south (sprout hardwoods region), a full discussion of its treatment has been given under this latter region, to which the reader is referred. The same general method of treatment can be used in both regions.

The hardwoods to favor are white ash, red oak, black cherry, and chestnut, — the latter only in case the chestnut bark disease loses its virulence within a few years. There is sometimes a small mixture of white pine in the type, and where this is the case the pine should be favored and the pine seed trees left when the final cutting is made.

7. *Soft Maple Swamp*.—Soft maple cordwood will always be the main product of this type. This species will yield greater amounts of wood on the site than any other, and should be favored. On some of the better sites a little soft maple lumber can be secured. On such situations some of the better associates of the soft maple, such as yellow birch, should be encouraged on account of the greater value of their timber. There should be no attempt, however, to eradicate soft maple from the stand. The simple coppice system is well adapted for reproducing soft maple swamps, since the maple coppices freely, and on swampy land produces vigorous sprouts. Where cordwood only is desired a rotation of thirty to forty years should prove most profitable. Where some lumber also is wanted a forty to fifty years' rotation will be better. If the longer rotation for lumber is used two thinnings at least should be made during the rotation. The coppice with standards could also be used to advantage where soft maple lumber was wanted, cutting the coppice on a thirty-year rotation, and the standards when sixty or ninety years of age. On a short rotation of thirty years for cordwood it will be unnecessary to make any thinnings.

8. *Waste Land*.—The treatment needed by this type of land is protection from fires, and planting. Because of the sandy nature of the site planting should be with pine; in many cases white pine, but on the poorest sites red pine or in the most unfavorable situations pitch pine or Scotch pine should be substituted for the white pine.

The loose sandy character of the soil makes the expense of setting the plants comparatively low. Strong, sturdy stock, transplanted, and at least three years old, should be used. Usually the present growth of scrub oak, shrubs, etc., is not

dense enough nor of such rapid growth as to interfere with the development of the plantation, which is often benefited by a light shade for a few years.

Included in the waste land type are certain lands in Massachusetts¹ at the end of Cape Cod, covered with drifting sands. The surface soil here is continually shifting, being blown by the winds into huge sand dunes. These moving dunes are a menace to adjoining lands as well as being utterly unproductive. The lands were formerly wooded, but as a result of cutting, grazing, and forest fires have been rendered barren. In order to stop the movement of these shifting sands it is necessary to reestablish the forest cover.

This is the most difficult planting proposition in the region, and one of the most difficult in the whole country. It is an example of protective planting, calling for a large outlay, too great to make the work pay financially. It is, therefore, a project which the state or federal government, rather than an individual, must handle.

Trees cannot be planted at once on such land. It is necessary first to hold the sands temporarily with some other form of vegetation. Usually beach grass is planted first, then some sort of a shrub such as bayberry is introduced. After these woody plants have become well established trees are set out. In past experience pitch pine, Austrian pine, Scotch pine, black locust, and black alder (*alnus glutinosa*) have all been successful.

Since sand dunes form but a small fraction of the land in the waste land type, a more detailed discussion of planting such land is unnecessary here. The reader is referred to an excellent bulletin on the subject, which gives the details of what has been done in planting the dunes on Cape Cod.²

¹ Approximately 2000 acres.

² Bulletin No. 65 of the United States Bureau of Plant Industry, entitled "Reclamation of Cape Cod Sand Dunes."

LOGGING METHODS, MARKET CONDITIONS, INDUSTRIES, OWNERSHIP OF WOODLANDS.

Logging Methods. — The topography of the white pine region makes logging here a relatively easy matter. Cutting and hauling of logs is often carried on the greater part of the year. This practice is most common in the central and southern portions of the region, where snow cannot be relied on for winter

Fig. 120. — The white pine type. A light thinning in a stand 40 to 50 years of age.

logging. In the southern portion for a few months in the summer the heat makes logging expensive. In the northern portions, with more snow, there is more of a tendency to concentrate logging operations in the winter.

Clear cutting has been the usual method of logging in the past. It will not need radical change when forestry methods are introduced. The use of thinnings, leaving of seed trees, and removal of a mature stand in two operations instead of one are the principal changes recommended. Under nearly all the systems of reproduction advised in the preceding chapter a final clear cutting of the stand is included.

The mills are of small capacity, either portable or stationary in character, the former being the more usual. With such a mill the lumberman can move onto the lot to be cut, the topography making this possible in nearly every instance. The owners of the mills often farm part of the year and saw timber during the remainder. Lack of virgin timber and the decreasing size and number of the tracts of timber to be cut is causing the same trend from portable toward stationary mills as was described in the northern hardwoods region. It is so much easier to take a mill onto a woodlot in the white pine region as contrasted to the northern hardwoods region that portable mills will perhaps always hold first place. There are also fewer available water-power sites for stationary mills than in the latter region.

Market Conditions. — Conditions for the sale of forest products are far better than in the two preceding forest regions and slightly better than in the sprout hardwoods region. Railroads ramify all parts of the region. Most of the area lies less than five miles from railroad lines, but a few points can be found, twelve to fifteen miles distant in a straight line from a railroad. The Maine and Central New Hampshire portions have the poorest railroad facilities.

The region is characterized by a dense population, the Massachusetts section being one of the most thickly settled sections in the United States, with the innumerable large towns situated here.

As would be expected with such a dense population this is not a timber exporting region. It does not produce enough forest products to supply its own local demands,¹ and large quantities of timber are imported.

The dense population creates a strong demand for wood, and makes possible a closer utilization than is found in the other New England forest regions. The possibility of utilizing small material is often the cause of cutting stands on short rotations,

¹ This does not mean that some products, like white pine for boxes, are not shipped outside.

sometimes as low as twenty years for timber, and even lower for some special product like willow wood for powder (cut on a rotation of seven to nine years).

Industries. — The white pine region is a great manufacturing and commercial region. These pursuits rank first, with agricultural interests second in importance. Strictly forest industries hold a subordinate position. Among the latter the lumber industry leads, the greater part of the timber cut being sawn into lumber of some sort rather than used for ties, pulpwood, telegraph, and telephone poles, etc.

The total lumber cut of the region exceeds one billion feet, being estimated at 1,085,402,000 feet,¹ board measure. Of this amount 935,000,000 feet,² board measure, was white pine and the balance, 150,402,000 feet, board measure, was mainly chestnut and hemlock with a variety of other woods. As the total amount of white pine cut in the United States in 1909 was 3,900,034,000 feet, board measure, this region is evidently an important producer, ranking second to the Lake States, which cut considerably over 2,000,000,000 feet, board measure.

The region is well equipped with numerous wood-working plants, in this respect leading the other New England forest regions. A large per cent (probably less than fifty per cent) of the lumber cut is worked up by these special wood-working plants into a variety of products. The most important of such products, both in amount of native grown lumber used and in value of the output, is the wooden-box industry. In fact the white pine region is characterized by the extent to which the box industry has developed within its borders, deriving its main source of supply from the white pine. The boundaries of the region correspond closely with the territory in New England covered by the box industry. The large number of manufac-

¹ The figures given here are based on the cut for the year 1909, as computed by the United States Bureau of the Census.

² This is approximately the amount of white pine cut in the New England States. A small per cent of it was undoubtedly cut in the other New England forest regions. Just how much it is impossible to determine and it has all been credited to the white pine region.

turing plants in the region create a heavy local demand for all kinds of wooden boxes; and it is fortunate that a wood so suitable for box construction as white pine is available.

There are several hundred box factories in the region, consuming annually from a few thousand to twenty and thirty million feet apiece. However, the small boxmen are gradually

By permission of the Massachusetts State Forester.

Fig. 121. — A heavy thinning in a rather open grown stand of white pine. Note the brush piled in the openings ready for burning.

giving way to the stronger concerns, owing to the difficulty of getting timber. Frequently a box shop is run in connection with some other wood-working plant to utilize the coarser grades. In some cases, as for example some of the shoe makers of eastern Massachusetts, manufacturing concerns maintain their own box shop for construction of the boxes needed in shipping their output. In connection with the production of white pine lumber for box boards close utilization is possible. Logs less than three inches at the top are sometimes run through the mill. Usually the lumber is sawn by the portable mills into planks or one-inch

boards, and later resawn in the box shops. The custom prevails in some localities in Massachusetts of cutting logs into very short lengths (often under four feet), and sawing the boards at the portable mills into thicknesses of a fraction of an inch, five-eighths inch being a common thickness. The contents, in feet, board measure, of such boards is figured as though they were of full inch thickness, which is somewhat confusing to the uninitiated. Each box shop employs a buyer, who purchases

Fig. 122. — Plant of the Diamond Match Co., at Athol, Mass., where white pine lumber is resawn into match blocks and shipped to the match factories.

logs or sawn box boards. Very few shops own the necessary amount of standing timber to supply their plant.

In some sections, especially around Athol, Massachusetts, a good deal of the white pine cut goes into the manufacture of matches. Material for matches has to be of a little larger size than for boxes and staves. Logs under six inches at the top are ordinarily disposed of to box shops or stave factories.

Beside the timber cut for lumber there are large quantities of material taken out in the New Hampshire, Massachusetts, Connecticut, and Rhode Island sections for railroad ties, telegraph, telephone, and trolley poles, and cordwood. Chestnut is the

principal species thus used, while oak is used for ties, and all species are used for cordwood.

In possibilities for the sale of cordwood the white pine region excels the other New England forest regions. This is due mainly to the dense population, which affects the sale of cordwood in two ways; first, by affording a market, and second, by making possible close utilization for other more valuable products, and hence effecting a reduction in the amount of material which has to be put into cordwood.

This last point has special weight with conifers which lend themselves more readily to close utilization in the tops for valuable products than do hardwoods.

Ownership of Woodlands. — The forest is held mainly in woodlots and small-sized tracts. The size of the average farm is about eighty to one hundred acres and part of it is usually wooded.

In Massachusetts, in the year 1906, the records showed only forty-five holdings of over one thousand acres each, and a number of them were in the western part of the state, outside the white pine region. In Maine, New Hampshire, and Vermont a relatively larger number of big holdings exist, but a holding of 10,000 acres is an exceptionally large tract for the region, and very few occur.

The large holdings are either in the possession of box concerns or lumbermen, or form private preserves and parks. All these classes of owners are apt to increase in the future. Except for small scattered tracts in Massachusetts, not exceeding a few thousand acres, and a couple of small state forests in Connecticut, the states do not appear as owners of forests lands.

FOREST PROTECTION.

Forest Fires. — It might at first thought seem that the white pine region with its wooded area broken up into woodlots, and with its dense population, should be comparatively free from fires. Unfortunately increased density of population is not necessarily accompanied by decrease in the number of forest

fires. In fact, an increase in population, due to manufacturing development, often brings in a class of people, who, by their carelessness, increase the fire danger. The railroads are numerous and carry a heavy traffic, and frequently traverse wooded areas instead of passing mainly through cleared valleys, as in the northern hardwoods region. There are large areas, in the aggregate, of coniferous stands on dry sandy soils, a combination causing great fire hazard. A large majority of the fires, and

Fig. 123.— A stand of white pine has just been cut clear here, for sawlogs and cordwood. The brush should be piled and burned and the land planted.

the most dangerous, occur on such situations. For these reasons the danger and frequency of forest fires is even greater than in the two forest regions already discussed.

Both surface and crown fires occur, though the former is the prevalent kind. On sandy soils, where the growth is pure or nearly pure of conifers, the surface fires may develop into destructive crown fires. The extent to which gray birch has spread over lands formerly in white pine or valuable hardwoods is the result largely of fires rather than cutting. This is one of the worst effects of forest fires in this region. On the

sandiest soils scrub oak is encouraged in the same way. The fires are, of course, more apt to start on cut-over lands, but run readily through stands of heavy timber. The ground cover of wet moss characteristic of the forest in the spruce region, and which, under ordinary circumstances prevents fire in an uncut stand, is here lacking. On sandy and gravelly soils in the white pine region the pine duff readily dries out and becomes inflammable. Stands of young pine fall an easy victim even to light fires, as on entering such a stand the fire feeds on the tinder-like dead branches covering the lower parts of the trunk.

The forest fire season is a longer one in the white pine region than in the two more northerly ones, due to the shorter winters. This is mainly noticeable in the southern half of the region, and not in the Maine, Vermont, and New Hampshire portions. Statistics published by the State Forester of Massachusetts for 1909 show that fires occurred in that state during every month in the year except December. In other years fires have occurred during that month, so that the season can be said to last the entire year, but for practical purposes the winter months are free from fires. Beginning the first of March and from then until well into November, forest fires may be expected. As previously stated in discussing fire conditions in the northern hardwoods region, the occurrence of wet or dry periods throughout the year really fixes the dangerous fire season. Within the last few years there has been variation enough in climatic conditions to allow serious fires in all months of the year, from March to November, inclusive. Prolonged droughts under present conditions are certain to result in a large number of forest fires.

Railroad locomotives are responsible for starting more forest fires than any other known cause. The close network of railroad lines and the frequent passage of locomotives directly through wooded areas increase their importance as a cause of fires. In the sections where extensive wooded areas occur on sandy soils, as, for example, in southeastern Massachusetts, locomotives are especially dangerous to the forest. Many fires

are set through carelessness in the use of matches or tobacco. Fishermen and hunters in the woods and especially people simply out for pleasure are responsible for this class of fires. On Sundays and holidays during the warmer months and in the vicinity of manufacturing towns many fires are apt to start from such causes. It is much more difficult to trace the cause of fires due to carelessness than those due to railroads since they may start in the most distant and out of the way places, while the latter start near the track, and therefore in a locality which can be easily reached and often is well watched.

Doubtless a large number of the fires of which the cause is reported as "unknown" are due to carelessness. It is believed that if accurate information about all fires could be secured carelessness would have to be ranked as at least equal to railroad locomotives as a cause of forest fires in the white pine region.

Burning brush in clearing land gives rise to a good many fires and should be ranked as third in importance among the causes of forest fires.¹

Methods of Fire Protection. — The situation as regards fire protection is the same in many respects as in the northern hardwoods region. Small areas of woodland lying in isolated bodies interspersed with cleared land are held by countless individuals. Here again state control of the organization for fire protection, with active wardens in each town, will be the ideal system.

The comparatively level nature of the country, with only small differences in relative altitude, make mountain lookout stations less effective than in a hillier country. There are a few peaks considerably above the general level which offer good sites for such stations. Mount Monadnock, in southern New Hampshire, and Wachusett Mountain, in northern Massachusetts, are two examples, but it is inadvisable to endeavor to extend a system of stations over the whole region. Good telephone facilities and the numerous local wardens will take the place of mountain lookout stations.

¹ See the appendix under "Forest Fire Statistics" for further information.

Fires caused through the carelessness of people in the woods are so frequent that special stress should be laid on educational measures. In the northern hardwoods region, with a population engaged largely in agricultural occupations and a high percentage of the inhabitants interested in woodlands, the necessity for arousing public sentiment against forest fires does not so strongly exist as in a densely populated section like the one under discussion, with many manufacturing towns close to wooded areas. Here a great number of people, entirely ignorant of and indifferent to the damage done by forest fires, and not owning woodlands, are found taking their pleasure in the woods, and are responsible for numerous fires. They must be educated to see the harmful results of these fires. The local fire wardens should thoroughly post their districts with warning and instructive notices concerning forest fires, printed in several languages, to meet the needs of the local population. To supplement these notices the newspapers should be furnished with plenty of copy on the subject. A campaign for better enforcement of the laws punishing persons setting fires, especially if a few convictions can be secured, will do much toward lessening the number of fires set intentionally.

The great danger of fires starting from railroad locomotives, which is amply proven by statistics, should lead to special efforts to reduce the fires from this cause with the purpose of finally eliminating locomotives as a source of forest fires. This may eventually come by the use of a safer fuel than wood or coal. On a few of the main lines electricity will probably be voluntarily adopted by the railroads within ten or fifteen years, but the general adoption of a new fuel, while undoubtedly most advantageous from a fire standpoint, will come only through state regulation. Since the main lines of railroads in the white pine region traverse alternately open and wooded land it is doubtful if a compulsory change of fuel could be secured, but with branch lines extending chiefly through woodland the use of a safe fuel might reasonably be demanded.

Until such action can be secured emphasis must be placed on

having railroad rights of way patrolled in wooded sections. This patrol should be in effect from early in the spring until late in the fall, only being laid off during rainy periods. The cost of the patrol can justly be laid upon the railroad. Indeed, when the amounts of money spent annually by them, in the white pine region, for settling damage suits arising from forest fires set by their engines, are contrasted with the cost of patrol, the latter will be found cheaper. Patrol will also result in making productive the wooded section tributary to the railroad lines, and build up the lumber business instead of turning the country into a desolate waste.

Besides patrol the use of fire lines along railroads in exceptionally dangerous country is advised. A plan similar to the New Jersey law regarding railroad fire lines should give the best results. Under this law the railroads are obliged to clear a line on each side of the track one hundred and ten feet in width. This must be cleared and kept clear of all inflammable material and small trees. The trees left on the line are trimmed of branches for six feet above ground. The last ten feet on the outside edge of the fire line should be entirely clear. The law has been in operation since 1909, and has given satisfactory results. The cost of the first clearing of the line varies with the nature of the forest growth, but ranges from about \$125 to \$500 per mile. Maximum costs come on rocky, hilly land, covered with hardwood growth, while minimum costs obtain on pine plains.

It would be well if such a law could be secured by the various states for use in the white pine region, the fire lines to be constructed along such stretches of railroad right of way as the state forestry officials might designate. It should first be applied to all lines passing through coniferous stands, and in hardwood growth at all places where the railroad has a heavy grade.

So far the use of fire lines has been advised only in connection with railroads, but they are also needed in the more extensive and unbroken forest tracts found on poor, sandy soils. For details in the use of such lines see Chapter VIII.

Inasmuch as very heavy or clear cuttings are the present custom and advisable under management, it follows that there will be a considerable amount of slash left after cutting. The close utilization reduces the slash but in heavy cuttings it is still

Fig. 124. — "Pine succeeding pine." Excellent reproduction of white pine on land cut clear, having seed woods adjoining, really the clear cutting in strips method of reproduction, though accidentally used.

a fire menace. This is especially so in pure coniferous stands, where the slash should always be removed. In hardwood stands the tops decay quicker and where cordwood has been taken out to a low limit disposal of the brush is not so essential, as the leaf litter furnishes the chief fuel for the fires.

Of the various methods of brush disposal piling and burning the tops as the logging is in progress is silviculturally preferable and should be the cheapest. Fires should be started at convenient points and the tops thrown on these fires as the trees are felled and trimmed. When done in this way the cost should range from ten to forty cents per thousand feet of lumber cut. The method can only be used when there is no danger of the fires spreading, and is therefore best for winter operations. In dry weather no burning should be done, and if logging is carried on it will be best to throw the tops into piles and burn these piles later, in a wet season. It may seem as though no special harm would be done if the fire was allowed to spread over the entire area logged, since it is clear cut, but the burning would result in making seed-bed conditions more unfavorable for the pine and very favorable for the reproduction of gray birch. Then, again, even on clear-cut areas there is apt to be reproduction which must be protected as well as any seed trees that were left.

Methods of Fighting Fires. — Owing to the well-settled conditions of the country in the white pine region the more intensive methods of fighting fires, such as the use of bucket pumps and chemical extinguishers,¹ are strongly recommended. It is in this region that the highest development of the use of extinguishers has been reached, by having special fire wagons equipped with extinguishers and all the necessary accessories.

Any town in the white pine region, in which the forest fire hazard is great, can profitably invest in one of these wagons.

Where pumps and extinguishers are not available the tools and methods of fighting surface fires and crown fires described in the two preceding regions should be employed. In sandy country there is plenty of loose dirt available and throwing this on the fire is the best method next to the use of water. Ground fires do not often occur.

Protection Against Grazing Animals. — Since dairying is the most important agricultural pursuit for the region as a whole

¹ For full description see Chapter VIII.

a great deal of grazing occurs on lands partly or completely forested. Damage by browsing is not so important as in the northern hardwoods region, because here the chief species, white pine, is practically immune from browsing by animals. The principal injury through grazing in the region is in lowering the reproduction of a tract, through partial stocking of the forest and competition of grass with the trees.

Fig. 125. — An open stand of the white pine type. The lack of reproduction in the openings is due to the grazing of stock.

What has been said under the northern hardwoods region, in regard to using lands either altogether for grazing purposes or for forestry purposes, applies in the white pine region.

Protection Against Insects and Fungi. — The white pine weevil is one of the most injurious insects in the forest of this region. It is abundant everywhere attacking the white pine, and should be looked for on every tract. Its habits and the method of prevention have been given in Chapter VII.

Both the gipsy¹ and brown-tail¹ moths are working in restricted portions of the white pine region. The damage done

¹ See Chapter VII.

by these pests to forest growth is so great that where they occur special methods of treating the forest often are needed.

There are no serious fungous diseases in the region against which it is practical to take remedial measures. The white pine blister rust has been found in a few cases on young pines imported from Europe, but unless continued importations of nursery stock are made from abroad the general spread of the disease in this country need not be feared.

The chestnut bark disease has already appeared in the Rhode Island and Massachusetts sections of the region and threatens the destruction of the chestnut. In the summer of 1911 the State Forester of Massachusetts had a party in the field ascertaining the extent to which the disease had spread, and acquainting forest owners with the disease. If the owners desire they can cut out the infected trees, but it is doubtful if the work will be thorough enough to prevent its spread.

Watershed Protection. — Watershed protection is needed in the white pine region, not so much for regulating steamflow¹ as to assist in keeping the streams pure for drinking purposes. The large number of towns and cities must be supplied with water, and in New England the water is secured largely from springs and streams with more or less extensive watersheds. Unless the water is filtered it is desirable to have a forest cover, which prevents surface run-off and causes the water to seep through the ground and come into the reservoirs free from impurities.

SUMMARY.

1. The white pine region is a manufacturing region with agriculture and lumbering following in the order named.
2. It is one of the three (eastern) white pine regions and is second only to the Lake States in annual cut.
3. It contains a high percentage of true forest soils.
4. The market conditions are so favorable as to encourage the practice of forestry on an intensive scale. In this respect it is one of the most promising regions in the United States.

¹ See explanation given under northern hardwoods region.

CHAPTER XVI

THE SPROUT HARDWOODS REGION.

GENERAL CONSIDERATIONS.

THE sprout hardwoods region occupies the extreme southern part of New England, including the greater portion of Connecticut and Rhode Island and a small area in the southwestern corner of Massachusetts. The region is not co-terminous with its New England boundaries, but extends southward through a corner of New York State into New Jersey and Pennsylvania. The present study is confined, however, to the New England portion.

On account of its southern situation and proximity to the coast the climate is more moderate than in the other forest regions of New England. It has the same rainfall of forty to fifty inches, but in temperature and duration of the winter season conditions are more favorable for the growth of certain species.

The region lies mainly below the six-hundred foot contour, and a great deal of the land is below two hundred feet in elevation. In Connecticut a broad central lowland runs from New Haven northward across the region, and on either side are highlands. These rise gradually from near sea level to over two thousand feet in a few peaks of southwestern Massachusetts. On the eastern side of this central area the hills do not average over five hundred feet. These highlands represent geologically a plateau which has been eroded by water and carved into a more or less hilly country. The eastern highland extends into the Rhode Island portion of the region, but in the eastern part of the state drops to somewhat lower levels in what is known as the Narragansett Basin.

In the neighborhood of the coast, throughout Rhode Island,

and in the central lowlands of Connecticut, gently rolling land is characteristic. In the northern, and especially in the western part of the region, the country loses this gently rolling character and becomes quite hilly.

Extensive stretches of level plain also occur in the central lowland. The level or rolling country of this plain is, however, broken in a most striking and picturesque manner by small

Fig. 126. — General view showing the distribution of the forest in the sprout hardwoods region. In the left center is seen a small knoll occupied by the old field type. The other wooded areas are of the mixed hardwoods type.

areas of rocky hills and mountains, which rise abruptly from the general level, in some cases reaching an elevation of over six hundred feet. Differences in the underlying rock account for the varied topography of the region, granites, gneisses, and schists prevailing over the greater part of the area, especially the highland portions. In the central lowland of Connecticut the bed rock is a soft red sandstone, which has been worn down more rapidly than the rocks of the highland areas. Soft rocks also occur in the Narragansett Basin. The isolated hills, rising abruptly from the central lowland, are intrusions of hard trap rock. The West Rock Ridge, near New Haven, and the

Hanging Hills of Meriden are excellent examples of these trap ridges. In a few places in western Connecticut, especially in the northwestern corner, and also in parts of the Massachusetts section, beds of limestone rock occur.

Drainage trends southward into Long Island Sound. The Connecticut is the largest river, and cuts directly across the region. This, together with the Housatonic, and its branch the Naugatuck, and the Thames drain the greater part of the region. These streams, where passing through the highlands, have often worn canyon-like valleys, on the slopes of which the steepest topography is found. On their lower reaches most of the streams are tidal and navigable to the head of the tide-water. Small lakes and ponds, while not so abundant as in the white pine region, are still plentiful. The streams afford many excellent water powers.

Areas of swamp are common. In the highlands the swamps occur on the plateau rather than in the valley bottoms, while near the coast extensive swamps sometimes occur near the main streams.

The soils owe their origin to glacial action, which has been present over the whole region. A great variation within short distances is common, ranging from coarse sands to a heavy clay, but the total amount of clay soil is not great. As a general rule the soils are fertile and do not average so sandy as those of the white pine region. They are characterized by the presence of abundant loose rock. This is rarely entirely absent except in the soils of the central lowland of Connecticut. Here are frequently found sands, loams, and clays free from stones.

The amount of loose stone present, the depth of the soil down to the underlying bed rock, and the degree of slope are the chief factors determining whether a soil is agricultural or best suited for forests. About forty per cent of the region must be classed as true forest soil. Approximately this percentage is forested at the present time. The mountains of trap rock, with their shallow soils and steep sloping sides, furnish excellent examples of permanent forest soils.

Long belts of forest occur on these trap ridges, elsewhere a broken distribution of the woodland is the rule. However, in some of the rougher sections of the highland eighty to ninety per cent of the country is in forest, while in other places, with gentler topography, the per cent of open land and forest is reversed.

This is a country in which the first settlement dates back many years, and as a consequence the original forest has disappeared with but rare exceptions. In the present forest the growth is made up chiefly of sprout trees, often of the third and fourth generation. Timber exceeding one hundred years of age is extremely rare.

The forest is composed of even-aged mixed hardwood stands. These are characterized by the abundance of chestnut, which often occurs pure and frequently forms more than one-half the growth over large districts. Commercially chestnut is even more important than the area in the forest occupied by it would indicate, on account of its rapid growth, and because it has a wider range of uses than any of the other species in the region.

Next in importance rank the oaks, the following five being the most important; white, red, black, scarlet, and chestnut oaks.¹

Chestnut oak makes its only appearance in New England in this region.

Not a single species finds its optimum range in the sprout hardwoods region. The oaks and chestnut all secure conditions for their optimum development farther to the south. Gray birch comes as near as any tree to securing optimum conditions, but thrives somewhat better in the white pine region.

Conifers are scarce, and not an important factor in the present forest. Originally quite large bodies of pitch and white pine occurred, but they were on the sandier soils in the lowland region, on lands easy to clear, and adjacent to the earlier settlements. Hence the large stands disappeared long ago. Occasional isolated individuals or small clumps of these conifers may

¹ Several other species of oak occur botanically within the region.

be found. Hemlock and southern white cedar are both present, and occasionally in commercial quantities. Red cedar is the most abundant conifer.

A great variety of hardwoods, such as beech, hard and soft maple, hickory, white, red, and black ash, yellow and black birch, tulip tree (or whitewood as it is called in this region), swamp white oak, white and pin oaks, basswood, butternut, and poplar are in mixture with chestnut and the principal oaks.

FOREST TYPES.

It is difficult here to distinguish between temporary and permanent types. The forest in its species and mixtures is not far distant from the original stands, yet, in its regular form, sprout origin, and certain changes in mixture, is quite different from the original growth. Mainly on account of the sprout origin of all but the coniferous stands it is considered best to class all the types as temporary.

The types are six in number, as follows:

TEMPORARY FOREST TYPES.

1. Mixed hardwoods.
2. Hemlock.
3. Hardwood swamp.
4. Cedar swamp.
5. White pine.
6. Old field.

1. *Mixed Hardwoods*.—This is the most important type commercially and in area. No accurate figures are available, but it is believed that the type covers at least eighty per cent of the forest area. It is common throughout the region and occupies a wide range of sites, from the shallowest soils to those deep and fertile enough for agricultural purposes. The type does not occur on very poor, sandy soils, or on swamp sites. Within it a wide range of composition is included. A mixture of oak and chestnut is characteristic, but all sorts of variations

from pure stands of oak to pure stands of chestnut occur. The quality of the site is the governing factor in controlling the composition. On dry, shallow soils the oak becomes pure; on deep, well-drained loams chestnut can be expected in pure stands. On soils of medium depth the oak and chestnut meet on equal terms. The oaks included in the type are the white,

By permission of the Connecticut State Forester.

Fig. 127. — A pure stand of chestnut, estimated to contain 22,000 feet, board measure, per acre. (The mixed hardwoods type.)

chestnut, red, black, and scarlet. It is not uncommon to find pure stands of chestnut oak alone on dry ridges, though mixtures of several species are more usual.

Other trees, such as hickory and soft maple, are characteristic though usually in a subordinate position. Occasionally hickory is found nearly pure, over small areas. The number of species in a single stand is greatest on the best sites, while on the shallowest soils only a few species grow. On third quality sites chestnut oak and hickory predominate.

The stands are even-aged in form and almost entirely of sprout origin, although a few seedling trees can usually be found.

The type yields all classes of forest products, such as cordwood, ties, poles, piles, and lumber. The kind of product, and the yield at a given age, depend greatly on the quality of the site, cordwood being the only product of the poorest soils. The percentage of chestnut in the stand greatly influences the yield of lumber and particularly of poles, piles, and ties, as many of the other species are not used for these purposes. Until recently reliable figures on the yield of the type had not been secured, but in 1910 the Connecticut Agricultural Experiment Station, in coöperation with the United States Forest Service, made a thorough study of the growth and yield of the type.¹

Generally speaking, in stands of pure chestnut a growth of about one cord per acre per year may be counted on in all but the poorest stands, while in stands of pure oak the growth rarely exceeds eight-tenths of a cord per acre per year on the better sites and may be as low as a quarter of a cord on poor soils. Maximum yields of lumber for stands containing a high percentage of chestnut run between 20,000 and 25,000 feet, board measure. In Connecticut it has been estimated that 30,000 feet, board measure, is the maximum possible yield on average soil for a pure chestnut stand (planted) at the age of seventy years. It is interesting to contrast this with the yields secured from unmanaged stands of pure white pine (see page 306). At seventy years a pine stand gives 55,800 feet, board measure, per acre on soils of average quality. These pure chestnut stands, the most productive in lumber of the hardwood types in New England, are by many persons erroneously considered to be as rapid growing as white pine stands. Actual figures prove quite the contrary and illustrate the great superiority of the white pine.

2. *Hemlock*.—The hemlock type is not one which covers a

¹ See Bull. 96 U. S. Forest Service.

large area, occupying less than five per cent of the total forested area. In the original forest the type was a more important one. It is generally distributed throughout the region on steep slopes and cool exposures where there is an abundant supply of atmospheric moisture. Stream gorges furnish ideal locations for the type.

Hemlock forms thirty to one hundred per cent of the composition, having as associates the chestnut oak, red oak, and

Fig. 128. — The hemlock type in the bottom of a ravine. Both chestnut and red oak are in mixture with the hemlock. Yield 20,000 feet, board measure, per acre.

chestnut, though many of the other hardwoods in the region may be present.

The hemlock has a tendency to spread over areas of the mixed hardwood type where the site conditions are favorable. It does this by seeding beneath the hardwoods where it persists and grows in the shade, due to its great tolerance. Finally if not removed by fires or cutting, it will thus secure for itself a place in the stand and cause a reversion to the hemlock type.

Oftentimes the type is two storied in form with a lower story of hemlock and an upper story of hardwoods. The most typical natural form is even-aged, either pure hemlock or

mixed hemlock and hardwoods, although in these stands there are apt to be several ages of hemlock represented. The hardwoods are usually of sprout origin. Sometimes, on account of inaccessibility on a steep slope, old growth of seedling origin persists.

It is a slow-growing type, producing lumber, however, and giving maximum yields as high as stands of pure chestnut but at a greatly advanced age (one hundred to one hundred and fifty years).

Fig. 129. — The hemlock type, occurring in a swale on the summit of a ridge of trap rock. The stand contains 10,000 to 15,000 feet, board measure, per acre.

3. *Hardwood Swamp*. — In point of area this type ranks second in importance, although probably less than ten per cent of the total area is characterized by it. It occurs throughout the region, but is most abundant along the Connecticut coast, especially in the eastern half of the state and in Rhode Island.

The soils are not well drained, and contain an excess of moisture. Many of the swamps when drained make excellent agricultural land, while others are too stony for such purposes.

Soft maple is the leading tree in the type, often growing in pure stands, especially in the wetter swamps but by no means

confined to them. In the drier situations, a mixed growth usually prevails with such trees as pin and swamp white oaks, white elm, white and black ash, gray and yellow birch, and whitewood in mixture with the maple.

Very little lumber is produced in the hardwood swamps, most of the material being only fit for cordwood. It is usually a rapid-growing type, except in situations where water stands for a good part of the year, and checks fast growth. On the average a growth of over a cord per acre per year can be expected from the hardwood swamps. Reproduction is almost wholly by sprouts.

4. *Cedar Swamp*. — In the section within twenty miles or so of the coast are found occasional swamps of southern white cedar. This same type was described in the white pine region, to which reference should be had for details. It covers an extremely limited portion of the forest area, probably a small fraction of one per cent, and deserves mention chiefly from its strong contrast in character of growth to the hardwoods swamp type.

5. *White Pine*. — The white pine type represents an extension southward of the chief type of the white pine region. Only a small per cent of the forest area is covered by this type, which is in area of less importance than the hemlock type. Its high yield per acre and the value of white pine lumber makes it a type of commercial interest.

Throughout Rhode Island and eastern Connecticut more of the type occurs than elsewhere. As a result of planting open lands with white pine the type will steadily increase in importance. For further description of the type the reader is referred to the type of the same name under the white pine region.

6. *Old Field*. — This is a widely distributed type, occupying lands at one time cleared, and covering about the same area as the hardwood swamp type, hence ranking second or third in importance. The soils are usually medium in quality, since the best have been reserved for farming and the poorest were never cleared. Red cedar and gray birch are the two

trees which form the typical forest growth on old fields. Pure stands of either species and mixtures of the two are all found, but pure stands are more common than mixtures. Gray birch is a species which requires a bare soil for a seed-bed, while red cedar can start well under more adverse conditions, even in a thick sod. This difference in the habits of the two species ex-

Fig. 130. — On the flat is a stand of the best quality swamp hardwoods. Soft maple, tulip tree, yellow birch, black birch, and elm are the principal species. A thinning is needed.

plains why pure stands now of one species and then of the other are met with on old fields. The gray birch seizes possession of those fields which were abandoned after having some other crop than grass, while on abandoned pasture or meadow opportunity was given the cedar to form pure stands. A fire running over a pasture or meadow might result in exposing mineral soil and creating a seed-bed favorable for gray birch.

Poplar, soft maple, and black birch are oftentimes associated with the gray birch and cedar. Stands of all degrees of density are found, from almost bare fields with a sprinkling of birch or cedar to a closed canopy. As the stands grow older the seeding up of the fields becomes more complete and the stand finally becomes a dense one.

Fig. 131. — A stand of the old field type which has nearly finished the process of reversion to the mixed hardwoods type. A liberation cutting is needed, removing such trees as the big spreading chestnuts at the right in order to favor the young growth of white oak and black birch underneath.

Both uneven-aged and even-aged forms of forest are characteristic of the type. When gray birch seeds up an old field it usually takes possession in one year, resulting in an even-aged stand, but red cedar is rarely found in such stands. This tree seeds in slowly, and stands containing a large per cent of cedar are extremely uneven-aged in character.

The type is strictly a temporary one, for as the stand ad-

vances in age chestnut, oak, hickory,¹ and white ash reproduce and develop beneath the light shade of the gray birch and cedar. These good hardwoods are more rapid growing than the cedar and do not mature so early as the gray birch. Hence they are able finally to crowd out the cedar and gray birch and change the type to the mixed hardwoods type. This is a long process, rarely as short as fifty years and sometimes requiring one hundred and fifty years for its completion.

Cedar furnishes an excellent grade of fence posts, but the chief product of the type is a poor quality of cordwood. The stands of pure gray birch are rapid growing for the first twenty years, and soon after that time begin to deteriorate, while those containing cedar are extremely slow in growth through life. Measurements show that it takes about forty years to grow a red cedar fence post eight feet long and four inches at the top.

METHODS OF HANDLING THE FOREST.

Intensive methods of management are possible throughout the greater part of the sprout hardwoods region. It is only in relatively few places, remote from the railroads, that intensive methods cannot be used, and here only because the sale of cordwood does not yield a profit. Within a distance of six miles from a railroad a profit can usually be secured on cordwood. Where the wood is cut and burned for charcoal a slight profit may be made at greater distances.

On account of the predominance of hardwoods in the forest and because on many sites nothing but cordwood is produced, a greater percentage of the forest products must be marketed as cordwood than in any of the other New England forest regions. There is a smaller per capita consumption of cordwood² than in the northern hardwoods region, because in this section the cold season is shorter and coal is largely used, even in the

¹ Heavy seeded species such as chestnut, oak, and hickory, gain a start on old fields, through the assistance of squirrels which scatter the seeds widely.

² Estimated to be twice as large in the northern hardwoods as in the sprout hardwoods regions.

country districts. In the white pine region the large areas covered with pine, which is used for other purposes, reduces the amount of cordwood to be disposed of and makes easier the disposal of what is cut.

The abundant supply of cordwood in the sprout hardwoods region of course keeps the price low, and makes the disposal of cordwood the hardest and often the most important problem in the management of a tract.

The species of the greatest commercial importance in the region is chestnut, which until recent years has been the tree to favor in management. The chestnut bark disease (discussed in Chapter VII) has spread so generally through the region and been so destructive in its work as to reduce the value of the tree for management. In Fairfield County, Connecticut, where the disease first appeared in New England, practically all the chestnut has been destroyed. If this continues its virulent spread for a few more years all the chestnut in the region will be destroyed and of course the tree cannot then be considered as one to be encouraged in management. But if the progress of the disease is stopped by natural causes within a few years, as some authorities expect, chestnut may still be favored.

Red oak, on account of its rapid growth, commercial value, and general distribution, is the second best tree to favor, and the other oaks are to be encouraged on certain sites.

When present white ash and white pine should be given preference over all other trees.

For the best financial returns a change from hardwood forest to coniferous forest is demanded. This was suggested in connection with the northern hardwoods region, and, as there, can be brought about only by planting. Many of the sites now yielding only hardwood cordwood could be so handled as to produce coniferous lumber.

If the region was occupied by forests of fast-growing conifers no portion would be so poorly situated as to prevent intensive management.

Planting on open lands is already in progress. Such lands

should be the first planted and until they are stocked the problem of planting hardwood lands to conifers need not be undertaken.

Wherever cordwood or charcoal can be disposed of at a profit improvement cuttings, especially thinnings, should be made.

1. *Mixed Hardwoods*. — At least two systems of reproduction can be used to advantage in handling the different kinds of stands which are included in this type.

By permission of W. O. Filley.

Fig. 132. — Mixed hardwoods type underplanted to white pine seedlings 7 years ago. The hardwoods should be cut soon, taking care not to injure the pine.

In stands of pure or nearly pure chestnut the simple coppice system¹ can be applied, using a rotation of fifty to sixty years. Chestnut will coppice vigorously at even a greater age. During the rotation several thinnings are advised. They will, of course, increase the yield and will bring in a little seedling reproduction. This latter is quite necessary, even though chestnut sprouts well for a much longer period than the length of this rotation, because at maturity the trees are so far apart that complete sprouting does not serve to fully stock the ground. Seedling

¹ Refer to simple coppice system in the chapter on "Silvicultural Systems."

reproduction is wanted to fill the gaps, and also because a forest will eventually deteriorate if reproduced by sprouts alone.

On the poorest of the third quality sites also the simple coppice system will be the best. Since the stand in these situations is mainly oak and hickory, whose sprouting capacity rapidly decreases with age, the system should be based on a lower rotation, forty years or under. The growth is slow and the product grown will only be cordwood, even though a much

Fig. 133. — A reproduction cutting in the mixed hardwoods type in a 60 year old stand of oak. Approximately 40 per cent of the volume has been removed.

longer rotation were used. As the third quality sites are mainly on ridges and steep slopes they are usually expensive to lumber. Therefore it will not pay to make thinnings, which, because of the slow growth, could furnish but a small yield per acre. The cost of the logging is also a strong argument in favor of the simple coppice system, as under it the stand is entirely removed in one operation, and reproduction assured.

Except on these extremely poor soils and where the stand is largely chestnut another system of reproduction is recommended. This is the polewood sprout system, which has been described in the chapter on "Silvicultural Systems." It is

better suited than the simple coppice system for use with oak where the rotation must be long enough to produce timber, and where expense of logging and slow growth do not prevent thinnings and the gradual removal of the mature stand.

The length of the rotation will depend somewhat on the species. Where red oak is abundant with a sprinkling of chestnut, a rotation as low as sixty years can be used and good yields of timber secured. But when other oaks compose the

Fig. 134. — Mixed hardwood type. A stand of chestnut and oak 5 years after being thinned. Note the thick leaf litter and lack of undergrowth showing that the thinning was not too heavy. A reproduction cutting under the polewood sprout system will now be made. Age of stand 70 years.

stand seventy or eighty years will be needed. At this greater age many of the stumps will fail to sprout, and seedling reproduction must be relied upon to fill the gaps. The details of making the cuttings have already been described under the description of the polewood sprout system.¹ Several thinnings during the rotation can be made under this system.

Quite a variety of products can be secured from stands of the mixed hardwoods type, lumber, ties, poles, and piles being the principal ones. It is not necessary to determine in advance of maturity the particular one of these products into which the

¹ See chapter on "Silvicultural Systems."

timber shall be cut. This is governed quite largely by the species; for example, only chestnut can be used for poles, chestnut and the oaks for ties, while for piles and lumber the range is wider. At the time of cutting an investigation should be made as to the most profitable product to cut for the stand in question. The best product will vary from place to place and season to season. It is not always possible to sell poles, except when they happen to be needed for construction or repair work. Piles are not salable everywhere and at all times. Ties and lumber are more uniformly and constantly in demand.

As a general rule poles and piles, when salable, are the most profitable products. Ties and lumber are often about equal in point of profit, with lumber leading in a majority of cases. Usually in every stand it will pay best to put the better cuts into lumber, the poorer into ties.

The management thus far advised for the mixed hardwoods type has been on the assumption that chestnut is desired, and that the present hardwood growth is to be retained. As already explained, the chestnut bark disease may in a few years destroy the chestnut. If this happens generally (and already there are tracts where the chestnut has been almost exterminated), other trees should be introduced to replace the chestnut. These should be conifers, preferably white and red pine. On lands where the mature chestnut has been killed the planting of the pines is strongly advised. Unless the stand was all chestnut a few hundred plants per acre will be sufficient.

For owners desiring the greatest ultimate financial returns, the planting of pines generally through lands of the mixed hardwoods type is strongly urged. The planting is best done when the stand is cut clear at the end of the rotation. For a few years after the planting the pine must be protected by means of cleanings from the fast-growing hardwood sprouts.

2. *Hemlock*. — The selection system is very effective if the object is to maintain or increase the per cent of hemlock in the type, but usually it is desirable to decrease the amount of hemlock and convert the type to one more productive. Hem-

lock is such a slow-growing tree and has so low a lumber value that it is less profitable than the hardwoods. Under certain circumstances, as on steep, poor soiled, but cool sites, hemlock may be as profitable as any hardwood, for it may there produce lumber while the hardwoods would only yield cordwood. It also makes an ideal protection forest, and is often desirable from the æsthetic standpoint.

By permission of the Connecticut State Forester.

Fig. 135. — A reproduction cutting (Shelterwood system) in a stand of mixed hardwoods and hemlock.

On the better soils of the type and where neither the protective nor æsthetic value of the forest needs special consideration the stand should be cut clear, taking out all young hemlock with particular care. The area occupied by the hemlock and by hardwoods which fail to sprout should at once be planted to pines. This will result in a stand containing a large percentage of pine.

3. *Hardwood Swamp*. — Both the simple coppice and the polewood sprout system are useful in managing this type. In

very wet situations (where soft maple usually is pure or predominates) seedling reproduction starts with difficulty and the main dependence should be placed on sprout reproduction. Thus the simple coppice system is needed. The soft maple furnishes excellent cordwood and on the wettest sites no attempt should be made to grow other products. A rotation of thirty to thirty-five years will be sufficiently long. On the drier sites of the type, where seedling reproduction can be more easily secured, the polewood sprout system is best. This will allow of a longer rotation and the growing of more valuable products than cordwood. Where soft maple composes the stand a forty to fifty-year rotation will be long enough, but with the other swamp hardwoods fifty to sixty years is better. When present, white ash, whitewood and swamp white oak should be favored. The first two, especially, scattered as single trees in association with soft maple, make a desirable combination. In order to secure a good yield of lumber in forty to sixty years, frequent thinings must be made.

4, 5. *Cedar Swamp* and *White Pine*. — The methods of handling these two types have been discussed in the white pine region under the types of the same name, which should be consulted for details as similar treatment is needed in the sprout-hardwoods region.

6. *Old Field*. — The object in managing this type is to hasten its conversion into some more valuable type of forest. This process is a natural one but so slow that it requires fifty to one hundred and fifty years. No treatment to improve the growth of the present trees in the type is advisable. The conversion can take place in two ways; either by artificial reproduction, the existing stand being cut clear and planted, or by aiding the natural seeding of the hardwoods which is slowly progressing beneath the shade of the old-field species. This latter can be accomplished by cutting out the inferior species wherever a valuable young seedling has gotten a start, thus encouraging its rapid development. Such cutting must not be made until the valuable seedlings are already started, as other-

wise the cedar and gray birch are apt to seed in again in the opening, and retain longer their control of the site.

Waiting for natural seeding of good hardwoods is much slower, but cheaper in present outlay than planting. Where a hardwood stand is wanted this method secures the desired result, but the quickest and largest returns will be secured by changing the type by planting to white and red pine.

It is not advisable to begin planting at every stage of development of the old-field type. In all cases where the lands are not fully stocked the openings should be planted at once. Stands of cedar with the trees nearly touching can be planted, as the cedar spreads out very slowly and the pine is encouraged in height growth by its presence. Where the land is densely covered with cedars or gray birch planting cannot be undertaken without preliminary work. The inferior species must be cut clear and the wood removed, and brush burned, before planting begins. In order to lessen the expense of this operation it is usually best to delay the cutting until the cedar is large enough for posts and the birch large enough to furnish cordwood. Such a stand will pay the costs of cutting the wood, and burning the brush, and leave a profit on the operation besides. The young plantation will meet the competition of sprouts from the gray birch stumps, and will need to be assisted by cleanings.

LOGGING METHODS, MARKET CONDITIONS, INDUSTRIES, OWNERSHIP OF WOODLANDS.

Logging Methods. — The logging is altogether on a small scale, and on account of the accessibility of the forest does not present great difficulties. The process is similar to that in the two other New England woodlot regions. Cutting, skidding to the mill, and hauling the product to market are often let out by contract to farmers or other persons. Logging is carried on throughout the year, though during the hottest months of the summer there is relatively little done. Snow cannot be relied on for logging work except in the northern portion of the region.

The farmers do considerable logging themselves during the winter months, but not nearly so much as in the other regions.

Sawing is by small mills, mostly portable, though there are a number of stationary mills, run by water power or steam, scattered over the region. The portable mills are moved from lot to lot. Oftentimes the owner of the mill does not buy timber himself, but simply rents the mill, sawing for a fixed price per thousand. Mill set-ups of 75,000 to 100,000 feet,

Fig. 136. — A "C" grade thinning in a stand of pure chestnut about 40 years old. Many of the suppressed trees, being soft and hard maples, and beech, were left according to the French method of thinning, to shade the soil. Yield about 28 cords per acre, cut 6 cords per acre. Brush is piled but does not need to be burned.

board measure, are considered profitable, and indeed in many sections of the region set-ups are made for only 30,000 to 40,000 feet, board measure.

The present logging methods need very little, if any, change to adapt them for use in forest management. Final cutting of the stand clean, as is now done, is generally recommended for all types. It is in making thinnings and cuttings under the polewood sprout system that changes in logging methods are needed. The changes here are simply to accustom choppers to cut the marked trees (usually the smaller ones) without injur-

ing the standing trees. A slight addition to the price for cutting wood and inspection of the work will ordinarily result in accomplishing what is desired.

Market Conditions. — Railroads cover the region thoroughly, very few points being over ten miles from one. Many trolley lines, in the rural communities, give additional transportation facilities. The road system of the region is highly developed, with many stretches of hard roads, extending into the more remote portions. While there is a large percentage of true forest soils in the region, the present output is small, since past cuttings have exhausted most of the timber and lack of proper handling and protection has prevented replacement. Even when producing the amount of wood of which it is capable the region will probably grow but little more than its own needs. It will never, under the best of handling, be a timber exporting section, but should eventually produce an amount equivalent to its own requirements. At the present time the production of the more valuable products is far below that point. Cordwood is supplied now for all local needs.

There is a dense population centering in the many manufacturing towns and cities with which the region is dotted.

Industries. — Manufacturing is the leading industry of the region, with agriculture next in importance, and strictly forest industries taking a third place.

Among the forest industries the manufacture of lumber is the leading one. For the year 1909 the cut was approximately 174,000,000 feet, board measure, of which chestnut furnished about 93,000,000 feet, board measure. This is not, however, the leading forest region for the production of chestnut, since the cut in the southern Appalachians is far higher. The production of oak was approximately 37,000,000 feet, while the balance of the total cut, 44,000,000 feet, was made up by a variety of species, of which hemlock, hickory, maple, ash, and birch are the more important. Practically all the lumber cut is used within the region. The material is largely of low grade and not suitable for export. For certain lines of manufactur-

ing, such as for furniture, tools, etc., the local forests provide a limited amount of material, though they by no means provide the entire supply. Most of the locally grown lumber is consumed for bridges and car construction and in the construction of buildings.

Minor wood-using industries and special wood-working plants are not so numerous as in the white pine region. The large number of manufacturing plants create a demand for wooden boxes, but the wooden box making industry is not developed in the sprout hardwoods region, because the native timber is not so well adapted for use in boxes as is the leading species of the white pine region.

Chestnut and oak are cut extensively for railroad ties, for steam and electric roads. It is impossible, from the census reports, to obtain the number of ties cut in the region. However, if the tie output were figured as lumber, it is probable that the results would show not over half the amount of material used for ties as is used for oak and chestnut lumber. In many sections of the region the cutting of chestnut for telephone, telegraph, and trolley and electric lighting poles takes considerable timber each year though much less than for ties. Piles of chestnut, oak, hemlock, and sometimes other species are cut in sections accessible to the coast.

A much larger amount of material is each year put into cordwood than into lumber. A great part of this is material cut in connection with tie and lumber operations, and which had to be cut in logging these more valuable products. A portion of the cordwood cut comes from situations on which the hardwood species can produce only cordwood, and which are stocked with inferior species. Allowing for all this, however, there still remains a large share of the cordwood output which comes from young and middle-aged stands cut especially for this product. This early cutting of stands for cordwood, instead of waiting for a yield of ties or lumber, is an economic waste which should be remedied. The cordwood cuttings should be confined, first, to utilizing the tops and inferior trees left after log-

ging for better products; second, to clear cuttings of inferior hardwood species and of valuable hardwoods growing on sites where they cannot produce better products; and third, to thinnings. An ample supply of fuel could thus be secured.

One of the chief reasons for the cutting of young and middle-aged stands for cordwood is to supply brick and lime kilns and brass plants with wood for fuel and use in manufacturing processes. In northwestern Connecticut the making of lime is an

Fig. 137. — Chopping out a thinning. Mixed hardwoods type, about 60 years of age, with a yield of 35 cords per acre, 8 cords per acre removed in the thinning.

important industry, while through the central part of the State are many brick yards. Brass plants are found in the Naugatuck valley of Connecticut. All these industries consume large quantities of cordwood and the owners often buy up young and middle-aged stands for the special purpose of cutting the trees into cordwood.

Ownership of Woodlands. — The sprout hardwoods is essentially a woodlot region and will always remain in that class. Practically all the woodland was at one time owned in connection with the farms. At the present time a good many tracts, large for the region, have been acquired. These are owned by wealthy men, in connection with their summer homes, or by

lumbermen. Some of the lime, brick, and brass companies own large tracts, while a good many lumbermen own from one to several thousand acres apiece. There may be a few holdings within the region of over 10,000 acres apiece, but such areas are unusual. Large holdings of woodland are apt to be made up of many scattered lots rather than a single extensive tract.

The states do not figure prominently as forest land owners, although Connecticut has at least one forest reserve within the region. Several private water companies and municipalities own large tracts located on the watersheds of their reservoirs supplying drinking water. This class of owners is usually interested in forestry and in many instances are already handling their lands under forestry principles.

Standing timber is usually sold without the land, the owner retaining this. If the land is sold with the timber the whole farm usually changes hands.

FOREST PROTECTION.

Forest Fires. — The forest fires in the sprout hardwoods region are surface fires, feeding on the litter of the deciduous leaves. Sometimes in dried-out swamps ground fires occur. The surface fires are common in uncut timber of all ages as well as on cut-over land, but the severest fires are on areas covered with slash or brush. In thick cedar stands of the old-field type the fires are often severe and take the form of crown fires.

Damage from forest fires is felt here principally in wounds at the bases of trees, admitting insects and fungi, which later may cause death. On account of the abundant reproduction by sprouts there are comparatively few absolutely barren areas due to forest fires, as occur in the other three New England forest regions. The stocking of the stand may be greatly reduced but rarely is entirely destroyed.

Sprouts in almost all cases start after the fire. But fires and especially repeated fires on the same area result in changing the composition of the stand. The species which sprout vigorously, of which chestnut is an example, increase in proportion. Fire-

resistant species, like oaks, increase in contrast to easily killed species. Scrub oak especially is aided in spreading by fires. Light seeded species, like gray birch, soft maple, and poplar, preferring an exposed soil for a seed-bed, increase on the burned

Fig. 138. — Chestnut and oak stand 40 years old after a damage cutting which removed over 50 per cent of the stand. The cutting removed trees injured by fire.

areas, resulting in a stand of valuable hardwoods mixed with these inferior species. The producing power of the woodlands has in many cases been seriously reduced by repeated forest fires.

In length, the forest fire season coincides with that of the white pine region, extending from early in March until late in

November. In the average year the most dangerous period is in the spring, before vegetation starts, and then after the leaves have dropped in the fall comes a second period of danger. The occurrence of drought may, however, change the season of greatest danger.

The lack of extensive coniferous stands and large areas of sandy soils makes the natural fire hazard less than in the white pine region. On the other hand, both regions are equally exposed in having a dense population; with many foreigners, careless about fires, attracted by the manufacturing interests; and in having many railroad lines running through woodlands.

Railroads, careless people, and brush burning to clear up land are the three principal causes of forest fires, given in order of importance. As in other regions, a large part of the fires are reported as of unknown cause, but probably the majority of these fires are due to carelessness of people in or near woodland, which should be classed as the chief cause of fires in the region.

Relatively few fires occur in the Massachusetts section of the region,¹ as conditions more nearly approach those of the northern hardwoods than of the sprout hardwoods region. The railroads here traverse cleared valleys with an agricultural population and few important manufacturing industries, and the region is therefore fairly free from this class of careless people. Two chief causes of forest fires are thus lacking in the Massachusetts section.²

Methods of Fire Protection. — In so far as an ideal system of fire protection is concerned, what was said in the two previously considered regions applies in the sprout hardwoods region. To avoid repetition the reader is referred for details to these regions and to Chapter VIII.

¹ The only portion of Massachusetts included in the sprout hardwoods region is a small area in the extreme southwest corner of the state. The portion of Massachusetts which suffers most lies in the pine region.

² Further information on forest fires will be found in the appendix, under the heading "Forest Fire Statistics."

The use of specially constructed fire lines is not recommended as a general thing in this region, because of the difficulty of keeping them in proper condition. Prolific sprouting of the cut stumps on the line follows the clearing, while grass and herbs are very troublesome. In sandy soils and those comparatively free from stone, as is the case in many instances in the white pine region, plowing is possible, and is a cheap and effective method of keeping the line clear. But in the sprout

Fig. 139. — A 70 year old stand of mixed oak and chestnut 2 years after a second thinning. Canopy now about .8 density. Present stand 35 cords per acre. Cut in second thinning, 2 years ago, 5 cords per acre. Cut in first thinning, 10 years ago, 8 cords per acre.

hardwoods region the shallow, stony soils, and rough topography usually prevent this. Occasionally along the boundary of a tract, where fires may enter from outside, a cleared fire line ten to fifteen feet wide may be of great value. The brushing out of woods roads to give easy access to the forest and serve as vantage points from which to fight fire is advisable.

From the standpoint of fire protection the disposal of brush after logging is not necessary. The hardwood tops decay rapidly and are not so easily set on fire as is the litter of leaves on the ground. Hence the tops will not materially assist the

starting of a fire, though they may increase its severity when once under way. Inasmuch as an ordinary leaf fire on a clear-cut area kills the sprouts which have started, there is no great gain from the fire protection standpoint in removing the brush and tops, certainly not enough to justify the expense of the operation. In making improvement cuttings the tops should be cut up and then scattered so that they lie close to the ground. If cordwood to a two- or three-inch top is taken, practically no extra work in brush disposal is needed. On areas cut clear it is often necessary to throw the brush into piles or windrows to give room for removing the wood. Here there is too much débris to make scattering practicable, so the present practice is preferable. In doing this care should be taken not to make heavy piles of brush on top of stumps which may sprout, or on groups of seedlings.

Where a cut-over area is to be planted the brush must be disposed of. This should be done by piling and burning, whenever possible, while the logging is in progress, in the manner described under the white pine region. The burning of hardwood tops will usually cost somewhat more than coniferous tops.

Methods of Fighting Fires. — Modern methods of fighting forest fires,¹ such as the use of bucket pumps and chemical extinguishers, are the most effective in this region. Probably so far the former has been employed more often than the chemical extinguishers.

Protection against Grazing Animals. — There is a great deal of grazing by farmers' stock in the woods, more in the scattered woodlots close to farms than on the larger tracts in the rougher portions. Here the producing power of the forest has often been greatly lowered by grazing, which has brought in grass and reduced the density of the stand. Red cedar is encouraged at the expense of valuable hardwoods, and is sometimes the only reproduction found seeding in under stands of hardwoods which have been opened by grazing. The lands should be

¹ See Chapter VIII.

cleared and devoted to grazing or else altogether protected from stock and utilized for timber crops. Eventually the separation of the two industries will be the most profitable.

Protection against Insects and Fungi. — There are no serious insect pests threatening the wholesale destruction of the sprout hardwood forests. Various borers attack the wood of the chestnut, oak, and hickory, usually effecting entrance through

Fig. 140. — The effect of grazing. In foreground, grazed land, formerly wooded. All the growth except cedars kept out by the cattle. To left, ungrazed land thickly stocked with young hardwoods.

fire scars. This injury affects the quality of the timber, but can be prevented only by stopping the forest fires which assist the insects in entering the trees.

The chestnut bark disease is the most serious pest in the region. Its effect on forest management has already been discussed. In the present state of knowledge it must be classed as a forest pest which there is no practicable way of combating.¹

Watershed Protection. — As in the white pine region, watershed protection is needed here in order to assist in keeping cer-

¹ See Chapter VII, where the habits and work of the chestnut bark disease are given.

tain streams pure for drinking purposes rather than for regulating stream flow.¹ To supply the dense population with water there are many private and municipal water companies, whose watersheds should be forested, unless the water is filtered.

SUMMARY.

1. This is a manufacturing region, with agriculture second and lumbering of subordinate importance.

2. It is a hardwood region, without virgin timber, the forest being of sprout origin, and with the woodland mainly in small holdings.

3. There is a large per cent of the area which is true forest soil, and this when properly managed will go far toward producing the amount of wood needed by the region.

4. Market conditions are so good as to place the region, so far as New England is concerned, second only to the white pine region in offering possibilities for the practice of forestry.

¹ See explanation given under northern hardwoods region.

CHAPTER XVII.

THE PROGRESS OF FORESTRY IN NEW ENGLAND.

THE six New England States have made more progress in forest legislation, in forest administration, and in the general forestry educational movement than any other group of states in the country. It is the purpose of this chapter to point out the general policies that are being pursued in the different states. These various governments have worked out their several schemes of forest administration quite independently of the national government, although no doubt unconsciously taking many ideas from the United States Forest Service as well as from other states. Connecticut, in 1901, first established the position of state forester, in which she was soon copied by Massachusetts. Rhode Island was the next to fall into line. Vermont then followed the example of the states to the south, first in establishing a system of fire wardens, then a state nursery, and in 1908 creating the position of state forester. New Hampshire has now followed the other states in all of these lines, so that Maine is to-day the only state without a regular forest service.

In tracing the history of this forestry movement in New England a singular fact stands out, namely, that the movement owes its success almost entirely to the foresight of city men, men of large business interests, often entirely unconnected with the forests. Except for the fire protective measures of Maine and northern New Hampshire, it may be said that the lumbermen, who should have been most interested, have done the least for the advancement of this movement. It can be as strongly asserted that the farmers, who, as a class, will benefit nearly as much as the lumbermen, have never taken the initiative in wise forestry legislation, although they have generously supported

such measures when they have been advocated in the various legislative bodies.

One incident of the forestry history of New England which should not be overlooked, and perhaps the only incident that has thus far affected all the New England States, was a conference held in Boston in November, 1908. This meeting which was called by Gov. Curtis Guild, for several years president of the American Forestry Association, and now American Ambassador to Russia, took the form of a two days' Conservation Congress for the discussion of such subjects as forestry, fruit growing, good roads, the shell-fish industries, etc. There were present the governors and governors-elect of the various New England States, the members of Congress from New England and a large number of experts and delegates appointed by the various governors. The results of this meeting along forestry lines have been much more far reaching than could have been anticipated or even hoped at the time.

Throughout the decade since 1901, while the states have been formulating and developing their several forestry policies, a movement quite apart from these influences has been steadily making headway. This movement, with headquarters at Boston, had for its object the acquisition by the federal government of large tracts of forest lands in the White Mountains. Political expediency soon led to the joining of interests on the part of these people with those who were striving for similar national forests in the Southern Appalachians. Several times the appropriation bill providing for these purchases passed one house of Congress but failed in the other. It was from start to finish bitterly opposed by Speaker Cannon and was finally held by its enemies to be unconstitutional. Its friends decided, whether wisely or not we cannot say, that such purchases could only be made under the clause in the Constitution which gives Congress the right to regulate interstate commerce. The bill was, therefore, drafted to provide for the purchase of such forests as have an effect upon the run-off of navigable streams. After a number of years of agitation and many discouraging episodes, the friends

of this movement, notably the Society for the Protection of the New Hampshire Forests, and the American Forestry Association, were rewarded for their efforts by the passage of the "Weeks' Bill" on March 1, 1911.

This bill provides a commission for the purchase of forest tracts meeting the aforementioned requirements in states whose legislatures have passed enabling acts. So far New Hampshire and Maine are the only New England States which have made such provision. While the bill provided that the tracts for purchase be selected and appraised by the Forest Service of the Department of Agriculture and administered by it after purchase in the same way as the western national forests, it also provides that the Geological Survey of the Interior Department is to decide whether or not the proposed tracts affect navigable streams. This branch of the government is apparently not in entire sympathy with the purposes of the bill, and has delayed the work of acquisition so much that at this writing, nearly one year after the passage of the bill, only a few areas in the Southern Appalachians have been purchased, although many tracts in New Hampshire have been approved by the Forest Service. The unfortunate thing about this delay is that at the end of each fiscal year (July 1), unexpended appropriations lapse, and can only become reavailable by another act of Congress.

There are in connection with this law two views which are perhaps equally sound, just as from the first establishment of our federal government there has been the theory of a strong federated government, and the theory of a confederation of strong state governments. The people of New Hampshire have been urgent in their demands for a national forest in the White Mountains, considering the project solely as a great park, and, therefore, as a money outlay. The time will come when it will be realized that well-managed governmental forests are something more than parks; and when the revenue from them exceeds the expenditures for improvements, the states will regret that their lawmakers were not far-sighted enough to provide for state rather than national purchase. It behooves every legisla-

ture, therefore, and especially those committees having such matters in charge, to carefully consider this question in all its phases before inviting the assistance of the federal government in solving its problems. However, there can be but one alternative. It is inexcusable for any state to decline this splendid offer of assistance unless it is willing to take the necessary measures for the acquisition of state forests on an adequate scale.

Section 2 of the "Weeks' Bill" providing for a system of fire protection on the watersheds of navigable streams, is perhaps of more general interest in New England than the part of the bill providing for land purchases. This gives the Secretary of Agriculture \$200,000, available until expended, for coöperation with the various states in the prevention of forest fires on the watersheds of navigable streams. The law stipulates that no state shall receive from the federal government, in any one year, a sum greater than it spends itself in the same kind of work. The United States Forest Service, which has the administration of this section in charge, under the Secretary of Agriculture, limited the amount to be spent in any state for the fiscal year beginning July 1, 1911, to \$10,000. It further decided that this federal money should all be spent in hiring men to prevent forest fires rather than for fire-fighting equipment, or for extinguishing fires. In many states where a more or less adequate system of fire wardens was already in operation, this law marked a new milestone, and made fire patrol possible, which is a long step in advance of mere extinguishing measures.

One of the most important forestry problems of New England, as well as of other sections of the country, is the taxation of forest lands. It is now very generally conceded by economists that the general property tax is not a just form of forest taxation. Until recently it can probably be said that quite as many land owners benefited by the lax system of taxation as were injured by it, and since overtaxation largely fell on non-residents the system has persisted. But with the present tendency to assess all property at its true value conditions have been

changed. There can be no question that the actual, present value forms the only proper basis for assessment under the present system, and that the rate should be reduced according as the tax list is raised. However, this cannot but work a hardship on woodland owners on account of the nature of their property which only produces a crop after a long period of years, but which is taxed crop and land, year after year. Under this system it is quite possible for an owner to have paid in taxes from twenty to fifty per cent of the value of his crop by the time it is harvested.

Up to the present time no adequate measures have been taken in New England to meet this serious situation, although several investigations and reports have been made. In a radical measure of this kind which in some states requires an amendment to the State Constitution, it is doubtful if conservative New England will take the lead in constructive legislation. Wisconsin, which now stands for progress in so many lines of legislation, has recently issued a report on this subject, with certain recommendations which we believe will eventually form the basis of legislation, not only in the middle West but throughout the country. This report says: "With respect to timbered land the general property tax is administratively unworkable." The substance of the recommendations here made is to allow owners of woodlots not exceeding forty acres in the agricultural portions of the state, and owners of large forest tracts to apply to the State Board of Forestry to have their lands especially classified for taxation. Lands so classified shall be managed under the direction of the State Board. The woodlots shall be assessed at not to exceed \$10 an acre and the large forest areas at not to exceed \$1 an acre. In neither case are the standing trees to be assessed. When any trees are cut they are to be taxed at the rate of ten per cent of their gross stumpage value.

A similar law would be of great benefit to New England.

The various states are here treated in the order in which they adopted definite forestry policies. Section I treats of Forest Administration; Section II, of Forestry Practice.

I. FOREST ADMINISTRATION.

CONNECTICUT.

Administration.

A. — Connecticut was the first state in New England to adopt a forestry policy and to employ a state forester, having made a beginning as early as the spring of 1901, when a forester was appointed in the Connecticut Agricultural Experiment Station.

All forestry work in Connecticut is under the direction of the state forester,¹ who is appointed by the board of control of the Connecticut Agricultural Experiment Station and is a member of the station staff. His office is at the experiment station in New Haven and his salary is paid by the station. The current appropriations by the state and the station available for forestry purposes for the year 1911 were approximately \$10,000. The legislature of 1911 established the position of assistant state forester, who is also a member of the Experiment Station staff.

Fire Service.

B. — The state forester is ex-officio state forest fire warden. Town fire wardens are appointed by the board of selectmen of the various towns, subject to the approval of the state forester. These town wardens are required to divide their towns into two or more districts and appoint district wardens in charge of them. Where city and town boundaries are co-terminous, the chief of the fire department is ex-officio warden.

The fire wardens are entrusted with preventing all forest fires and enforcing all laws pertaining to fires. They have authority to arrest without warrant any person taken in the act of violating any of the laws for the protection of the forests. In seasons of drought, wardens may establish patrols, and, in case of fire, may summon male residents between the ages of eighteen and fifty, may destroy fences, plow land, and set back fires.

¹ The present state forester is Mr. Samuel N. Spring.

The fire wardens are paid at the rate of thirty-five cents an hour for all time spent in the performance of their duties as wardens; the pay of other employees at fires is fixed by the selectmen, but is not to exceed twenty cents an hour. All bills are paid by the town in which the fire occurred, after first being sent to the state forester for examination and record and after being approved by the selectmen. The towns are annually reimbursed for one quarter of this expenditure by the county and one quarter by the state.

A law requiring permits to be secured from the fire wardens for the burning of brush during certain seasons of the year has aided in lessening the number of fires started from burning brush.

In July, 1911, the state forester entered into an agreement under the Weeks' law with the United States Secretary of Agriculture to coöperate in the prevention of fires on the watersheds of navigable streams in Connecticut, as he was authorized by Act of the General Assembly of 1911. This act provided that the State Forest Fire Warden shall take such steps as he deems necessary to provide for the prevention and control of fires in groups of towns, may appoint and equip patrolmen, establish and equip fire lookout stations, etc. Patrolmen are given the right to arrest, without warrant, offenders of the forest laws.

One thousand dollars was allotted Connecticut in 1911 under the Weeks' law but no expenditures were made, since the fall season was not dry.

Educational Work.

C. — The Yale Forest School was established as a graduate department of Yale University in 1900, and has taken a leading part in the training of professional foresters, especially for the rapidly growing government service.

The Connecticut Agricultural College at Storrs offers a three-hour course in forestry during the senior year, and special lectures are given by the state forester. There are, however, in Connecticut no forestry courses open to farmers and farm boys other than the regular students of the Agricultural College.

All forest extension work is under the direction of the state forester, who with his assistant lectures before organizations of the state, holds forestry exhibits at the agricultural fairs, and in other ways is doing much to arouse an interest in forestry.

The press of the state has been rather indifferent to the needs of the state from a forestry standpoint and, although friendly to the cause, has not been as aggressively back of the movement as in Massachusetts, New Hampshire, and Vermont.

Much of the progress in Connecticut has been due to the activities of an unusually energetic forestry association which has given splendid support to Dr. E. H. Jenkins, the director of the experiment station, who originated the present forestry movement in Connecticut. Through its presidents, Prof. H. S. Graves, now forester of the United States, and Mr. Theodore L. Bristol of Ansonia, and its secretary, Mr. Frank Stadmueller, the Connecticut Association has done much not only in framing legislation, but in the general educational movement of the state.

State Forests.

D. — As Connecticut was the first state in New England and one of the first in the country to employ a state forester, it was also one of the first to purchase state forests. While it cannot be said that the legislature has come to a full appreciation of the value of state forests, the beginnings made in this direction are encouraging. There can be little doubt that state forests, especially where large areas are planted, do more to arouse public interest in forestry than anything else. This has been noted especially in the case of the state forest in Union, in the northeastern part of the state. At the time this forest was purchased there was not only no interest in forestry in that section of the state, but there was an open attitude of derision. Within two years of its purchase and planting, this attitude was almost entirely changed to one of interest, so that now it is one of the most progressive parts of the state. Several large private holdings within a few miles are now being managed under forestry

principles, and, in the summer of 1911, a fire station was maintained coöperatively by several adjoining towns, a thing which would have been impossible five years previously.

The first state forest in New England was purchased by the first state forester, Mr. Walter Mulford, in Portland, near the geographical center of the state. This tract of hardwood sprout land consists of a little over one thousand acres. Many portions have been given improvement thinnings, and open areas have been planted. A series of special experiments in group thinnings was begun in 1905, supplemented by the establishment of sample acres with control plots to determine the effect of various grades of thinning.

Another smaller forest was purchased in Simsbury to demonstrate the possibility of preventing forest fires in one of the worst situations in the state, a sand plain traversed by a railroad which had been responsible for almost annual conflagrations. Through the coöperation of the state, the town, and the railroad, these fires have been practically eliminated and the land planted with pines.

The present areas of the state forests are as follows:

Portland.....	1100 acres.
Union.....	287 acres.
Simsbury.....	130 acres.
	<hr/>
Total	1517 acres.

One of the chief needs of Connecticut is an extension of this state forest policy into every portion of the state and the creation of at least half a dozen other tracts large enough to be handled economically. The original act making the purchase of these forests possible limited the purchase price to \$4.00 an acre. At that time the price was sufficient but the funds available were entirely inadequate. The General Assembly of 1909 appropriated \$5000, available until expended, but this could not be wisely invested because of the restriction on the price and the fact that land values had risen. This maximum price for land has now been increased to \$8 an acre.

State Nursery.

E. — As early as 1901, the experiment station started in Windsor an experimental forest nursery for the raising of various kinds of forest seedlings. In connection with it, a series of experimental plantations on sand-plain land were started and have been uninterruptedly continued so that to-day they form the most interesting experimental tract of forest plantations in New England, amply demonstrating what species are and are not suitable for sand-plain planting. Many people have been saved the expense and disappointment of planting such lands with catalpa, poplar, and maple, and have been taught the value of Scotch, red, and white pine by an inspection of these plantations.

In 1906, it had become apparent that the only reason that forest planting was not extensively carried on among private owners was an absolute lack of plant material at reasonable prices. The experiment station, therefore, adopted the policy, which has since been followed in other states both in and out of New England, of furnishing forest seedlings at cost price. Not being able to supply the demand, large quantities were imported from Europe and distributed at wholesale rates. Forest planting became so popular that an extensive private nursery company has been established,¹ the first company started in New England for the avowed purpose of raising seedlings at prices conducive to forest planting. With the establishment of this company and others in more recent years, it has become unnecessary for the state to maintain a nursery to supply stock for private planters. A small state nursery will be maintained to grow stock for planting on the state forests.

Taxation.

F. — The General Assembly of 1911 very properly appointed a commission consisting of the state tax commissioner, the state forester, and three others to investigate the taxation of woodlands, and report a bill to the next General Assembly. It is hoped

¹ The North-Eastern Forestry Company, New Haven, Connecticut.

that this report when made will receive more serious consideration on the part of the legislature than did a very admirable report on this subject made in Massachusetts in 1905.

The only special forest tax law at present in Connecticut is one exempting forest plantations from taxation for a period of twenty years. This exemption takes effect immediately after planting. The law as amended by the General Assembly of 1911 very unfortunately does not limit the exemption to lands of low value. There is, therefore, nothing to prevent the owner of valuable city lots thus securing exemption, provided they are at least an acre in size.

MASSACHUSETTS.

Administration.

A. — Massachusetts was the second New England State to establish the position of state forester,¹ having passed the law providing for that office in 1904. The state forester is appointed by the Governor, and is ex-officio a member of the State Board of Agriculture. Under him are three assistant foresters in charge respectively of moth work, forest management, and nursery work. There are also assistants in charge of forest fire work, and of moth-disease work. The moth work is organized under fifteen divisions, each in charge of a division superintendent. The appropriations are \$20,000 for forestry proper, \$5000 for fire prevention, and \$315,000 for moth work.

Fire Service.

B. — Town fire wardens are appointed by the selectmen upon the approval of the state forester. These wardens are responsible for extinguishing fires, and are empowered to appoint deputy wardens and to employ such assistance as is needed. Wardens have the right to cross lands and set back fires without being liable for trespass.

In towns so voting, a written permit from the fire warden is

¹ The present state forester is Mr. Frank W. Rane.

necessary to build a fire in the open between March 1 and December 1. The state forester may use part of his appropriation not to exceed \$2000 a year for paying the traveling expenses of wardens to conventions within the state.

The state law requires that every locomotive be provided with a spark arrester. The legislature of 1910 prohibited the flying of fire balloons.

Another provision of the Acts of 1910 permits the state forester to reimburse every town up to \$250 for money spent by the town for apparatus to be used in extinguishing or preventing forest fires, provided an equal expenditure is made by the town and that such assistance cannot be rendered to towns with total valuation of property exceeding \$1,500,000. The state appropriates yearly \$5000 for the expenditures under this law.

Another of the 1910 acts, intended to lessen the number of fires set by foreigners in southeastern Massachusetts, provides that it is unlawful for any unnaturalized, foreign-born person to pick wild berries, or flowers, or to camp or picnic, upon any land of which he is not the owner in Barnstable or Plymouth counties without written permission of the owner or owners of the land.

Massachusetts received in 1911 an allotment of \$1800 under the Weeks' Bill for the prevention of fires on the watersheds of the navigable streams. Only a portion of the sum was used, this being expended for hiring patrols, lookout men and assistants.

Educational Work.

C.—Harvard maintains in connection with its School of Applied Science a two years' forestry course, open to college graduates. The laboratory and lecture work at Cambridge is supplemented by field work on the Harvard forest, a tract of 2000 acres at Petersham, Massachusetts.

The Massachusetts College of Agriculture at Amherst has now established a course in farm forestry and it is intended in connection with this course to carry on extension work. Altogether this seems to be the most useful forestry work thus far undertaken by any of the New England agricultural colleges.

The state forester does a great deal by means of publications, lectures, and exhibits to arouse an interest throughout the state in better forest management.

The Massachusetts Forestry Association has been an active agent in arousing public interest in forestry, in the care of shade trees, the prevention of fires, and the control of the injurious forest insects.

State Forests.

D. — Massachusetts has no state forests in the true sense of the term, although the state owns five reservations aggregating 15,000 acres, including the Blue Hills, Graylock Mountain, Wachusett Mountain, Mount Tom, and Mount Everett.

There is also a law giving the state forester authority to purchase tracts of not exceeding eighty acres in extent and of reforesting the same. In connection with this, there is a clause making the repurchase of these lands possible by the expenditure of the original price, the cost of planting, interest, etc. Under this law, 3000 acres have been planted in various parts of the state. The wisdom of this policy has often been questioned. Judging from the experience of other states there seems to be little reason for the state to undertake the planting of private lands, which it virtually does under this provision, if the original owners care to repurchase.

State Nursery.

E. — The state maintains a nursery at Amherst, which was established largely for the purpose of selling trees to land owners at cost price. The annual output of the nursery is needed largely to supply stock with which to plant the small tracts secured under the reforestation law.

Forest Taxation.

F. — A commission, appointed in 1905, to investigate the question of forest taxation recommended the following:

1. "That the value of the land without the crop be assessed as cut-over land; and that the value of the average annual cut in cords, or board measure, which the forest might advantageously bear, be assessed and added to the value of the land — the sum to be the total assessment."

2. "That the law be restricted in its application to woodlands which the owner agrees to manage under a forest-working plan, which (1) fixes the average annual cut, (2) has been approved by the state forester, and (3) is subject to his inspection; that the working plans be revised at least once in ten years, or the owners forfeit their privileges, etc."

Unfortunately these recommendations were never passed by the legislature. They, perhaps, were not the best that could be devised, but are certainly far ahead of any taxation scheme at present in force in any state in the Union.

His Excellency, Governor Foss, in a special message, urged, upon the legislature of 1911, the importance of giving this question prompt and serious consideration. He recommended a constitutional amendment which would enable the general court to enact such legislation relative to the methods of taxing wild or forest lands as will serve best to encourage the development of forestry in the Commonwealth.

The following resolve, based upon the Governor's message, was passed by both branches of the legislature in July, 1911.

Resolved: That it is expedient to alter the constitution of the Commonwealth by the adoption of the subjoined article of amendment; and that the said article, being agreed to by a majority of the senators and two-thirds of the members of the house of representatives present and voting thereon, be entered on the journals of both houses, with the yeas and nays taken thereon, and be referred to the general court next to be chosen; and that the said article be published, to the end that if agreed to in the manner provided by the constitution, by the general court next to be chosen, it may be submitted to the people for their approval and ratification, in order that it may become a part of the constitution of the Commonwealth.

ARTICLE OF AMENDMENT.

Full power and authority are hereby given and granted to the general court to prescribe for wild or forest lands such methods of taxation as will develop and conserve the forest resources of the commonwealth.

Control of Gipsy and Brown-tail Moths.

G. — The control of the gipsy and brown-tail moths was turned over to the forestry department in 1909, and, as is indicated under "Administration," by the relative size of the appropriations, this work has naturally assumed greater proportions than the regular forestry work of the department. Besides the state appropriation of \$315,000, the cities and towns spend on this work \$350,000, property owners pay as a special tax between \$150,000 and \$200,000, and there is spent on state parks and other public lands nearly \$200,000, so that altogether nearly \$1,000,000 a year is spent in Massachusetts in the suppression of these insects. Of recent years the United States government has coöperated with the state in this work. The total expenditures in the state from May, 1905, to January, 1910, were: State, \$5,500,000; United States, \$417,763.84. As stated under "Administration," the moth work is organized under fifteen divisions. All of the various methods of suppression are used, but binding the trees with burlap and tanglefoot for the gipsy moth is not as much in use as formerly, owing to the great expense of putting it on, and tending it. Spraying in residential sections against both insects has been confined mostly to wooded roadsides, private property, and small wooded areas, where the infestation menaced orchards or shade trees. Arsenate of lead has been extensively used, and with great success.

Perhaps the greatest hope of the final control of these disastrous insects is by the introduction of natural enemies. Many thousands of parasitic insects have been planted in various localities. Several varieties of insects have been tried and have successfully survived our winters. The most promising varie-

ties have been imported in vast numbers from Japan and from Europe. These varieties include the Calosoma beetle, a small green beetle, several species of flies, and smaller insects. It is confidently hoped by the experts that in a few years these parasites will multiply and keep the gipsy and brown-tail moths in check, as has been the case in their native habitat.

Another form of natural enemy which is giving much encouragement to those engaged in the work is a fungous disease, *Entomophthora*, which affects the caterpillar of the brown tail, and in a few days results in its death. Spores are given off from these dead caterpillars, which are blown about by the wind, and infect others so that the disease spreads easily. In May, 1909, another species of *Entomophthora*, which attacks the gipsy moth, was successfully imported from Japan. There is also a so-called "wilt disease," which attacks the larvæ of the gipsy moth. Altogether there certainly seems to be abundant reason to hope that these two insects, the worst forest insects so far imported into America, may be soon controlled, although probably not exterminated, by natural enemies.

RHODE ISLAND.

Administration.

A. — The office of Commissioner of Forestry was created in 1906 by Rhode Island, which was the third state in New England to establish such an office. The commissioner¹ is appointed by the governor for a period of three years. The appropriation available is \$1500 for salary and expenses.

Fire Service.

B. — The town council of every town appoints a town forest fire warden, and in towns having over 4000 acres of woodland two or more district wardens are appointed in the same way. The town and district wardens are paid thirty cents an hour, and employees at fires eighteen cents an hour, and a minimum of five

¹ The commissioner of forestry is J. B. Mowry of Chepachet, R. I.

hours' pay is allowed to all persons officially summoned to a fire. All expenses incurred in extinguishing fires are borne one-half by the state and one-half by the town. The wardens have power similar to those of Connecticut to summon aid, etc.

During periods of drought the town warden may require the district wardens to patrol their several districts subject to the approval of the town council. There are in the Rhode Island fire law two or three provisions peculiar to the state. For example: "Whenever any two or more adjoining towns, having an aggregate of 8000 or more acres of woodland, or whenever any number of forest owners whose woodland in any two or more adjoining towns aggregates 4000 acres, shall build and equip a lookout station and connect the same with telephone, the town fire warden is authorized to appoint a watchman who is paid one-half by the town and one-half by the state." Another clause provides: "In any town having 1000 or more acres of woodland that the fire warden may have three-quarters of the expense of his telephone paid by the state." The Rhode Island law also provides a number of checks: for example, no warden is to be paid for more than three hundred hours' services in any one year whatever the danger from fire. Employees are not to be paid for over one hundred hours in a single year." The state is not liable for an expenditure of over \$300 for extinguishing fires in any one town. There is also a check clause preventing more than two lookout stations in a county from drawing state money.

The Rhode Island law prohibits the setting of fires in the open air between March 1 and December 1, except by written permission of the town or district forest warden, and except, further, that débris, etc., may be burned by the owner or lessee, agent, etc., on land devoid of inflammable material.

Educational Work.

C.—The Commissioner of Forestry advises forest owners, upon request, in regard to the management of their forests; delivers addresses on forestry, publishes bulletins and reports, and in

various other ways stimulates a better interest in forest management throughout the state.

State Forests.

D. — No legislation has thus far been passed looking to the establishment of state forests, although the measure has been recommended by the Commissioner of forestry; and there can be no doubt that state forests would have great educational value.

Taxation.

F. — Rhode Island has an ineffective law providing an exemption from taxes on plantations, similar to the laws of several other states. No serious attempt has thus far been made to revise the general system of taxing woodlands.

Control of Gipsy and Brown-tail Moths.

G. — The fighting of the gipsy and brown-tail moths, both of which occur in Rhode Island, is under the direction of the experiment station. Between May, 1905, and January, 1910, there was expended in this state on this work: \$33,000¹ by the state and \$38,000 by the United States.

VERMONT.

Administration.

A. — The position of state forester was created by the legislature of 1908. The state forester is appointed by a State Board of Agriculture and Forestry consisting of the Governor, the Director of the Agricultural Experiment Station, and two others appointed by the Governor, one every two years. The forestry department of the state is connected with the University of Vermont through the state forester,² who is professor of forestry in the College of Agriculture and forester of the experiment station. The appropriation made by the legislature for agriculture and forestry is divided according to the needs of the two de-

¹ See "Report of the State Forester of Massachusetts," 1910.

² The present state forester is A. F. Hawes.

partments by the State Board. The forestry apportionment for the year beginning July 1, 1911, was \$11,000.

Fire Service.

B. — The state forester is ex-officio state fire warden. In every organized town of the state the first selectman is ex-officio forest fire warden. While this is not as good a system as that of Connecticut, where the fire wardens are appointed especially for their work, in most cases it proves effective. The state forester is authorized to appoint fire wardens in the unorganized towns or gores, and to appoint district wardens in parts of towns where it is difficult for the first selectman to act. Fire wardens are paid at the rate of \$2 per day for time employed in performing the duties of their office. They have the right to call on all male inhabitants of the town for assistance, who are paid at the rate of \$1.50 per day. Expenses for fire fighting are borne by the town, but if in any town the expense exceeds, in any one year, five per cent of the grand list,¹ the balance is paid by the state, upon approval of the bill by the state forester. So far as is known, Vermont is the only state which has this kind of a provision for a division of expenditures and it may be highly commended, since the greatest benefit accrues to the poorest towns, which are usually those most in need of forest preservation.

The county game wardens are also ex-officio fire wardens. The governor has authority to postpone the hunting season if he believes that serious danger of forest fires will result thereby, but as the open season on deer has now been put over into November, there is little likelihood of this again being necessary.

The fire wardens have the authority, upon obtaining consent of the state forester, to establish patrols in dangerous localities. The state forester is authorized to pay the expenses of fire wardens to local meetings to discuss matters pertaining to forestry and the prevention of fires.

¹ It should be stated here by way of explanation that Vermont has a unique system of taxation, by which the grand list of a town is one per cent of the total valuation of property instead of the grand total as in most states.

Whenever a forest owner or group of owners shall establish a lookout station on the summit of a hill or mountain, and connect the same by telephone with some regular telephone line, the state forester is authorized to furnish a watchman for such stations, at a salary not exceeding \$2 a day. Up to the present time only one such station has been established, namely, that on the summit of Camel's Hump, a mountain recently given to the state.

Under the provisions of the "Weeks' Bill," Vermont received for coöperative fire protection \$2000 for the year ending Dec. 31, 1911. With this fund, a system of federal fire patrolmen was inaugurated in the most dangerous districts of the state. These patrolmen, who were paid \$2 a day, were employed during dry weather in patrolling railroads and other points of danger. The coöperative agreement did not go into effect until July 1, 1911, and was not in good working order until the driest part of the season had passed. During the latter part of the season, when not needed for patrol, these men were employed in mapping their districts and making trails. Only about one-third of Vermont has been mapped by the United States Geological Survey, and good maps of many of the worst fire districts are entirely lacking. Town maps are on file in the offices of most of the town clerks. These maps, together with those of the large lumber companies, were corrected in the field, and all reduced to a uniform scale of 2000 feet to the inch. In coöperation with the Green Mountain Club, the Forest Service is laying out a system of trails connecting the more important mountains which can serve as lookout stations. Considerable trail construction was started in 1911 by the patrolmen, and will later be continued on an extensive scale. All trails are laid out with an Abney level on a maximum grade of fifteen per cent.

Vermont suffers less from forest fires than any other state of New England, partly because there are few extensive unbroken coniferous forests, partly because the railroads practically all pass through agricultural valleys instead of forests, as in some states, and partly because the inhabitants largely follow agri-

cultural pursuits. In recent years, the most serious fire seasons have been the early summer of 1903, the late summer and fall of 1908, and May, June, and July of 1911.

Educational Work.

C. — The most important line of forestry work in Vermont at present is the educational work which is being carried on in a number of ways. The state forester addresses granges, clubs, and numerous organizations, and accompanies the commissioner of agriculture on regular institute trips. Forestry exhibits are displayed at the agricultural fairs, and on the "Better Farming Special" trains.

During the summer, the state forester, in coöperation with the University, maintains a two weeks' school of forestry and horticulture on the "Downer State Forest" in Sharon. This course is open to boys over sixteen years of age. The object of the school is to teach the farm boys the actual operations in forestry and horticulture, and much of the time is devoted to field work.

The University of Vermont at Burlington offers several courses in forestry with the aims of teaching the agricultural students enough forestry for their later practice in farm management, and of fitting students for the professional forestry schools. During the winter's short course, several forestry lectures are also given the farm boys attending.

The press of Vermont, including "The Vermonter," the state magazine, has taken an active part in furthering the development of forestry, and recognizes that the betterment of forest conditions is as necessary to the welfare of the state as good roads and improved methods of agriculture.

The Vermont Forestry Association was largely instrumental in starting the forestry movement in the state, and still actively assists in arousing interest.

State Forests.

D. — While Vermont has not yet adopted any very extensive policy of state forest purchase, it has made a modest beginning

in this line. The small areas thus far acquired, whether by gifts or by purchase, are chiefly valuable for their demonstration possibilities. Planting is the chief line of work needed on most of them, and a series of planting experiments have been established on the state forests in Plainfield and Sharon. On the latter, a small nursery is also maintained, while in Plainfield the tract offers exceptional opportunity for thinnings, and various silvicultural operations.

The other two tracts are Bromley Mountain and Camel's Hump, which are most interesting on account of their splendid views, and, therefore from a forestry standpoint, as lookout stations.

The total area of state forests, January 1, 1912, is as follows:

Plainfield	530 acres
Sharon	300 acres
Camel's Hump	1000 acres
Bromley Mountain ¹	850 acres
Total	2680 acres

¹ The title of only one hundred and six acres of this land rests with the state, although the remainder has been placed by deed permanently under the management of the state forester.

State Nursery.

E. — One of the first and most effective agencies for arousing public interest in forestry was the state nursery, which was established on a small scale by the legislature of 1906, and has since been considerably enlarged. This is located at Burlington on land furnished by the University, with a branch on the state forest at Sharon. During the few years that this nursery has been in operation, over one million seedlings, mostly of white pine, have been sold at cost price, to the land owners of all parts of the state.

Taxation.

F. — The system of forest taxation is the same in Vermont as in other parts of New England. The only special tax law relating to forestry is one exempting plantations from taxation for

a period of ten years. So far, only two planters have applied for this exemption. Most of the plantations made were uninfluenced by this law, and it may be considered, therefore, of practically no importance in bringing about forestry work.

NEW HAMPSHIRE.

Administration.

A. — The forestry work in New Hampshire is under the direction of an active forestry commission of three members, and of a state forester¹ appointed by this commission. The first state forester was appointed June 22, 1909, with an office at the capitol in Concord. The appropriation available for the forestry work for the year ending Aug. 31, 1912, is \$18,500 made up as follows: For fire prevention \$5500, for reimbursing towns for one-half of expense fighting forest fires \$4500, salaries and administrative expenses \$7700, nursery \$800.

Fire Service.

B. — The state forester is ex-officio fire warden, and appoints, upon the recommendation of the selectmen and others, one fire warden, and such deputy fire wardens as he deems necessary in every town and city. The state forester also has the authority to remove any fire warden from office. In seasons of drought, and when directed by the state forester, the wardens are required to patrol the woods, warn campers, hunters, and fishermen of the danger of forest fires, and post notices of the law. They also have authority to arrest, without warrant, anyone who builds a fire after receiving due warning. Wherever he desires, the state forester may appoint one warden over a group of towns or unincorporated places, and for better organization has divided the state into four forest districts, each under a chief fire warden.

The fire wardens are charged with the duties of extinguishing all brush and forest fires, and may summon assistance. The remuneration for services of wardens is fixed by the forestry

¹ The present state forester is Mr. E. C. Hirst.

commission and the state forester. The state and town share equally the expense of fighting forest fires. Permits must be secured for burning brush near woodland between April 1 and November 1 of each year.

The state forester is authorized to build and equip lookout stations on the mountains. Thirteen of these are at present in operation, and at least five more will be ready for the spring fire season of 1912. Five temporary stations are in operation during dangerous seasons in southern New Hampshire. On account of the numerous high peaks in the state, the views are more broken than in the more rolling country of northern Maine with its occasional high mountains, and, therefore, less country can be protected from one station.

Although it is no part of the state service, the work of the New Hampshire Timberland Owners Association should be mentioned in this connection. This is an association of the large timber owners of the state on the basis of a payment by each of one cent an acre a year for the land to be protected. About 1,000,000 acres are thus represented. This association employs a trained forester, who in turn hires a large number of patrolmen in dry seasons. The association also maintains supplies of fire-fighting tools at a number of convenient points, ready for immediate use in time of emergency.

New Hampshire received in 1911 for fire prevention, under the Weeks' Bill, \$7200. Under the coöperative agreement, this money was expended for patrol on the forested areas of navigable streams. Twenty-four patrolmen were on duty from June 4 until late in October. The most important duties of the patrolmen, when covering their routes, were putting out small fires, warning persons they met about fire danger, and recording the names of parties going into the woods. About sixty small fires, caused by campers, fishermen, or smokers, were put out by the patrolmen, and their reports to the district chiefs show that 4200 warnings were given. The educational value of the patrolmen's work in New Hampshire deserves especial mention. The number of warnings given would indicate that many people have

been restrained who otherwise might have caused fires through carelessness. Several of the patrolmen have reported larger fires and rendered valuable assistance in putting them out. During damp weather when there was no danger from fire, the federal patrolmen were used to good advantage on permanent improvement work, aiding in the construction of six new mountain lookout stations, constructed by the New Hampshire Timberland Owners Association. They also helped in the construction of telephone lines, brushed out old trails, and cut new ones, and rebuilt old camps, and built new camps for temporary headquarters.

There is a state law requiring portable sawmills to be provided with spark arresters, and giving the power of inspection to the state forester.

Educational Work.

C. — The state forester takes an active part in forestry education, speaking before organizations, holding exhibits, and in various other ways forwarding the forestry work among private owners, as by the inspection of private tracts, and giving advice. He is greatly aided in this work by the Society for the Protection of New Hampshire Forests, an organization which employs a trained forester who does a great deal of lecturing. It is largely through the efforts of this society that the Weeks' Bill was passed by Congress and that the position of state forester in New Hampshire was established. One of the educational measures taken by this society has been the creation of several local forestry associations to bring the forestry work nearer to the people. The State College of Agriculture has now engaged a forester, and offers courses in farm forestry, aiming especially to bring about a better management of the woodlands of the farms.

State Forests.

D. — There are at present three forest reservations belonging to the state. One of these, the Monadnock Reservation, comprises six hundred acres, and the other two, the Haven Reservation at Jaffrey, and the Walter Harriman Reservation at

Warner, are smaller tracts of sixty and two hundred and ten acres respectively. The legislature of 1911 provided for the purchase by the state of a tract of 11,000 acres in Crawford Notch, which will be under the management of the state forester. The revenue received from the sale of products from the state forests reverts to the state treasury.

State Nursery.

E. — A nursery was started by the forestry commission in 1910, there being quite a demand for nursery stock. The legislature of 1911 appropriated, for the establishment and maintenance of a state nursery for 1911, \$500; for 1912, \$800; and for 1913, \$300. One nursery is located at Gerrish. Here are raised white, red, and Scotch pine, Norway spruce, European larch, ash, basswood, chestnut, and red oak, with a present stock of about 700,000 seedlings and 100,000 transplants in all. Another nursery is located at Pembroke, and is devoted entirely to white pine transplants. Three hundred thousand seedlings and transplants have been distributed through the office of the forestry commission, since starting the nursery work in 1910. Two private nurseries have recently been established in New Hampshire, so there is little question of a sufficient supply of home grown nursery stock within a few years.

Taxation.

F. — The taxation problem in New Hampshire is much the same as in other states. An investigation of the matter was made a few years ago by the United States Forest Service and state in coöperation.

MAINE.

Administration.

A. — Maine, which has the largest forest area of any of the New England States, is the only one which does not employ a trained state forester. It has, however, a forest commissioner,¹

¹ The present forest commissioner is F. E. Mace.

who has charge of the fire service, which is perhaps the best in New England.

Fire Service.

B. — In Maine, since the spring of 1909, the organization for fire protection has been under the control of the forest commissioner. Under the law, passed by the legislature of 1909, the wild lands (virtually the spruce region) of Maine were formed into an administrative district known as the Maine Forestry District. A tax of one and a half mills on the dollar is levied on all property, in the district, to be used for protection of the forests from fire. This tax has made available the sum of \$63,945 for each of the years 1909 and 1910. The unexpended balance of the tax in any year continues available for the purposes of the law. The forest commissioner is given control with ample powers. He has divided the district into subdistricts with a chief forest fire warden in each, who in turn may have deputy forest fire wardens. The forest commissioner is specifically authorized to construct and maintain lookout stations connected with telephone, to patrol the woodlands, when necessary, and to equip and maintain depots of fire-fighting tools. The chief fire wardens and deputy fire wardens can summon assistance of citizens, when necessary, to extinguish fires. The law plainly provides for the development of a comprehensive system of protection. The eighth report of the forest commissioner of Maine shows what has been accomplished during the years 1909 and 1910. In the field force are listed three hundred and sixty-seven men, thirty-nine as chief wardens, and three hundred and twenty-eight as deputy wardens and patrolmen. Patrol is usually along lines where traffic is passing, such, for example, as railroad lines and waterways, frequented by river drivers and sportsmen.

Twenty-four lookout stations are in operation, located on high mountains with the widest possible outlook. Some of these command a view of from 100,000 to 250,000 acres of timberland.

Outfits of fire-fighting tools, such as axes, pails, shovels, and mattocks, have been purchased and distributed through the district at convenient points. These tools are usually kept in special tool boxes.

The average annual expenditure, for the years 1909 and 1910, for the Maine forestry district has been \$57,838.70, of which amount an average of \$27,493.80 was spent for patrol. During the year 1911, the available funds were expended before the end of the fire season, but disastrous results were fortunately prevented by fall rains.

Maine was the first state in the Union to make use of mountain lookout stations in fire protection. The first station was established and maintained coöperatively by the lumbermen and the state on Squaw Mountain. Now the system has been adopted in many parts of the country, and can be used to advantage in all mountainous regions.

Nowhere else in the country is there a system of fire protection so completely and thoroughly covering a wooded region of equal size as in northern Maine. The nearest approach to it is found in some of the coöperative fire-protective associations in the northwest, and in the organization of the forest service in protecting the national forests.

Conditions in Maine have been especially favorable for the development of such a system. The chief place among the natural resources of the state, which the forests hold, give those connected with the forest industries the controlling position in state politics. The majority of the wild land owners have long recognized the vital necessity of fire protection. Many of them employed private patrols before the present law was passed. The first private efforts at protection date back more than ten years, and were the forerunners of the present complete state system of control. The great advantage of placing the patrol under state direction supported by a tax, levied on all property in the Maine forestry district, is that all owners are compelled to coöperate and pay their share. The coöperative associations of lumbermen, as organized in New Hampshire and elsewhere,

do not often succeed in getting all owners, large and small, to join. They are, therefore, often compelled to protect lands of non-members, owing to the danger of fires spreading from these lands to lands of members. Another advantage of the Maine system is that there is no large force of regular patrolmen, but, instead, a big force of wardens always available, who can be called out to patrol at short notice, and kept at work only as long as actually needed. This gives great elasticity to the patrol system, and works for economy.

In the organized towns of Maine, the selectmen act as fire wardens. One provision, which is peculiar to Maine, permits any person whose property has been injured by a forest fire to collect damages from the town in which the injury was caused, provided the injury was caused "in consequence of the negligence or neglect of the selectmen in performing the duties required by the law."

Educational Work.

C. — The State University at Orono was one of the first in the country to offer instruction in forestry, establishing a course in 1903. It has developed a four-years' under-graduate course in forestry, somewhat similar to that of Pennsylvania State College, with the purpose of developing trained foresters in four years instead of six as at graduate schools. The professor of forestry has done some extension work among the farmers' organizations of the state, but no definite policy of propaganda has yet been established. There is in the state a forestry association.

State Forests.

D. — Maine has no state forests in the sense of the newly acquired forests of Vermont, Connecticut, and Pennsylvania, or of the forest reservations of New York and Wisconsin. Most of the immense forest territory, once owned by the state, or by Massachusetts before Maine came into the Union as a separate state, has been disposed of, some to pay off soldiers of the early wars, some to educational institutions, but much of it

was sold to lumber companies and other individuals. One thousand acres in every unorganized town was held by the state against the day when that town should be settled, and, when a town was organized, this land was turned over to the town for school purposes. There are still sixty-nine of these tracts so held by the state in as many unorganized towns. These lands are under the control of the land commissioner, and bring in some revenue to the state from time to time as timber is sold from them.

Maine is, therefore, fortunate in having, under state ownership, larger tracts of land than any other New England state, and it is very much to be hoped, from the standpoint of forestry, as well as from that of the school system, that some change of policy can be effected whereby such portions of these tracts as are true forest soils may be permanently managed by the state under forestry principles; the income from each individual tract to be paid by the state to the town after it is organized, for school purposes. Under such a plan this land could be managed to produce a larger permanent income than in any other way. The state would realize a considerable income from the unorganized townships, and the school systems in towns, hereafter organized, could rely definitely on a fairly steady, or increasing income. Such tracts would also serve the educational and protective purposes so valuable in state forests.

Insects.

G. — Both the brown-tail and gipsy moths are present in southern Maine. The work of exterminating them is under the state entomologist. During the period from May, 1905, to January, 1910, there has been expended on this work by the state, \$95,000, by the United States, \$50,000.

II. FORESTRY PRACTICE.

Lands Under State Ownership.

A. — From the foregoing pages the following summary of the lands in New England under state ownership has been derived.

At the time of writing (January, 1912), no national reserves have been acquired, although it is probable that such national forests will soon be established in New Hampshire.

STATE-OWNED FORESTS OF NEW ENGLAND.

State.	Area in acres.
Maine.....	69,000
New Hampshire.....	900
Vermont.....	2,000
Massachusetts.....	18,000
Connecticut.....	1,500
Total.....	91,400

This total of about 91,000 acres of land, owned by the states of New England, forms less than four-tenths of one per cent of the forested area of the six states, and when it is considered that very little forestry is at present practiced on the large school tracts of Maine, or the reservations of Massachusetts, it will be realized that they are at present of very little value so far as the real practice of forestry throughout New England is concerned. The New England States should own at least ten per cent of their total forest area, and should manage these public forests for revenue production, which would also furnish the best possible practical examples of forestry to private owners.

Lands Under Corporate and Private Ownership.

B. — The large pulp concerns of northern New England control the largest areas of forest lands upon which forestry principles, even of a rough nature, have thus far been practiced. These companies, which own expensive manufacturing plants, usually located on waterpowers distant from the forests, are dependent largely upon their own tracts for a permanent supply of timber, and the maintenance of their business. Partly because they have often stripped land clean in their past operations, and partly because they represent large capital in agricultural states, these corporations have become very unpopular. In many cases, the

smaller lumbermen have been as much at fault as the large pulp concerns, but in a smaller and less conspicuous way. These two factors, the necessity of a permanent supply of wood, and the public attitude of antagonism, have led several of the large pulp companies to introduce some kinds of forestry measures. In Maine, these measures have been largely confined to the avoiding of waste in lumbering such as the substitution of the saw for the ax in felling, by cutting lower stumps, and higher into the tops, by removing all lodged trees, and by the use of inferior material for skids and corduroys. In Vermont and New Hampshire, silvicultural measures are being introduced by at least one of these companies.¹ Some of the lumbering is being done according to foresters' marking with special reference to securing spruce reproduction.

This same company is building up a large nursery for the purpose of supplying seedlings for the replanting of their waste and cut-over lands.

Very little has as yet been done by the large lumber companies toward the introduction of forestry principles in their cuttings. Some have experimented, in a small way, with planting and conservative cutting, but so far on a scale not at all comparable to their cutting operations. The fire-protective organization of New Hampshire lumbermen is the most effective move toward forestry thus far made by New England lumbermen.

As mentioned in the discussion of the spruce region, many of the large hotel companies of northern New England, especially of New Hampshire, own the forests surrounding their hotels, and realize the necessity from the æsthetic standpoint of preserving them. Some of these companies are realizing the advisability of practicing forestry on these lands, and it is to be hoped that they will all be maintained in a productive condition, and not merely as pleasure tracts. The well-managed forests of Europe furnish abundant proof that good management not only does not detract from the beauty of a forest, but rather enhances it, and makes it available to a greater number of people.

¹ The International Paper Co.

In southern New England, the most extensive forestry work is being done by the various water companies, many of which own large forest areas for the protection of their water supplies from contamination. The practice of forestry not only maintains these lands in a condition for retaining the water in the soil, but makes possible an annual income, from the watersheds, which would otherwise have to be administered at an expense. The lands owned by these companies are largely made up of farms, which have been purchased to do away with undesirable drainage. Much of the land is, therefore, of good agricultural value, but cannot be used for farming because it cannot be fertilized. Such lands are, therefore, being afforested, and, on account of their fine quality, should become some of the most productive forest lands in New England. Woodlands, already existing, are being thinned, and in some cases whole tracts are being managed after a detailed working plan, very much like those prepared for some European forests. In fact, the forestry being carried on upon such lands is probably the most intensive form at present in use on any considerable areas in New England.

Many public institutions, such as hospitals, schools, and colleges, own forest tracts varying in size from a few acres up to the large college grants of several thousand acres. A number of such tracts are now being managed upon forestry principles with a view to a permanent and increasing income. Probably the most extensive area of this kind is the Dartmouth College Grant in northern New Hampshire.

A class of land owners which is growing very rapidly, especially in southern New England, is composed of city people who have purchased summer homes in the country. With the development of good roads and the use of automobiles an ever-increasing number of these people are making their permanent homes in the country. They have found by experience that dairying and most other forms of farming cannot be practiced profitably through the employment of expensive help, and that country life can usually be enjoyed with the minimum expenditure of money and worry on lands largely devoted to forests. The

practice of forestry gives to such owners a form of work which they can often supervise themselves, and which gives them a more intimate knowledge of the various parts of their estates than they would otherwise have. Many owners of this class, especially in Massachusetts and Connecticut, have planted large tracts of waste lands, and are systematically thinning their woodlands.

The greater portion of the forest land of New England is still owned by the farmers and lumbermen, who are for the most part mismanaging it, much as they always have, for only a few of these owners are here and there planting or making forestry cuttings. One cannot fail to realize, however, that the past few years have seen a considerable change in the general attitude of these owners. They are apt to think twice before they clean the evergreens off an old pasture, and they cut their winter's wood supply in many cases more or less after a crude selection system. In these and various other measures there is an indication that forestry is to be gradually adopted by many people, who will never realize that they have changed their methods.

It is very difficult to form any estimate of the total area in New England at present under forest management, especially because there is no well-defined line between old-time management and the crude forestry measures which in many cases are little more than the expression of a desire for better management. If management with the aim of permanent profit rather than for present gain alone is the line of distinction, it is estimated that five per cent of the forested lands of New England are so managed at present. If, however, the application of the term "Practice of Forestry" is restricted to lands upon which cultural operations are actually being practiced, it is doubtful if even one per cent of the entire wooded area could be classed as under forest management.

In the future it is probable that less forest land will be owned by farmers and lumbermen, and more by the governments, state and national, by large estates, and by companies formed with the express purpose of practicing forestry.

CHAPTER XVIII.

THE YIELD TO BE EXPECTED FROM NEW ENGLAND FORESTS UNDER PROPER MANAGEMENT.

THE previous chapters have brought out the fact that New England has large areas of waste land suitable for forest growth but now bare, and has even greater areas of forest land, only partially stocked or occupied by slow-growing species or those of inferior value for which trees of higher value and faster growth could be substituted advantageously. Reckless cutting, forest fires, and the grazing of stock are largely responsible for the deplorably bad silvicultural conditions of many stands. The woodlands of New England on which forestry actually is practiced are, as explained in Chapter XVII, insignificant in amount compared to the total forest area.

For these reasons it follows naturally that the present annual growth must fall far below what the forest lands of New England are able to produce. The object of this chapter is to compare present annual growth with what may be expected from the same territory when the forests are placed under scientific management.

Estimating the annual growth for the forests of New England is, in the present state of knowledge, no easy task, and all that can be done is to obtain an approximation to the truth. In Circular No. 159, entitled, "The Future Use of Land in the United States," the United States Forest Service estimates the annual growth per acre for the forests of the United States at twelve cubic feet.¹ This average for the whole country is be-

¹ Cubic feet are chosen as the unit for this discussion because it more accurately expresses the entire growth of a forest than do other units, especially board feet, in which unit there is oftentimes no growth over extensive areas.

lieved to be altogether too low for New England, since the forested lands are better stocked, the soils are of a greater productive power, and the forests contain large areas of second-growth stands (ordinarily more productive in a given time than virgin stands). It will be safer to place the annual growth per acre of the forested area of New England at thirty cubic feet, and applying this figure to the area forested gives about 757,000,000 cubic feet as the total annual growth.

This growth, however, is more than offset by the annual cut for lumber, pulpwood, ties, poles, cordwood, etc., which is estimated to reach 850,000,000 cubic feet. There is not such a large discrepancy between annual cut and annual growth as exists in many other sections of the country; the growth in some cases being far below the annual cut and in a few regions greater than the cut. The ideal arrangement is to have the yearly growth equal the amount cut, or slightly exceed the latter, since then it is usually possible to continue the annual cut indefinitely¹ without fear of exhausting the supply.

As the annual cut of the New England forests is only about 12 per cent greater than the growth there would appear to be no immediate danger of the local wood supply being exhausted; although the quality of the timber cut is deteriorating from year to year, the bulk of the present cut coming from second-growth stands or from lands already culled of the highest grade material.

Moreover, while the annual growth is nearly as large as the cut, yet in quality it is much poorer than the latter. The abundance of inferior species and the partial stocking of many areas (resulting in the production of knotty trees) are the principal causes for the poor quality of the annual growth. Thus with the decreasing quality of the cut, and of the growth, the productive power of the forest lands must fall off; if not in amount, certainly in grade of product. This is unnecessary and should not be allowed to continue as under scientific management of

¹ Even though the growth is equal to the amount cut the latter cannot be indefinitely maintained unless the forests are fully stocked and unless stands of young, middle-aged, and old timber are found occupying fairly equal areas.

the forests the quality of the wood produced and the actual amount annually grown can be greatly improved over present conditions.

In order to learn what results in the way of increased growth and better wood production may be secured through forestry, it is necessary to turn to the countries where forestry has been in practice for considerable periods of time, and where accurate records of the results are kept. No tracts in New England have been under treatment long enough to furnish the desired information. Certain of the European countries provide the best illustrations for our purpose, and in the following table the average annual growth per acre is given, together with the forested area on which based, for several countries.

ANNUAL GROWTH PER ACRE IN CUBIC FEET, TOGETHER WITH THE FORESTED AREA FOR VARIOUS COUNTRIES.¹

Country.	Forested area, acres.	Annual growth, cubic feet.
Austria.....	23,906,266	42.4
Belgium.....	1,303,735	58.2
France.....	24,021,587	37.9
Germany.....	34,989,675	48.7
Holland.....	617,567	46.0
Hungary.....	18,602,000	44.4
Switzerland.....	2,140,012	51.0

¹ The figures are taken from Bulletin No. 83 of the U. S. Forest Service, entitled "The Forest Resources of the World."

The annual growth per acre is seen to range from 37.9 to 58.2 cubic feet. It should be remembered that in these European countries the classification of lands into those suitable for agricultural and forest use is farther advanced than in New England, and that while in the latter region some soils suitable for agriculture are still forested, this rarely occurs in the European countries, where only the poorest grade soils are forested. Hence the forested areas of the European countries may be expected to have a somewhat lower productive power than those of New England. Some of the countries with the poorest and

shallowest soils show the best growth, — see Switzerland,¹ for example, with its annual growth of fifty-one cubic feet — rendered possible only by the best management.

The forest soils of New England certainly are capable of producing as much per acre as those of Switzerland or Germany, or in round numbers fifty cubic feet per acre annually. Such an annual growth can only be secured after years of forestry work, though a gradual increase over the present growth should begin soon after proper treatment is started.

While for the entire forested area of New England an annual growth of fifty cubic feet per acre may be considered as fairly representing the possibilities, yet on small portions a much higher annual growth can be secured. Instances are frequent in European practice of relatively small tracts annually producing from seventy-five to over one hundred cubic feet per acre. Such a production indicates either that the soil is of good quality or that the forest is stocked with fast-growing species.

The difference between stands of fast-growing and slow-growing species and the effect of quality of the soil on production is shown clearly by the following comparison between stands of oak and spruce grown in Saxony on five qualities of soil.

YIELD PER ACRE IN CUBIC FEET AT 100 YEARS FOR FULLY STOCKED STANDS OF OAK AND SPRUCE IN SAXONY.

	Quality classes.				
	I	II	III	IV	V
			Cubic feet.		
Oak:					
Yield per acre.....	6960.	5660.	4360.	3070.	1520.
Mean annual growth...	69.6	56.6	43.6	30.7	15.2
Spruce:					
Yield per acre.....	14,910.	11,520.	8130.	4730.	1900.
Mean annual growth...	149.1	115.2	81.3	47.3	19.0

This table indicates, for example, that a forest of oak would produce on quality I soil, 69.6 cubic feet per acre annually, in

¹ The soils of Switzerland are probably not as sandy or infertile as those of some other regions, but on account of their elevation and shallowness are often inferior.

contrast to 149.1 cubic feet for spruce, or comparing stands of two qualities having the same species, that spruce on quality I annually produces 149.1 cubic feet per acre, but on quality V only 19.0 cubic feet.

Second-growth white pine stands in New England furnish a good illustration of large annual production. Taking the data from the Yield Table for white pine in "The Forest Mensuration of the White Pine in Massachusetts," for stands fifty-five years old, gives the following result:

YIELD PER ACRE OF WHITE PINE STANDS IN MASSACHUSETTS¹
AT 55 YEARS, IN CUBIC FEET.

	Quality Classes.		
	I	II	III
Yield per acre.....	8575	7200	Cubic feet. 6015
Mean annual growth.....	156	131	109

¹ It should be understood that these figures are for unmanaged forests, while the European figures are for forests which have always been well managed.

It is easily within the possibilities throughout much of New England to develop forests of white pine and other fast-growing species which will produce annually 100 or more cubic feet per acre, and an average growth of 50 cubic feet is thought to be a very conservative figure of what may be accomplished through forestry.

The average quality of the product will be greatly increased, as one of the main objects of forestry is to grow the better grades at the expense of inferior material. Low-grade material, such as cordwood, must always form an important part of the yield, either as material which is sold, or in undeveloped regions as material which must be left in the forest and wasted. But whereas in an uncared-for forest perhaps 60 per cent of the volume may be low-grade material, ultimately the same forest may be so managed that possibly only 40 per cent of the output is of poor quality. The results of management in Europe show

that a steadily rising percentage of the better qualities may be expected in the yield. For example, the "workwood per cent," as the percentage of the annual cut suitable for higher grade products is termed, increased in the state forests of Baden from 30 per cent in 1878 to 40 per cent in 1904, and in the state forests of Prussia rose from 47 per cent in 1890 to 63 per cent in 1907. A comparison of present financial returns from New England's forests with those received from forests abroad is instructive and indicates what opportunity there is for improvement. Based on statistics for 1909, the annual gross value of forest products cut in New England is estimated at \$85,000,000. A large share of this value, however, is consumed by the expenses of manufacturing and bringing the material to market, so that the net value, or value standing in the forest, of the annual cut falls to approximately \$20,000,000. From this net value there must still be deducted such items as the cost of administering the forest lands, of protection and taxes. These various charges are estimated to equal \$5,000,000 a year, leaving \$15,000,000 as the annual net returns from a forested area of 25,238,458 acres, or \$0.59 per acre per year. This return would be less were it not that the annual cut exceeds the growth at the present time.

Figures of net return per acre vary widely in the different European countries, and of course vary from year to year in the same country, but the tendency year by year is towards higher net returns, although the cost of management is constantly rising.

Single private or communal forests of relatively small areas often yield annual net returns of from \$8 to over \$15 per acre, while instances of even higher yields are on record.¹

From the values in the preceding table it can easily be seen that the present net return per acre of the New England forests is very low. Results, fully as good as those in Europe, can be

¹ See "Forestry Quarterly," Vol. VII, p. 471, where a private tract of six thousand acres in Suabia, composed 92 per cent of spruce (a very profitable species), is mentioned giving an annual net return of \$17.47 per acre.

secured here, of from \$1.50 to \$5 per acre for the large forest areas, and much higher returns on exceptionally situated and intensively managed forests; but of course it will take time. Forestry has been practiced in the countries from which these figures have been taken for fifty to one hundred years, and the net returns increased from little or nothing to the present amounts.

The following table shows the net annual income from forested areas in several European countries:

Country.	Forested area, acres.	Net returns per acre. ¹	For year.	Remarks.
Switzerland (The Sihlwald)....	2,560	\$7.69	1907	Chiefly beech under management since 1802.
Wurtemberg (State forests)....	468,790	6.74	1906	
Belgium (State forests)....	62,600	4.16	1906	
Hesse (Crown forests)...	166,215	4.00	1902	
Bavaria (State forests)....	2,088,592	3.50	1909	Much of the forest is on very poor soil.
Prussia (State forests)....	6,396,172	2.52 ²	1907	
Austria (State forests)....	2,573,000	.80	1911	Forestry poorly developed compared with the other states listed.

¹ Usually the larger the area of a country the smaller are the net returns per acre.

² The Prussian state forests have increased their net return per acre from \$1.36 in 1800 to \$2.52 in 1907.

High returns per acre from the business of forestry can only be secured by intensive management requiring large annual expenditures. For example, the state forests of Bavaria in 1909 gave gross returns of \$6.11 per acre of which \$2.61 were taken by expenditures, leaving \$3.50 per acre as the net return. In the Prussian state forests the same year, gross returns amounted to

\$4.35 per acre, expenditures totaled \$2.41, or considerably more than the net return of \$1.94 per acre.

In conclusion, what may be expected of forestry as an investment? It offers the only method of making profitable large areas of land in New England, but even thus it may not necessarily offer a highly tempting field for investment for the average landowner. Briefly, the growing of timber crops in New England, as a business, may be expected to pay from 3 to 6 per cent on the investment, depending on a variety of factors, among which the following three are especially important, the quality of the soil, species grown, and the location of the tract with reference to markets. Forestry is not a business paying high dividends and, if judged by the dividends paid, must be classed with investments affording good security to the principal invested. Hence if it is to attract private capital it must offer good security for the principal invested.

Until recently the practice of forestry in New England has not offered a secure investment at all comparable with a good 4 per cent bond, owing principally to the great danger from forest fires,¹ but public sentiment for protection of the forests from fire has crystallized within the last few years and taken shape in the form of action by the state authorities with the coöperation of the Federal Government to insure better protection. Already much has been accomplished to lessen the fire hazard, and it is believed that now protection for a given tract can be assured at reasonable expense.

With protection assured, and with productive soils, valuable, fast-growing species of trees suited to the soils and excellent markets, there is no reason why growing timber crops in New England should not be considered as a secure investment.

When once a tract is brought into proper condition, steady returns are received annually, but owing to the length of time and the investment involved in waiting for this condition to be

¹ The probability under present methods of taxing forest lands, of being compelled to pay excessively high taxes is another drawback to the practice of forestry.

attained as well as the low rate of interest many private owners will undoubtedly be unable to practice forestry. To the state, municipalities, and to corporations with ample funds and a permanent existence, forestry offers an excellent investment.

To all owners of non-agricultural lands it offers the opportunity of obtaining the greatest permanent profits from such lands.

APPENDIX.

FOREST FIRE STATISTICS.

THE statistics given here have been compiled from the reports of the state forestry departments of the six New England states. As these reports are for states and not for forest regions it has been necessary to combine figures from several states in order to obtain totals for the four regions. The reports are not full enough in some instances, and often do not cover enough years for a fair average and are not arranged with sufficient uniformity to give this compilation complete accuracy. However, it is believed that the tables faithfully picture conditions in the four forest regions, and in acreage burned over, damage done, and cost of protection are conservative.

The total annual loss from forest fires in New England is nearly \$1,000,000, which, as shown in Table I, is composed of three items:

First. Damage as ordinarily reported.

Second. Cost of protection (including fighting fires).

Third. Damage not ordinarily reported.

The amount of the first represents the damage as given in by the fire wardens and patrolmen, and is mainly to merchantable material. Very rarely is damage to unmerchantable material properly estimated and reported. Where trees nearly of merchantable size are injured the damage to them is sometimes reported, but more often even this is omitted.

Damage not ordinarily reported consists of injury to young growth, ranging from trees a little under the merchantable size to small seedlings or "reproduction" as these small plants are collectively termed. Injury to the soil and to seed-bed conditions is also included in unreported damage. Fire injury to the soil has been previously described in Chapter VIII. Fre-

quently fire results in an entire change of seed-bed conditions. Usually these changes result in the seeding in of a less desirable tree. The damage caused by such a change in the composition of the stand must be charged against the fire.

TABLE I. FOREST FIRE LOSSES FOR AN AVERAGE YEAR IN NEW ENGLAND.

Region.	Area annually burned over, acres.	Damage ¹ as ordinarily reported.	Damage ² not ordinarily reported.	Cost of protection and fighting fires.	Total ³ expenditure or loss due to forest fires.
Spruce ⁴	40,000	\$150,000	\$75,000	\$60,000 ⁵	\$285,000
Northern hardwoods ⁶ ...	3,600	8,000	7,000	3,500	18,500
White pine ⁷	66,500	315,000	100,000	32,500	447,500
Sprout hardwoods ⁸	48,500	181,000	50,000	9,000	240,000
All New England.....	158,600	\$654,000	\$232,000	\$105,000	\$991,000

¹ Based on reports of the local forest fire wardens and patrolmen.

² Includes injury to reproduction, to young growth, to soil and seed-bed conditions.

³ Secured by adding together the amounts in the three preceding columns.

⁴ Based chiefly on the seventh and eighth annual reports of the Forest Commissioner of Maine, giving data for the years 1907, 1908, 1909, and 1910. While the reports of the Vermont and New Hampshire state foresters have been consulted the data in these last two states does not cover so many years.

⁵ The basis for this estimate is the average annual expenditure for 1909 and 1910, by the State of Maine within the territory of the spruce region.

⁶ For an average year, based on available figures for the years 1907-8, 1909-10.

⁷ Based on averages for from two to four fire seasons.

⁸ This estimate is based on the report of the State Forester of Connecticut for 1910, printed in the Biennial Report of the Conn. Agri. Exp. Station, for 1909-1910, and on the Fifth Annual Report of the Rhode Island Commissioner of Forestry.

TABLE II. COMPARISON BETWEEN REGIONS IN THE AMOUNT SPENT FOR FIRE PROTECTION.

Region.	Per cent of the forested area annually burned.	Cost of protection (including fighting fires) per acre protected.	Per cent of total value of forest lands spent annually for protection.	Forested area valued at. ¹
Spruce.....	.0026	\$.0038	$\frac{1}{10}$ of 1%	\$4 per acre ²
Northern hardwoods..	.0010	.0010	$\frac{1}{50}$ of 1%	6 per acre
White pine.....	.0140	.0067	$\frac{4}{50}$ of 1%	8 per acre
Sprout hardwoods.....	.0356	.0066	$\frac{8}{50}$ of 1%	10 per acre
United States National Forests.....	.0018 ³	.0170 ⁴		

¹ These values are the ones used in getting the figures in the preceding column and are believed to be extremely conservative especially for central and southern New England.

² Based on the value of the wild lands of Maine, as assessed for the year 1906.

³ Season 1909.

⁴ Average for 1909 and 1910. This is really the cost of administrating the National Forests and includes cost of protection.

Probably the most noticeable thing in Table I is the small area burned over and the low damage in the northern hardwoods region as compared to the other three regions. This is more accurately shown in Table II. From this table it is seen that in the northern hardwoods region only .001 of the forested area is annually burned over as against .0026, .014 and .0356 respectively in the spruce, white pine, and sprout hardwoods region. It is all the more striking since less money per acre protected is spent here than in any of the other regions. The northern hardwoods region is naturally comparatively immune from forest fires, as has been explained in discussing the forest fire situation there.

The tables clearly show that the well-settled regions have a more serious fire problem than the unsettled regions. Compare the per cent burned over and cost of protection for the spruce and sprout hardwoods region, and compare the latter with the United States National forests where only .0018 of the forested area was burned over in 1909.

The amount of money spent annually for fire protection (including fighting fires) should be looked upon as an insurance premium paid for the protection of the forest. To show the rate of premium now paid, column 4 of Table II gives the per cent of the total value of the forest lands spent annually for fire protection. This ranges annually from one-fiftieth of one per cent in the northern hardwoods region to one-tenth of one per cent in the spruce region. By comparison with rates paid for insurance on buildings in cities where the best fire protection is afforded and fire hazard is enormously less than in the forest, the absurdly low rate now paid for the protection (insurance) of forests from fires will be at once apparent.

Sentiment for the better protection of the forest is rapidly growing in New England, and the state organizations for forest fire protection are each year becoming more efficient.

The increase of public sentiment should result in making available larger sums of money for fire protection and this, with the greater efficiency of the organization, will undoubtedly result in a lessening of the annual forest fire loss

BIBLIOGRAPHY.

THIS bibliography is not intended to cover all material bearing on the trees and forests of New England, but an effort has been made to include such books, pamphlets and articles dealing with forestry problems as might prove of practical value to the reader.

Nearly all the reports and bulletins issued by the various state forestry departments will be found listed here, as well as such of the bulletins and circulars issued by the United States Forest Service, as bear on New England conditions.

State and federal publications, reports of forestry associations and societies, current articles and a few books make up forestry literature at the present time.

The material is arranged alphabetically according to authors.

- AYRES, PHILIP W. Annual Reports of Society for Protection of New Hampshire Forests. Concord. (Commence with 1902.)
- AYRES, PHILIP W. Commercial Importance of the White Mountain Forests. Circular 168, Forest Service, U. S. Department of Agriculture. Washington. 32 pages. 1909.
- AYRES, PHILIP W. Is New England's Wealth in Danger? New England Magazine, March, April, May, 1908.
- BOWMAN, ISAIAH. Forest Physiography. New York. 730 pages. 1911.
- BRADLEY, REGINALD R. Suggestions for Handling Pulpwood Lands in Eastern Canada. Forestry Quarterly. Vol. VI. Ithaca. Pages 220-228. 1908.
- BRISTOL, T. L. Some Practical Results of Forestry in Connecticut. Fifth Annual Bulletin, Connecticut Forestry Association. Hartford. Pages 13-17. 1907.
- BRITTON, W. E. Tenth Report of the State Entomologist, contained in Report of the Connecticut Agricultural Experiment Station. Part IX of Biennial Report of 1909-10. New Haven. Pages 657-712. 1911.
- BRONSON, ELLIOTT B. Discussion of the Connecticut Forest Fire Law. Proceedings of the Connecticut Forestry Association. Hartford. Pages 20-23. 1909.
- BRYAN, A. HUGH. Maple-sap Sirup: Its manufacture, composition and effect of environment thereon. Bulletin 134, Bureau of Chemistry, U. S. Department of Agriculture. Washington. 10 pages. 1910.

- BRYANT, EDW. SOHIER. Practical Forestry for Waterworks. Reprinted from Journal of the New England Waterworks Association. Vol. XXV. Boston. Pages 243-246. 1911.
- CARD, FRED W. Forests of Rhode Island. Bulletin No. 88, Rhode Island Agricultural Experiment Station. Kingston, R. I. 39 pages. 1902.
- CARR, M. S., and others. Soil Survey of Washington County, New York. Advance Sheets, Bureau of Soils, U. S. Department of Agriculture. Washington. 59 pages. 1911.
- CARY, AUSTIN. Unprofessional Forestry. Forestry Quarterly. Vol. IV. Ithaca. Pages 183-187. 1906.
- CARY, AUSTIN. Practical Forestry on a Spruce Tract in Maine. Circular 131, Forest Service, U. S. Department of Agriculture. Washington. 15 pages. 1907.
- CARY, AUSTIN. A Manual for Northern Woodsmen. Published by Harvard University, Cambridge. 250 pages. 1909.
- CHANDLER, B. A. Vermont Summer School of Forestry and Horticulture. American Forestry, Dec., 1911. Pages 735-740.
- CLARK, A. M. Trees of Vermont. Bulletin No. 73, Vermont Agricultural Experiment Station. Burlington. 50 pages. 1899.
- CLINTON, G. P. Report of the Station Botanist, contained in Connecticut Agricultural Experiment Station Report for 1908. New Haven. Pages 849-907. 1909.
- CONNECTICUT, STATE FORESTER. Forest Survey of Litchfield and New Haven Counties. Connecticut Forestry Publication No. 5, Connecticut Agricultural Experiment Station. New Haven. 47 pages. 1909.
- CONNECTICUT, STATE FORESTER. Instructions to Fire Wardens and Others, Relative to Forest Fires in Connecticut. New Haven. 40 pages.
- CONNECTICUT, STATE FORESTER. Annual Reports of the State Forester of Connecticut. New Haven. (Commence with 1906.)
- CONNECTICUT, STATE FORESTER. Chestnut in Connecticut, and the Improvement of the Woodlot. Bulletin No. 154, Connecticut Agricultural Experiment Station. 41 pages. 1906.
- COOK, H. O. A Forest Fire-wagon for Massachusetts Towns. Bulletin of the Harvard Forestry Club. Vol. I., pp. 42-43. Cambridge. 1911.
- COTTON, J. S. Improvement of Pastures in Eastern New York, and the New England States. Circular No. 49, Bureau of Plant Industry, U. S. Department of Agriculture. Washington. 10 pages. 1910.
- CURTIS, E. D. The Practice of Forestry by a Connecticut Land Owner. Proceedings of the Connecticut Forestry Association. Hartford. Pages 24-31. 1909.
- DANA, S. T. Paper Birch in the Northeast. Circular No. 163, Forest Service, U. S. Department of Agriculture. Washington. 37 pages. 1907.
- DEFEBAGH, JAMES ELLIOTT. History of the Lumber Industry of America. Vol. II. New England. Chicago. Pages 1-301. 1907.
- EDDY, E. M. C. Coöperation of a Town and Railroad for Fire Protection. Proceedings of the Connecticut Forestry Association. Hartford. Pages 16-19. 1909.

- FIPPIN, ELMER O. Soil Survey of the Connecticut Valley. Fifth Report Field Operations of the Bureau of Soils, U. S. Department of Agriculture. Washington. Pages 39-58. 1904.
- FISHER, R. T. An Account of Operations in the Harvard Forest, 1908-09. Bulletin of the Harvard Forestry Club. Vol. I. Pages 1-9. Cambridge. 1911.
- FOX, WM. F., and HUBBARD, WM. F. The Sugar-maple Industry. Bulletin No. 59, Forest Service, U. S. Department of Agriculture. Washington. 56 pages. 1905.
- GOODRICH, L. W. Forestry. Reprinted from Journal of the New England Waterworks Association. Vol. XXIV. Hartford. Pages 345-352. 1910.
- GOULD, H. F. Some Preliminary Investigations concerning the Ratio between DBH and DIB at Stump for White Pine in Massachusetts. Bulletin of the Harvard Forestry Club. Vol. I. Pages 44-45. Cambridge. 1911.
- GRAVES, H. S. American Forestry. Proceedings of the Connecticut Forestry Association. Hartford. Pages 32-40. 1909.
- GRAVES, H. S. The Management of Second-growth Sprout Forests. Separate 525, Yearbook, U. S. Department of Agriculture, 1910. Washington. Pages 157-168. 1910.
- GRAVES, H. S. Notes on the Rate of Growth of Red Cedar, Red Oak and Chestnut. Forestry Quarterly, Vol. III. Ithaca. Pages 349-353. 1905.
- GRAVES, H. S. Principles of Handling Woodlands. New York. 320 pages. 1911.
- GRAVES, H. S. Forest Mensuration. New York. 437 pages. 1906.
- GRAVES, H. S., and FISHER, R. T. The Woodlot. Bulletin No. 42, Forest Service, U. S. Department of Agriculture. Washington. 89 pages. 1903.
- HAWES, A. F. Economic Thinning of White Pine. Forestry Quarterly, Vol. V. Ithaca. Pages 368-372. 1907.
- HAWES, A. F. Review of the Forestry Situation in Connecticut. Fifth Annual Bulletin, Connecticut Forestry Association. Hartford. Pages 5-13. 1907.
- HAWES, A. F. The Forests of Connecticut. The Connecticut Magazine, Vol. X, No. 2.
- HAWES, A. F. Forestry. The Salvation of a Wornout Connecticut Town. New England Magazine, September, 1908.
- HAWLEY, R. C. Treatment of Hardwood Lands in Southwestern Connecticut. Forestry Quarterly, Vol. V. Ithaca. Pages 283-295. 1907.
- HOPKINS, A. D. Bulletin No. 28, Division of Entomology, U. S. Department of Agriculture. Washington.
- HOPKINS, A. D. Some of the Principal Insect Enemies of Coniferous Forests in the United States. Yearbook of the U. S. Department of Agriculture, 1902. Pages 265-282.
- HOPKINS, A. D. Contributions Toward a Monograph of the Bark-weevils of the Genus *Pissodes*. Technical Series No. 20, Part I, Bureau of Entomology, U. S. Department of Agriculture. Washington. 67 pages. 1911.
- HOPKINS, A. D. Barkbeetles of the Genus *Dendroctonus*. Bulletin No. 83, Part I, Bureau of Entomology, U. S. Department of Agriculture. Washington. 169 pages. 1909.

- JONES, L. R. Forestry in Vermont. Forestry Quarterly, Vol. VI. Ithaca. Pages 234-236. 1908.
- JONES, C. H., and others. The Maple-sap Flow. Bulletin No. 103, Vermont Agricultural Experiment Station. 140 pages. 1903. (Bulletin No. 105, by J. L. Hills, is a popular edition of Bulletin No. 103. 28 pages.)
- KEMPTON, HAROLD B. Planting of White Pine in New England. Bulletin No. 45, Forest Service, U. S. Department of Agriculture. Washington. 40 pages. 1903.
- KIRKLAND, A. H. The Gipsy and Brown-tail Moths. Bulletin No. 1, Office of the Superintendent for suppressing the gipsy and brown-tail moths. Boston. 27 pages. 1905.
- LEE, ORA, JR. Soil Survey of the Orono Area, Maine. Advance Sheets, Field Operations of the Bureau of Soils, 1909, U. S. Department of Agriculture. Washington. 37 pages. 1910.
- MAINE, FOREST COMMISSIONER. Biennial Reports of the Forest Commissioner of Maine. Waterville. (Commence with 1892.)
- MASSACHUSETTS. Mountain Parks of Massachusetts. Woodland and Roadside. Page 23. Boston. June, 1909.
- MASSACHUSETTS, STATE FORESTER. Reforestation in Massachusetts. Boston. 35 pages. 1910.
- MASSACHUSETTS, STATE FORESTER. The Chestnut-bark Disease. Boston. 7 pages. 1911.
- MASSACHUSETTS, STATE FORESTER. Laws Relating to Forestry and the Suppression of the Gipsy and Brown-tail Moths. Boston. 67 pages. 1910.
- MASSACHUSETTS, STATE FORESTER. We Must Stop Forest Fires in Massachusetts. Boston. 43 pages. 1909.
- MASSACHUSETTS, STATE FORESTER. How to make Improvement Thinnings in Massachusetts Woodlands. Boston. 21 pages. 1910.
- MASSACHUSETTS, STATE FORESTER. A Study of the Massachusetts Wood-using Industries. Boston. 37 pages. 1910.
- MASSACHUSETTS, STATE FORESTER. Annual Reports of the State Forester of Massachusetts. Boston. (Commence with 1904.)
- MASSACHUSETTS, STATE FORESTER. The "Wilt Disease," or "Flacherie," of the Gipsy Moth. Boston. 60 pages. 1911.
- MASSACHUSETTS, STATE FORESTER. Forest Working Plan for Land of City of Fall River on the North Watuppa Watershed. Boston. 30 pages. 1909.
- MASSACHUSETTS, STATE FORESTER. Forest Mensuration of the White Pine in Massachusetts. Boston. 50 pages. 1908.
- MASSACHUSETTS. A Harvard University Forest. Woodland and Roadside. December, 1907.
- MASSACHUSETTS. Moth Work. American Forestry. Washington. Page 501. August, 1911.
- METCALF, H. The Present Status of the Chestnut-bark Disease. Bulletin No. 141, Part V, Bureau of Plant Industry, U. S. Department of Agriculture. Washington. 1911.

- METCALF, H. The Immunity of the Japanese Chestnut to the Bark Disease. Bulletin No. 121, Part VI., Bureau of Plant Industry, U. S. Department of Agriculture. Washington. Pages 3-4. 1908.
- MOONEY, C. N., and BYERS, W. C. Soil Survey of the Nashua Area, New Hampshire. Advance Sheets, Field Operations of the Bureau of Soils, 1909, U. S. Department of Agriculture. Washington. 34 pages. 1910.
- MOONEY, CHARLES N., and others. Soil Survey of Merrimack County, New Hampshire. Advance Sheets, Field Operations of the Bureau of Soils, 1906, U. S. Department of Agriculture. Washington. 39 pages. 1908.
- MOORE, BARRINGTON, and ROGERS, R. L. Notes on Balsam Fir. Forestry Quarterly, Vol. V. Ithaca. Pages 41-50. 1907.
- NEW HAMPSHIRE, FORESTRY COMMISSION. Reports of the Forestry Commission of New Hampshire, under dates of 1885, 1891, 1893 and 1894.
- NEW HAMPSHIRE, FORESTRY COMMISSION. Biennial Reports of the Forestry Commission of New Hampshire. Concord. (Commence with 1895-96.)
- NEW HAMPSHIRE, FORESTRY COMMISSION. Forest Laws and Organization of the Forestry Department. Concord, N. H. 63 pages. 1911.
- NEW HAMPSHIRE, STATE FORESTER. Forest Laws of New Hampshire. Bulletin No. 1, New Hampshire Forestry Commission. Concord. 17 pages. 1909.
- PETERS, J. G. Coöperation with States in Fire Patrol. American Forestry. Washington. Pages 383-384. July, 1911.
- PETTIS, C. R. How to Plant and Grow Conifers in the Northeastern States. Bulletin No. 76, Forest Service, U. S. Department of Agriculture. Washington. Page 36. 1909.
- RHODE ISLAND, COMMISSIONER OF FORESTRY. Laws Pertaining to Forests. Providence. Page 17.
- RHODE ISLAND, COMMISSIONER OF FORESTRY. Annual Reports of Commissioner of Forestry of Rhode Island. Providence. (Commence with 1907.)
- RODGERS, D. M., and BURGESS, A. F. Report on the Field Work Against the Gipsy Moth and the Brown-Tail Moth. Bulletin 87, Bureau of Entomology, U. S. Department of Agriculture. Washington. 81 pages. 1910.
- SCHWARTZ, G. FREDERICK. Sprout Forests of the Housatonic Valley. Forestry Quarterly, Vol. V. Ithaca. Pages 121-153. 1907.
- SPALDING, V. M. The White Pine. Bulletin No. 22, Division of Forestry, U. S. Department of Agriculture. Washington. 179 pages. 1899.
- SPAULDING, PERLEY. The Blister Rust of White Pine. Bulletin No. 206, Bureau of Plant Industry, U. S. Department of Agriculture. Washington. 88 pages. 1911.
- SPAULDING, PERLEY. European Currant Rust on White Pine in America. Circular No. 38, Bureau of Plant Industry, U. S. Department of Agriculture. Washington. 4 pages. 1909.
- SPAULDING, PERLEY. Present Status of the White Pine Blight. Circular No. 35, Bureau of Plant Industry, U. S. Department of Agriculture. Washington. 12 pages. 1909.
- SPRING, SAMUEL N. Natural Replacement of White Pine on Old Fields in New England. Bulletin No. 63, Forest Service, U. S. Department of Agriculture. Washington. 32 pages. 1905.

- START, E. A. Known by Their Fruits. *American Forestry*, September, 1910. Washington. Pages 535-539. 1910.
- STEPHEN, JOHN W. Lopping Branches in Lumbering Operations. Reprint from the Fifteenth Annual Report Forest, Fish and Game Commission, New York State. Albany. Pages 94-102. 1909.
- SUTER, H. M. Forest Fires in Adirondacks in 1903. Circular No. 26, Forest Service, U. S. Department of Agriculture. Washington. 15 pages. 1904.
- THOMSON, E. H. Agricultural Survey of Four Townships in Southern New Hampshire. Circular No. 75, Bureau of Plant Industry, U. S. Department of Agriculture. Washington. 19 pages. 1911.
- VERMONT, STATE FORESTER. The Management of Vermont Forests with Special Reference to White Pine. Bulletin No. 156, Vermont Agricultural Experiment Station. Burlington. Pages 100-139. 1911.
- VERMONT, STATE FORESTER. Annual Reports of the State Forester. Burlington. (Commence with 1909.)
- VERMONT, STATE FORESTER. Preliminary Statement Regarding the Forestry Problems of Vermont. Publication No. 1, Vermont Forest Service. Burlington. 13 pages. 1909.
- VERMONT, STATE FORESTER. Forest Fires in Vermont. Publication No. 2, Vermont Forest Service. Burlington. 48 pages. 1909.
- VERMONT, STATE FORESTER. Instructions to Forest Fire Wardens and Woodland Owners Regarding Forest Fires. Forest Service Publication No. 7. Burlington. 19 pages. 1911.
- VON SCHRENK, HERMAN. Some Diseases of New England Conifers. Bulletin No. 25, Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture. Washington. 56 pages. 1900.
- WEIGLE, WM. G., and FROTHINGHAM, E. H. The Aspens. Bulletin No. 93, Forest Service, U. S. Department of Agriculture. Washington. 33 pages. 1911.
- WENTLING, J. P. Wood Used for Packing Boxes in New England. Circular No. 78, Forest Service, U. S. Department of Agriculture. Washington. 4 pages. 1907.
- WESTGATE, J. M. Reclamation of Cape Cod Sand Dunes. Bulletin No. 65, Bureau of Plant Industry, U. S. Department of Agriculture. Washington. 36 pages. 1904.
- WILDER, HENRY J., and BELDEN, H. L. Soil Survey of the Vergennes Area, Vermont—New York. Sixth Report Field Operations of the Bureau of Soils, U. S. Department of Agriculture. Washington. Pages 73-94. 1905.
- WILDES, W. K. State Forests in Vermont. *American Forestry*, May, 1911. Washington. Pages 253-256.
- WILSON, JAMES. Report of Secretary of Agriculture on Southern Appalachian, and White Mountains Watersheds. Senate Document No. 91. Sixtieth Congress. Washington. 39 pages. 1908.
- WOOLSEY, T. S., JR. Strip Thinning. *Proceedings Society of American Foresters*. Vol. II. Washington. Pages 38-41. 1911.

TABLES.

It has been the aim of the authors to gather together all the reliable tables at present available, which contain figures showing volumes and growth for New England trees and forests. The principal log rules used in the region have also been included. In connection with the practice of forestry such tables are of great value, and it is unfortunate that as yet, owing to the recent rise of the movement, more information has not been obtained. The field is very incompletely covered and indeed for many important species data is entirely lacking. For certain trees, such as white pine and chestnut, comparatively full studies have been made, and many valuable tables are available.

Except for tables XII and XXXIV, none of the tables given here are original, but have been taken from various sources, of which acknowledgment has been made in the preface. Also, in connection with each table will be found a statement as to the source from which it was secured.

The tables have been arranged in the following groups:

Log Rules.

Volume Tables.

Growth of Individual Trees.

Yield Tables.

LOG RULES.

TABLE III. — SCRIBNER LOG RULE.¹(Decimal "C")²

Diameter in inches.	Length in feet.						Diameter in inches.
	6	8	10	12	14	16	
	Contents in board feet.						
6	0.5	0.5	1	1	1	2	6
7	0.5	1	1	2	2	3	7
8	1	1	2	2	2	3	8
9	1	2	3	3	3	4	9
10	2	3	3	3	4	6	10
11	2	3	4	4	5	7	11
12	3	4	5	6	7	8	12
13	4	5	6	7	8	10	13
14	4	6	7	9	10	11	14
15	5	7	9	11	12	14	15
16	6	8	10	12	14	16	16
17	7	9	12	14	16	18	17
18	8	11	13	16	19	21	18
19	9	12	15	18	21	24	19
20	11	14	17	21	24	28	20
21	12	15	19	23	27	30	21
22	13	17	21	25	29	33	22
23	14	19	23	28	33	38	23
24	15	21	25	30	35	40	24
25	17	23	29	34	40	46	25
26	19	25	31	37	44	50	26
27	21	27	34	41	48	55	27
28	22	29	36	44	51	58	28
29	23	31	38	46	53	61	29
30	25	33	41	49	57	66	30
31	27	36	44	53	62	71	31
32	28	37	46	55	64	74	32
33	29	39	49	59	69	78	33
34	30	40	50	60	70	80	34
35	33	44	55	66	77	88	35
36	35	46	58	69	81	92	36

¹ Taken from "The Woodsman's Handbook."² The total scale is obtained by multiplying the figures in this table by 10. Thus the contents of a 6-inch 8-foot log are given as 0.5, so the total scale is 5 board feet. A 30-inch 16-foot log is given as 66, or a total scale of 660 board feet.

TABLE IV. — DOYLE LOG RULE.

Diameter in inches.	Length in feet.				
	8	10	12	14	16
	Contents in board feet.				
6	2.0	2.5	3.0	3.5	4.0
7	4.5	5.6	6.8	7.9	9.0
8	8	10	12	14	16
9	12	16	19	22	25
10	18	23	27	32	36
11	24	31	37	43	49
12	32	40	48	56	64
13	40	50	61	71	81
14	50	62	75	88	100
15	60	75	91	106	121
16	72	90	108	126	144
17	84	106	127	148	169
18	98	122	147	171	196
19	112	141	169	197	225
20	128	160	192	224	256
21	144	181	217	253	289
22	162	202	243	283	324
23	180	226	271	313	359
24	200	250	300	350	400
25	220	276	331	386	441
26	242	302	363	423	484
27	264	330	397	463	530
28	288	360	432	504	576
29	312	391	469	547	625
30	338	422	507	591	676
31	364	456	547	638	729
32	392	490	588	686	784
33	420	526	631	736	841
34	450	562	675	787	900
35	480	601	721	841	961
36	512	640	768	896	1,024

TABLE V. — MAINE, HOLLAND, OR BANGOR LOG RULE.¹

Length in feet.	Diameter in inches.								
	6	7	8	9	10	11	12	13	14
	Contents in board feet.								
10	12	19	27	32	42	51	65	75	89
11	14	21	30	36	46	57	70	81	98
12	15	23	33	39	51	62	78	90	107
13	17	25	36	43	55	67	85	98	115
14	18	27	39	46	59	72	92	105	124
15	19	29	41	49	64	78	98	113	133
16	20	31	44	52	68	83	105	120	142
17	22	33	47	56	72	88	111	128	151
18	23	35	50	59	76	93	118	135	160
19	24	37	52	62	81	98	124	143	169
20	25	39	55	65	85	103	131	150	178
21	27	41	58	69	89	109	137	158	186
22	28	43	61	72	94	114	144	165	195
23	29	45	63	75	98	119	150	173	204
24	30	47	66	78	102	124	157	180	213
25	32	49	69	82	106	129	164	188	222
26	33	50	72	85	111	134	170	195	231
27	34	52	74	88	115	140	177	203	240
28	36	54	76	92	119	145	183	210	249
29	37	56	79	95	123	150	190	218	258
30	38	58	82	98	128	155	196	225	266

Length in feet.	Diameter in inches.									
	15	16	17	18	19	20	21	22	23	24
	Contents in board feet.									
10	101	111	128	145	169	189	210	227	250	274
11	111	123	142	160	187	209	232	250	274	298
12	121	134	154	174	203	227	252	272	300	327
13	131	145	167	189	220	246	273	295	326	357
14	141	157	179	203	237	265	294	318	351	384
15	151	168	192	218	254	284	315	340	376	412
16	161	179	205	232	271	302	336	363	401	439
17	171	190	218	247	288	321	357	386	426	466
18	181	201	231	261	305	340	378	408	451	494
19	192	212	243	276	322	359	399	431	476	521
20	202	223	256	290	339	378	420	454	501	549
21	212	235	269	305	356	397	441	476	526	576
22	222	246	282	319	373	415	462	499	551	604
23	232	257	295	334	390	435	483	522	576	631
24	242	268	307	348	407	454	504	545	601	659
25	252	279	320	363	424	473	525	567	626	686
26	262	291	333	378	441	491	545	590	651	713
27	272	302	346	392	458	510	566	613	676	741
28	282	313	359	407	475	529	587	635	701	768
29	292	324	371	421	492	548	608	658	726	796
30	302	335	384	436	509	567	629	681	751	823

¹ Taken from "A Manual for Northern Woodsmen."

TABLE VI. — NEW HAMPSHIRE LOG RULE.¹

Length in feet.	Diameter in inches.														
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	Contents in board feet.														
12	...	1	...	3	...	...	...	7	8	9	11	12	...	15	...
13	...	...	...	...	4	5	6	...	10	11	13	15	...	...	...
14	...	...	2	...	...	...	...	8	9	11	12	14	...	...	...
15	...	...	...	...	...	...	6	7	...	10	...	13	15	...	...
16	1	...	3	4	5	...	...	9	...	12	14	16	...	20	...
17	...	...	...	...	...	...	...	8	...	11	13	15	17	...	...
18	...	...	...	...	...	...	7	...	10	12	14	16	18	20	...
19	...	...	...	...	...	6	...	9	...	...	17	19	...	...	...
20	...	2	...	5	...	...	8	...	11	13	15	18	20	...	25
21	...	...	3	4	...	...	...	10	12	14	16	18	21	...	...
22	...	...	...	...	...	7	...	...	...	17	19	22	25	...	...
23	...	...	...	...	...	...	9	11	13	15	...	20	23	...	...
24	...	...	...	6	...	...	...	...	16	18	21	24	27	...	30
25	...	...	...	...	...	8	...	12	14	...	19	22	25	...	...
26	...	...	5	...	...	10	...	...	17	20	23	26	29	...	...
27	...	...	...	...	...	...	13	15	18	21	24	27	30	...	...
28	...	...	4	...	7	9	11	...	16	...	25	28	...	35	...
29	...	...	...	...	...	...	...	...	19	22	25	29	32	...	...
30	...	...	...	...	...	...	...	14	17	20	23	26	30	...	...
31	...	3	...	6	...	...	12	...	...	24	27	31	35	...	...
32	2	...	...	8	10	...	...	15	18	21	...	28	32	...	40
33	...	...	...	...	...	13	...	...	22	25	29	33	...	...	...
34	...	...	...	...	...	...	16	19	...	26	30	34	...	43	...
35	...	...	...	...	...	11	...	...	23	27	31	35	40	...	...
36	...	5	...	9	...	...	14	17	20	24	...	32	36	...	...
37	...	...	7	...	...	...	...	...	21	...	28	32	37	...	...
38	...	...	...	...	12	15	18	...	25	29	33	38	...	48	...
39	...	...	...	...	...	...	...	22	26	30	34	39	...	...	...
40	...	...	...	10	...	16	19	...	...	31	35	40	45	50	...

¹ Taken from "A Manual for Northern Woodsmen."

TABLE VI.—NEW HAMPSHIRE LOG RULE.—*Continued.*

	Diameter in inches.																		
Length in feet.	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
	Contents in board feet.																		
12	...	...	21	...	25	27	29	32	34	37	39	42	45	48	51	54.0	57	61	
13	...	20	...	25	...	29	...	...	37	40	43	46	49	52	55	58.0	62	66	
14	...	20	...	...	...	...	34	37	40	43	46	49	53	56	60	63.0	67	71	
15	...	...	26	...	31	...	...	...	43	46	49	53	56	60	64	68.0	72	76	
16	...	25	...	30	...	36	39	...	46	49	53	56	60	64	68	72.0	77	81	
17	...	...	...	...	35	...	...	45	48	52	56	60	64	68	72	77.0	81	86	
18	...	25	...	31	...	40	44	...	51	55	59	63	68	72	77	81.0	86	91	
19	...	30	...	36	39	...	...	50	54	58	62	67	71	76	81	86.0	91	96	
20	...	...	...	...	...	45	49	...	57	61	66	70	75	80	85	90.0	96	101	
21	...	30	...	36	40	...	...	...	60	64	69	74	79	84	89	95.0	100	106	
22	...	...	...	...	45	49	...	58	63	67	72	77	83	88	94	99.0	105	111	
23	...	36	40	...	...	...	56	...	65	70	76	81	86	92	98	104.0	110	116	
24	...	...	...	45	50	...	...	...	68	74	79	84	90	96	102	108.0	115	121	
25	...	35	39	...	...	56	61	66	71	77	82	88	94	100	106	113.0	120	126	
26	...	...	45	49	...	...	...	...	74	80	85	91	98	104	111	117.0	125	132	
27	...	...	...	...	56	...	66	...	77	83	89	95	101	108	115	122.0	129	137	
28	...	40	...	...	...	63	...	74	80	86	92	98	105	112	119	126.0	134	142	
29	...	45	50	55	60	65	71	...	83	89	95	102	109	116	123	131.0	139	143	
30	...	...	...	...	...	...	...	...	85	92	99	105	113	120	128	135.0	144	152	
31	...	...	...	...	64	...	...	82	88	95	102	109	116	124	132	140.0	148	157	
32	...	45	50	55	60	...	72	78	...	91	98	105	112	120	128	136	145.0	153	162
33	...	...	...	...	...	74	...	...	94	101	108	116	124	132	140	149.0	158	167	
34	...	...	...	64	70	...	83	90	97	104	112	119	128	136	145	154.0	163	172	
35	...	49	55	60	...	...	...	...	100	107	115	123	131	140	149	158.0	167	177	
36	...	...	...	...	74	81	88	95	102	110	118	126	135	144	153	162.5	172	182	
37	...	...	...	70	...	...	...	...	105	113	122	130	139	148	157	167.0	177	187	
38	...	...	65	...	...	...	...	100	108	116	125	133	143	152	162	172.0	182	192	
39	...	55	61	...	...	81	...	95	...	111	120	128	137	146	156	166	176.0	187	197
40	...	...	...	75	...	90	...	106	114	123	131	140	150	160	170	181.0	191	202	

TABLE VII. — VERMONT LOG RULE.

Length in feet.	Diameter in inches.												
	6	7	8	9	10	11	12	13	14	15	16	17	18
	Contents in board feet.												
8	12	16	21	27	33	40	48	56	65	75	85	96	108
9	13	18	24	30	37	45	54	63	73	84	96	108	121
10	15	20	27	34	42	50	60	70	82	94	107	120	135
11	16	22	29	37	46	55	66	77	90	103	117	132	143
12	18	24	32	40	50	60	72	84	98	112	128	144	162
13	19	27	35	44	54	66	78	92	106	122	139	157	175
14	21	29	37	47	58	71	84	99	114	131	149	169	189
15	22	31	40	51	62	76	90	106	122	141	160	181	202

Length in feet.	Diameter in inches.											
	19	20	21	22	23	24	25	26	27	28	29	30
	Contents in board feet.											
8	120	133	147	161	176	192	208	225	243	261	280	300
9	135	150	165	181	198	216	234	253	273	294	315	337
10	150	167	184	202	220	240	260	282	304	327	350	375
11	165	183	202	222	242	264	286	310	334	359	385	412
12	180	200	220	242	264	288	312	338	364	392	420	450
13	196	217	239	262	287	312	339	366	395	425	456	487
14	211	233	257	282	309	336	365	394	425	457	491	525
15	226	250	276	302	331	360	391	422	456	490	526	562

TABLE VIII.—CLARK'S INTERNATIONAL LOG RULE.¹

Diameter in inches.	Length in feet.												
	8	9	10	11	12	13	14	15	16	17	18	19	20
	Contents in board feet. ²												
6	10	10	10	15	15	15	20	20	20	25	25	30	30
7	15	15	15	20	20	25	25	30	30	35	35	40	45
8	20	20	25	25	30	35	35	40	45	45	50	55	60
9	25	30	30	35	40	45	50	50	55	60	65	70	75
10	30	35	40	45	50	55	60	65	70	75	85	90	95
11	40	45	50	55	65	70	75	80	90	95	105	110	115
12	50	55	65	70	75	85	90	100	105	115	125	130	140
13	60	65	75	85	90	100	110	120	130	140	145	155	165
14	70	80	90	100	110	120	130	140	150	160	175	185	195
15	80	90	105	115	125	140	150	160	175	185	200	215	225
16	95	105	120	130	145	160	170	185	200	215	230	245	260
17	105	120	135	150	165	180	195	210	225	245	260	275	295
18	120	135	155	170	185	205	220	240	255	275	295	310	330
19	135	155	175	190	210	230	250	270	290	310	330	350	370
20	150	170	195	215	235	255	275	300	320	345	365	390	410
21	170	190	215	235	260	285	305	330	355	380	405	430	455
22	185	210	235	260	285	315	340	365	390	420	445	475	500
23	205	230	260	285	315	345	370	400	430	460	490	520	550
24	225	255	285	315	345	375	405	440	470	500	535	565	600
25	245	275	310	345	375	410	445	475	510	545	580	615	650
26	265	300	335	370	405	445	480	520	555	595	630	670	705
27	290	325	365	405	440	480	520	560	600	640	680	725	765
28	310	350	395	435	475	520	560	605	645	690	735	780	825
29	335	380	425	470	510	560	605	650	695	740	790	835	885
30	360	405	455	500	550	600	645	695	745	795	845	895	950
31	385	435	485	540	590	640	695	745	800	850	905	960	1015
32	410	465	520	575	630	685	740	795	850	910	965	1025	1080
33	440	495	555	610	670	730	790	850	905	970	1030	1090	1150
34	470	530	590	650	715	775	840	900	965	1030	1095	1160	1225
35	495	560	625	690	755	825	890	955	1025	1095	1160	1230	1300
36	525	595	665	735	800	875	945	1015	1085	1160	1230	1305	1375
37	560	630	705	775	850	925	1000	1075	1150	1225	1300	1380	1455
38	590	665	745	820	895	975	1055	1135	1210	1295	1375	1455	1535
39	620	705	785	865	945	1030	1110	1195	1280	1365	1450	1535	1620
40	655	740	825	910	995	1085	1170	1260	1345	1435	1525	1615	1705
41	690	780	870	960	1050	1140	1230	1325	1415	1510	1605	1700	1795
42	725	820	915	1010	1100	1200	1295	1390	1490	1585	1685	1785	1885
43	760	860	960	1060	1155	1260	1360	1460	1560	1665	1770	1870	1975
44	800	900	1005	1110	1215	1320	1425	1530	1635	1745	1855	1960	2070
45	835	945	1055	1160	1270	1380	1490	1600	1715	1825	1940	2050	2165
46	875	990	1100	1215	1330	1445	1560	1675	1790	1910	2030	2145	2265
47	915	1035	1150	1270	1390	1510	1630	1750	1870	1995	2120	2240	2365
48	955	1080	1205	1325	1450	1575	1700	1830	1955	2085	2210	2340	2470

¹ By permission of Judson F. Clark.² The contents are for logs sawn with band saws cutting one-eighth inch kerf.

TABLE IX.—LOG SCALE FOR WHITE PINE, 1-INCH BOARDS.¹

Based on the measurement of 1209 logs sawed in Massachusetts mills. —
Circular saw, $\frac{1}{4}$ -inch kerf.

Diameter, inside bark at small end, in inches.	Length of log, feet.				Diameter, inside bark at small end, in inches.	Length of log, feet.			
	10	12	14	16		10	12	14	16
	Contents in board feet.					Contents in board feet.			
4	9	13	17	21	15	104	129	150	180
5	13	17	21	26	16	117	146	170	205
6	17	22	27	32	17	131	165	192	230
7	23	29	35	40	18	.....	184	220	256
8	30	37	44	51	19	.....	206	243	288
9	39	47	55	64	20	.....	230	272	.....
10	48	58	68	79	21	.....	255	300	.....
11	58	70	82	98	22	.....	280	330	.....
12	69	83	97	115	23	.....	310	.....	.....
13	80	96	113	136	24	.....	340	.....	.....
14	92	111	131	158					

¹ Taken from "Forest Mensuration of the White Pine in Massachusetts."

TABLE X.—LOG RULE FOR SECOND-GROWTH WHITE PINE.¹
— SOUTHERN NEW HAMPSHIRE.

(Cut into both square and round-edged boards; circular saw, $\frac{1}{4}$ -inch kerf.)
Based on measurements of 5177 logs.

Diameter, inside bark at small end of log, in inches.	Length of log, feet.			Diameter, inside bark at small end of log, in inches.	Length of log, feet.		
	10	12	14		10	12	14
	Basis, 613 logs.	Basis, 1915 logs.	Basis, 2649 logs.		Basis, 613 logs.	Basis, 1915 logs.	Basis, 2649 logs.
	Contents in board feet.				Contents in board feet.		
3	5	7	9	14	89	112	134
4	8	10	12	15	102	130	155
5	13	15	17	16	.....	149	176
6	18	21	24	17	.....	169	198
7	24	28	33	18	.....	189	222
8	30	36	42	19	.....	211	247
9	38	46	52	20	.....	235	275
10	47	56	65	21	.....	260	304
11	56	68	80	22	.....	284	333
12	66	81	97	23	.....	.....	364
13	77	96	115	24	.....	.....	398

¹ Taken from Biennial Report of the New Hampshire Forestry Commission for the years 1905-1906.

TABLE XI. — LOG RULE FOR SECOND-GROWTH HARDWOODS.¹
— SOUTHERN NEW HAMPSHIRE.

(Cut into 1½-inch, round-edged boards; circular saw, ¼-inch kerf.)

Based on 1831 12-foot logs.

Diameter, inside bark at small end of log, in inches.	Length of log, feet.			Diameter, inside bark at small end of log, in inches.	Length of log, feet.		
	10	12	14		10	12	14
	Contents in board feet.				Contents in board feet.		
4	6	8	10	12	68	82	96
5	9	11	13	13	83	100	117
6	13	16	19	14	100	120	140
7	18	22	26	15	117	141	165
8	25	30	35	16	137	165	193
9	32	39	46	17	160	192	224
10	42	51	60	18	185	222	259
11	54	65	76				

¹ Taken from Biennial Report of the New Hampshire Forestry Commission for the years 1905-1906.TABLE XII. — LOG RULE GIVING VOLUME OF CHESTNUT LOGS
8 FEET LONG IN TIES.¹

Diameter, out- side bark at small end, in inches.	Number of ties.	Class.	Diameter, out- side bark at small end, in inches.	Number of ties.	Class.
7	1	Second	16	2	First
8	1	Second	17	2	First
9	1	First	18	3	First
10	1	First	19	3	First
11	1	First	20	4	First
12	1	First	21	4	First
13	1	First	22	5	First
14	2	First	23	6	First
15	2	First	24	7	First

¹ Taken from Bull. 154 of the Connecticut Agricultural Experiment Station.

TABLE XIII. — SOLID CUBIC CONTENTS OF LOGS.¹

Diameter in inches	Length in feet.															
	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
3	0.20	.25	.29	.34	.39	.44	.49	.54	.59	.64	.69	.74	.79			
4	0.35	.44	.52	.61	.70	.79	.87	.96	1.05	1.13	1.22	1.31	1.40			
5	0.55	.68	.82	.95	1.09	1.23	1.36	1.50	1.64	1.77	1.91	.05	2.18			
6	0.79	.98	1.18	1.37	1.57	1.77	1.96	2.16	2.36	2.55	2.75	2.95	3.14			
7	1.07	1.34	1.60	1.87	2.14	2.41	2.67	2.94	3.21	3.47	3.74	4.01	4.28			
8	1.40	1.75	2.09	2.44	2.79	3.14	3.49	3.84	4.19	4.54	4.89	5.24	5.59			
9	1.77	2.21	2.65	3.09	3.53	3.98	4.42	4.86	5.30	5.74	6.19	6.63	7.07			
10	2.18	2.73	3.27	3.82	4.36	4.91	5.45	6.00	6.55	7.09	7.64	8.18	8.73			
11	2.64	3.30	3.96	4.62	5.28	5.94	6.60	7.26	7.92	8.58	9.24	9.90	10.56			
12	3.14	3.93	4.71	5.50	6.28	7.07	7.85	8.64	9.42	10.21	11.00	11.78	12.57			
13	3.69	4.61	5.53	6.45	7.37	8.30	9.22	10.14	11.06	11.98	12.90	13.83	14.75			
14	4.28	5.35	6.41	7.48	8.55	9.62	10.69	11.76	12.83	13.90	14.97	16.04	17.10			
15	4.91	6.14	7.36	8.59	9.82	11.04	12.27	13.50	14.73	15.95	17.18	18.41	19.63			
16	5.59	6.98	8.38	9.77	11.17	12.57	13.96	15.36	16.76	18.15	19.55	20.94	22.34			
17	6.31	7.88	9.44	11.03	12.61	14.19	15.76	17.34	18.92	20.49	22.07	23.64	25.22			
18	7.07	8.84	10.60	12.37	14.14	15.90	17.67	19.44	21.21	22.97	24.74	26.51	28.27			
19	7.88	9.84	11.81	13.78	15.75	17.72	19.69	21.66	23.63	25.60	27.57	29.53	31.50			
20	8.73	10.91	13.09	15.27	17.45	19.63	21.82	24.00	26.18	28.36	30.54	32.72	34.91			
21	9.62	12.03	14.43	16.84	19.24	21.65	24.05	26.46	28.86	31.27	33.67	36.08	38.48			
22	10.56	13.20	15.84	18.48	21.12	23.76	26.40	29.04	31.68	34.32	36.96	39.60	42.24			
23	11.54	14.43	17.31	20.20	23.08	25.97	28.85	31.74	34.62	37.51	40.39	43.28	46.16			
24	12.57	15.71	18.85	21.99	25.13	28.27	31.42	34.56	37.70	40.84	43.98	47.12	50.27			
25	13.64	17.04	20.45	23.86	27.27	30.68	34.09	37.50	40.91	44.31	47.72	51.13	54.54			
26	14.75	18.44	22.12	25.81	29.50	33.18	36.87	40.56	44.24	47.93	51.62	55.31	58.99			
27	15.90	19.88	23.86	27.83	31.81	35.78	39.76	43.74	47.71	51.69	55.67	59.64	63.62			
28	17.10	21.38	25.66	29.93	34.21	38.48	42.76	47.04	51.31	55.59	59.86	64.14	68.42			
29	18.35	22.93	27.52	32.11	36.70	41.28	45.87	50.46	55.04	59.63	64.22	68.80	73.39			
30	19.63	24.54	29.45	34.36	39.27	44.18	49.09	54.00	58.90	63.81	68.72	73.63	78.54			
31	20.97	26.21	31.45	36.09	41.93	47.17	52.41	57.66	62.90	68.14	73.38	78.62	83.86			
32	22.34	27.93	33.51	39.10	44.68	50.27	55.85	61.44	67.02	72.61	78.19	83.78	89.36			
33	23.76	29.70	35.04	41.58	47.52	53.46	59.40	65.34	71.27	77.21	83.15	89.09	95.03			
34	25.22	31.53	37.83	44.14	50.44	56.75	63.05	69.36	75.66	81.97	88.27	94.58	100.88			
35	26.73	33.41	40.09	46.77	53.45	60.13	66.81	73.49	80.18	86.86	93.54	100.22	106.90			
36	28.27	35.34	42.41	49.48	56.55	63.62	70.69	77.75	84.82	91.89	98.96	106.03	113.10			

¹ Taken from "The Woodsman's Handbook."

TABLE XIV. — STACKED CUBIC FEET IN LOGS OF GIVEN DIMENSIONS.¹
128 MAKE A CORD TRUE TO NEAREST TENTH UP TO 10 CUBIC
FEET, ABOVE THAT TO NEAREST FOOT.

Length in feet.	Diameter at middle in inches.															
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
4	0.2	0.4	0.7	1.0	1.4	1.8	2.3	2.8	3.4	4	4.7	5.4	6.2	7.1	8	9
8	0.5	0.9	1.4	2.0	2.7	3.5	4.5	5.5	6.7	8	9.4	11	12	14	16	18
10	0.6	1.1	1.7	2.5	3.4	4.4	5.6	6.9	8.4	10	12	14	16	18	20	22
12	0.7	1.3	2.1	3.0	4.1	5.3	6.8	8.3	10	12	14	16	19	21	24	27
13	0.8	1.4	2.2	3.4	4.4	5.8	7.3	9	11	13	15	18	20	23	26	29
16	1.0	1.8	2.8	4.0	5.5	7.1	9	11	13	16	19	22	25	28	32	36
20	.....	2.2	3.5	5.0	6.8	8.9	11	14	17	20	23	27	31	36	40	44
21	.....	2.3	3.6	5.2	7.2	9.3	12	15	18	21	25	29	33	37	42	47
22	.....	2.4	3.8	5.5	7.5	9.8	12	15	18	22	26	30	34	39	44	49
23	.....	2.5	4.0	5.8	7.8	10	13	16	19	23	27	31	36	41	46	52
24	.....	2.6	4.2	6.0	8.2	11	14	17	20	24	28	33	38	43	48	54
25	.....	2.7	4.3	6.2	8.5	11	14	17	21	25	29	34	39	44	50	56
26	.....	2.8	4.5	6.5	8.8	11	15	18	22	26	31	35	41	46	52	59
27	.....	2.9	4.7	6.8	9.2	12	15	19	23	27	32	37	42	48	54	61
28	.....	3.0	4.8	7.0	9.5	12	16	19	23	28	33	38	44	50	56	63
29	.....	3.1	5.0	7.2	9.9	13	16	20	24	29	34	39	45	52	58	65
30	.....	3.2	5.2	7.5	10	13	17	21	25	30	35	40	47	53	59	67
31	.....	3.3	5.4	7.8	11	14	18	22	26	31	36	42	48	55	62	70
32	.....	3.4	5.6	8.0	11	15	19	23	27	32	38	44	50	57	64	72
33	.....	3.5	5.8	8.2	11	15	19	23	28	33	39	45	51	59	66	74
34	.....	3.6	6.0	8.5	12	16	20	24	29	34	40	46	53	60	68	76
35	.....	3.7	6.2	8.8	12	16	20	24	29	35	41	47	55	62	70	78
36	.....	3.8	6.4	9.0	12	16	20	25	30	36	42	48	56	64	72	81
37	.....	3.9	6.6	9.2	13	17	21	26	31	37	43	50	58	66	74	83
38	.....	4.0	6.8	9.5	13	17	21	26	32	38	45	52	59	68	76	86
39	.....	4.1	7.0	9.8	13	17	22	27	33	39	46	53	61	69	78	88
40	.....	4.2	7.2	10.0	14	18	23	28	34	40	47	54	62	71	80	90

¹ Taken from "A Manual for Northern Woodsmen."

VOLUME TABLES.

TABLE XV. — ASPEN,¹ MERCHANTABLE VOLUME,² IN CUBIC FEET.¹ Based on measurements of 362 trees.

Diameter, outside bark, breast high, in inches.	Height of tree in feet.						
	30	40	50	60	70	80	90
	Volume in cubic feet.						
5	0.5	1.0	1.5	2.0	3.0	.....	.....
6	2.0	2.5	3.0	3.5	4.5	6.0	.....
7	3.5	4.0	4.5	5.5	7.0	8.5	.....
8	5.5	6.0	7.0	8.0	10.0	11.5	13.0
9	.....	8.0	9.5	11.0	12.5	14.5	16.5
10	.....	10.5	12.0	14.0	16.0	18.0	20.0
11	.....	.....	15.0	17.0	19.0	21.5	25.0
12	.....	.....	18.0	20.5	23.0	26.5	30.0
13	.....	.....	.....	24.0	27.0	31.5	36.0
14	.....	.....	.....	28.5	32.0	37.0	43.0
15	.....	.....	.....	32.0	37.0	43.0	51.0
16	.....	.....	.....	37.0	43.0	50.0	59.0
17	.....	.....	.....	43.0	49.5	57.0	68.0
18	.....	.....	.....	.....	57.0	66.0	76.0
19	.....	.....	.....	.....	65.0	75.0	85.0
20	.....	.....	.....	.....	74.0	84.0	95.0

¹ Taken from U. S. Forest Service Bull. 93.² Merchantable volume includes that portion of the bole between a stump 1 foot high and a minimum upper diameter of 4 inches inside bark and all branches 4 inches and over inside bark. The volumes do not include bark.

TABLE XVI.—ASPEN,¹ MERCHANTABLE VOLUME,² IN CORDS AND NUMBER OF TREES PER CORD.

Based on measurements of 362 trees.

Diameter, breast high.	Height of tree in feet.					
	30		40		50	
	Volume.	Trees per cord.	Volume.	Trees per cord.	Volume.	Trees per cord.
Inches.	Cords.	Number.	Cords.	Number.	Cords.	Number.
5	0.01	100.0	0.02	50.0	0.03	33.3
6	.03	33.3	.04	25.0	.05	20.0
7	.05	20.0	.06	16.7	.07	14.3
8	.08	12.5	.09	11.1	.10	10.0
9	.....	.....	.11	9.1	.12	8.3
10	.....	.....	.14	7.1	.15	6.7
11	.....	.....	.....	.....	.18	5.6
12	.....	.....	.....	.....	.21	4.8

Diameter, breast high.	Height of tree in feet.							
	60		70		80		90	
	Volume.	Trees per cord.	Volume.	Trees per cord.	Volume.	Trees per cord.	Volume.	Trees per cord.
Inches.	Cords.	Number.	Cords.	Number.	Cords.	Number.	Cords.	Number.
5	0.03	33.3	.....	.....	.....	.....	.....	.....
6	.06	16.7	0.07	14.3	0.10	10.0	.....	.....
7	.08	12.5	.10	10.0	.13	7.7	.....	.....
8	.11	9.1	.14	7.1	.16	6.3	.....	.....
9	.14	7.1	.16	6.3	.19	5.3	.....	.....
10	.18	5.6	.20	5.0	.23	4.3	0.25	4.0
11	.20	5.0	.23	4.3	.26	3.8	.30	3.3
12	.24	4.2	.27	3.7	.31	3.2	.34	2.9
13	.27	3.7	.30	3.3	.35	2.9	.40	2.5
14	.31	3.2	.35	2.9	.40	2.5	.46	2.2
15	.....	.....	.39	2.6	.45	2.2	.53	1.9
16	.....	.....	.44	2.3	.52	1.9	.60	1.7
17	.....	.....	.....	.....	.57	1.8	.68	1.5
18	.....	.....	.....	.....	.65	1.5	.75	1.3
19	.....	.....	.....	.....	.....	.....	.82	1.2
20	.....	.....	.....	.....	.....	.....	.90	1.1

¹ Taken from U. S. Forest Service Bull. 93.² See footnote 2 under Table XV.

TABLE XVII.—PAPER BIRCH,¹ MERCHANTABLE VOLUMES, BY DIAMETER AND HEIGHT.

Based on measurements of 445 trees.

Diam- eter, breast high.	Height of tree in feet.										Diam- eter, inside bark of top.
	50		60		70		80		90		
	Volume.										
Inches.	Cu. ft.	Bd. ft. ²	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Inches.
5	2.7	16	3.2	19	3.7	23	....	...	.....	...	3.3
6	3.8	22	4.6	26	5.4	30	6.2	35	.....	...	3.7
7	5.2	28	6.3	34	7.3	40	8.5	46	9.6	52	4.2
8	6.8	38	8.2	45	9.5	52	11.0	60	12.4	68	4.5
9	8.7	48	10.4	57	12.2	67	14.0	76	15.5	86	4.8
10	10.9	60	13.0	72	15.2	85	17.4	95	19.3	108	5.1
11	13.4	73	16.0	88	18.8	104	21.4	117	24.0	132	5.3
12	16.3	88	19.5	106	22.8	124	26.1	141	29.3	160	5.5
13	19.8	106	23.3	127	27.3	148	31.3	169	35.0	191	5.6
14	.....	.....	27.7	150	32.3	176	37.0	201	41.5	226	5.8
15	.....	.....	32.5	177	37.8	207	43.2	236	48.5	266	5.9
16	.....	.....	.....	206	43.8	242	50.0	276	56.3	310	6.0
17	.....	.....	.....	.....	50.3	280	58.0	320	64.9	360	6.1
18	.....	.....	.....	.....	57.4	320	.....	366	.....	412	6.1

¹ Taken from U. S. Forest Service Circular 163.² New Hampshire rule.

TABLE XVIII.—PAPER BIRCH,¹ MERCHANTABLE VOLUMES, BY DIAMETER AND MERCHANTABLE LENGTH.

Based on measurements of 396 trees.

Diam- eter, breast high.	Merchantable length in feet.													
	12		16		20		24		28		32		36	
	Volume.													
Inches.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.
5	1.7	7	2.0	10	2.3	13	2.6	15	2.9	18	3.2	21	....	...
6	2.4	12	2.9	16	3.4	19	3.9	22	4.3	25	4.8	28	5.4	31
7	3.3	17	3.9	21	4.6	25	5.3	29	5.9	33	6.5	37	7.2	41
8	4.2	23	5.2	28	6.0	32	6.8	37	7.6	42	8.4	47	9.2	52
9	5.3	29	6.6	34	7.5	40	8.5	46	9.5	51	10.5	57	11.4	64
10	...	35	8.1	41	9.2	48	10.3	55	11.5	61	12.7	68	13.8	76
11	...	...	...	49	11.0	56	12.2	64	13.5	71	15.0	80	16.4	89
12	...	...	...	...	...	...	...	73	15.7	82	17.5	92	19.2	103
13	...	...	...	...	...	...	...	...	...	...	20.1	105	22.7	120
14	...	...	...	...	...	...	...	...	...	...	...	118	27.0	138

Diam- eter, breast high.	Merchantable length in feet.											
	40		44		48		52		56		60	
	Volume.											
Inches.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.
5	...	...	...	...	...	...	...	...	...	...	...	...
6	5.8	35	6.3	...	7.0	...	...	...	...	...	...	...
7	7.9	45	8.4	49	9.3	53	9.9	57	...	...	...	...
8	10.0	57	10.8	62	11.6	67	12.4	72	13.2	76	14.0	80
9	12.3	69	13.3	75	14.2	81	15.2	86	16.1	92	17.1	99
10	14.9	83	16.0	90	17.2	97	18.4	104	19.4	111	20.6	118
11	17.8	97	19.3	107	20.7	115	22.2	124	23.6	134	25.2	142
12	21.0	114	23.0	125	24.8	137	26.7	148	28.6	160	30.6	168
13	24.9	133	27.4	146	29.8	160	32.3	174	34.9	187	37.5	200
14	30.0	154	33.0	170	35.9	185	39.1	201	41.5	...	...	...

¹ Taken from U. S. Forest Service Circular 163.

TABLE XIX.—PAPER BIRCH,¹ SOLID CONTENTS PER STACKED CORD FOR SPOOLWOOD BOLTS OF DIFFERENT DIAMETERS, IN THE ROUND.

Average diameter of stick.	Sticks per cord.	Solid wood per cord.	Average diameter of stick.	Sticks per cord.	Solid wood per cord.
Inches.	Number.	Cubic feet.	Inches.	Number.	Cubic feet.
5	135	82.0	9	57	100.0
6	106	86.7	10	47	102.8
7	85	91.4	11	39	104.6
8	69	96.0	12	32	105.2

¹ Taken from U. S. Forest Service Circular 163.

TABLE XX.—CHESTNUT VOLUME TABLE FOR SPROUT TREES,¹ PISGAH, NEW HAMPSHIRE.

Based on measurements of 658 trees.

Diameter, breast high, in inches.	Height in feet.				
	60	70	80	90	100
	Volume of used length, including bark, in cubic feet.				
8	7.7	8.5	9.7	.....	.....
9	10.0	11.1	13.0	14.4	.....
10	12.4	14.1	16.4	18.0	.....
11	15.0	17.3	20.0	22.0	25.4
12	18.0	20.9	24.0	26.5	30.2
13	21.1	24.7	28.0	31.0	35.1
14	24.4	28.3	32.0	35.7	40.0
15	28.0	32.7	36.5	40.6	45.1
16	32.0	36.8	41.0	45.6	50.3
17	36.0	40.8	45.9	50.8	56.1
18	39.9	45.0	51.0	56.1	62.0
19	43.7	49.5	56.4	62.0	68.3
20	.....	54.0	62.0	68.0	74.8
21	.....	.....	68.1	74.4	81.3

¹ Taken from Biennial Report of the New Hampshire Forestry Commission for 1905-1906.

TABLE XXI.—CHESTNUT¹ VOLUME TABLE IN CUBIC FEET, LITCHFIELD AND MIDDLESEX COUNTIES, CONNECTICUT.²

Based on measurements of 218 trees.

Diameter, breast high, in inches.	Height of tree in feet.							
	20	30	40	50	60	70	80	90
	Volume in cubic feet.							
2	0.2	0.3	.....	.....	.....	.....	.....	.....
3	.4	.7	0.9	.....	.....	.....	.....	.....
4		1.2	1.6	2.1	.....	.....	.....	.....
5		1.9	2.6	3.3	.....	.....	.....	.....
6			3.7	4.6	5.6	.....	.....	.....
7			5.0	6.2	7.3	.....	.....	.....
8			6.5	7.9	9.4	11.0	.....	.....
9			8.4	10.1	11.8	13.6	.....	.....
10			10.5	12.5	14.5	16.6	17.8	19.0
11			12.8	15.3	17.9	20.7	22.6	24.3
12			15.4	18.4	21.5	25.0	27.4	30.0
13			18.2	19.7	25.2	29.1	32.1	35.3
14				25.0	29.2	33.8	37.7	41.3
15				28.8	33.6	38.8	43.4	48.0
16				32.6	38.1	44.0	49.5	55.0
17				36.5	42.7	49.5	56.0	63.0
18				40.5	47.4	55.5	63.0	70.5
19				44.3	51.4	61.5	70.0	79.0
20				49.0	58.5	68.5	78.0	85.0
21					65.0	75.5	86.0	97.0
22					71.0	83.0	95.0	106.5
23					78.0	91.0	104.0	117.0
24					85.5	99.5	114.0	128.0
25					93.0	108.5	124.0	140.0

Volumes include stem and topwood, with bark, up to a minimum diameter of 2 inches. Average stump heights vary from 6 inches for small trees to 21 inches for large ones.

¹ Taken from U. S. Forest Service Bull. 96.

² For volume of trees under 8 inches diameter, breast high, twenty-one measurements made in 1905 at Hyde Park, N. Y., by Mr. J. G. Peters, were combined with those made in Connecticut.

TABLE XXII.—CHESTNUT¹ VOLUME TABLE IN BOARD FEET,
LITCHFIELD COUNTY, CONNECTICUT.By International² Log Rule. Based on measurements of 118 trees.

Diam- eter, breast high.	Height of tree in feet.										Diam- eter (inside bark) of top.
	50		60		70		80		90		
	Volume.										
	Stem.	Top- wood.	Stem.	Top- wood.	Stem.	Top- wood.	Stem.	Top- wood.	Stem.	Top- wood.	
Inches.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Inches.
9	10	5.8	15	6.9	22	8.0	...	...	...	...	7
10	26	5.2	32	6.2	40	7.1	48	6.9	56	6.6	7
11	42	4.9	50	6.2	50	7.2	69	7.2	80	7.0	8
12	58	4.8	68	6.1	78	7.3	92	7.5	107	7.7	8
13	74	4.7	87	6.1	100	7.5	116	7.6	133	7.8	8
14	92	4.6	107	6.2	122	7.6	141	8.4	160	8.6	8
15	110	4.9	127	6.6	147	8.2	168	9.0	190	9.8	9
16	129	5.1	150	6.9	172	8.7	196	10.0	222	11.3	9
17	.....	.....	174	6.9	200	9.3	226	11.2	255	13.5	9
18	.....	.....	198	6.9	227	10.0	257	12.6	291	15.0	10
19	.....	.....	223	6.9	257	10.4	292	13.6	328	17.0	10
20	.....	.....	250	7.1	288	11.6	327	15.2	368	19.2	10
21	.....	.....	276	7.9	318	12.5	363	16.8	409	21.4	11
22	.....	.....	305	7.9	350	13.8	400	19.1	451	23.7	11
23	.....	.....	333	8.5	385	15.2	440	21.3	493	27.0	11
24	.....	.....	363	9.2	420	16.8	479	24.3	538	31.0	12
25	.....	.....	396	9.7	457	18.7	520	27.2	583	35.8	12

Note. — The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of sawlogs to a top diameter of 6 inches, inside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

¹ Taken from U. S. Forest Service Bull. 96.² Ten per cent deducted for circular saw kerf.

TABLE XXIII.—CHESTNUT¹ VOLUME TABLE IN TIES,
LITCHFIELD COUNTY, CONNECTICUT.

Diameter, breast high.	Height of tree in feet.										
	50		60		70		80		90		
	Volume.										
	Ties.	Top-wood.	Ties.	Top-wood.	Ties.	Top-wood.	Ties.	Top-wood.	Ties.	Top-wood.	Basis.
Inches.	No.	Cu. ft.	No.	Cu. ft.	No.	Cu. ft.	No.	Cu. ft.	No.	Cu. ft.	Trees.
10	1	9.0	1	10.3	1	11.1	1	10.5	3	9.5	4
11	1	8.2	1	9.6	2	10.7	2	10.4	4	9.8	9
12	2	7.5	2	9.0	3	10.4	3	10.3	4	10.1	9
13	3	6.9	3	8.3	3	9.7	4	10.0	5	10.2	11
14	3	6.2	3	7.8	5	9.4	5	10.0	8	10.3	17
15	5	6.1	5	7.6	5	9.3	6	10.0	9	10.7	6
16	6	6.0	6	7.2	7	9.1	7	10.2	9	11.2	14
17	.....	.....	6	6.7	8	9.0	8	10.7	10	12.7	6
18	.....	.....	7	5.9	8	9.2	9	11.5	11	13.5	11
19	.....	.....	7	5.6	8	9.2	10	12.1	12	15.3	6
20	.....	.....	8	5.1	10	9.9	11	13.5	13	17.3	4
21	.....	.....	9	5.1	10	10.3	11	14.7	14	19.4	3
22	.....	.....	11	4.5	10	10.9	14	16.8	17	21.8	4
23	.....	.....	12	4.4	12	11.8	14	18.8	17	25.2	5
24	.....	.....	12	4.7	13	13.2	15	21.6	19	29.1	2
25	.....	.....	16	4.9	15	14.8	18	24.4	21	34.0	2

All first-class ties — 6"×8"×8'.

Note.—The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of tie logs to a minimum top diameter of 9 inches, outside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

¹ Taken from U. S. Forest Service Bull. 96.

TABLE XXIV.—RED OAK¹ VOLUME TABLE IN CUBIC FEET AND BOARD FEET, SOUTHERN NEW HAMPSHIRE.

Based on measurements of 683 trees.

Diam- eter, breast high.	Used length in feet.										Number of board feet per cubic foot of log.
	10		20		30		40		50		
	Volume.										
Inches.	Cu. ft.	Bd. ft. ²	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	
5	1.7	7	2.3	.....	.....	.....	.....	.....	.....	.....	3.6
6	2.2	9	3.2	15	.....	.....	.....	.....	.....	.....	4.0
7	2.9	14	4.7	22	6.0	29	7.5	34	.....	.....	4.4
8	3.6	18	6.0	30	7.5	39	9.2	43	.....	.....	4.8
9	4.6	25	7.5	40	9.4	48	11.4	58	.....	.....	5.1
10	5.7	31	9.1	50	11.3	60	13.8	73	17.4	99	5.4
11	7.0	37	11.0	63	13.9	74	16.4	90	20.5	118	5.5
12	8.3	44	13.1	78	16.3	89	19.5	110	23.9	143	5.7
13	9.5	54	15.7	93	19.2	107	22.9	132	27.4	174	5.8
14	11.1	65	18.3	109	22.2	126	26.5	160	31.8	208	5.9
15	.....	.....	21.2	124	25.8	149	30.7	190	36.1	243	6.1
16	.....	.....	24.2	143	29.2	173	35.0	225	41.2	288	6.2
17	.....	.....	27.8	163	33.3	201	39.9	262	46.8	330	6.4
18	.....	.....	31.2	181	37.8	232	45.0	308	53.0	378	6.6
19	.....	.....	34.9	202	42.0	265	50.7	356	59.3	428	6.8
20	.....	.....	.....	223	.....	300	56.7	405	.....	478	7.0
									Average		5.57

¹ Taken from Biennial Report of the New Hampshire Forestry Commission for 1905-1906.² Actual mill cut in 1½-inch round-edged boards, allowing ¼-inch for drying and dressing.

TABLE XXV.—RED, BLACK AND SCARLET OAKS¹ VOLUME
TABLE IN CUBIC FEET, NEW LONDON COUNTY,
CONNECTICUT; HYDE PARK, NEW YORK.²

Based on measurements of 441 trees.

Diameter, breast high, inches.	Height of tree in feet.						
	20	30	40	50	60	70	80
	Volume in cubic feet.						
2	0.3	0.4	.....	.....	.....	.....	.....
3		.9	1.0	.....	.....	.....	.....
4		1.5	2.0	2.6	.....	.....	.....
5		2.4	2.8	3.6	.....	.....	.....
6			4.2	5.0	6.0	.....	.....
7			5.7	6.6	7.6	8.9	.....
8			7.0	8.5	10.2	12.0	.....
9			8.7	10.9	13.0	15.2	17.3
10			10.5	13.1	15.7	18.4	21.0
11			13.0	16.0	19.0	22.1	25.2
12			16.4	19.7	22.3	26.2	29.3
13			21.0	24.3	27.7	31.0	34.3
14			25.3	29.0	32.6	36.3	40.0
15			30.2	34.2	38.1	42.0	45.8
16				40.0	44.1	48.2	52.4
17						54.6	59.1
18						61.0	66.0
19						68.0	74.0

Volumes include stem and topwood, with bark, up to a minimum diameter of 2 inches. Average stump heights vary from 5 inches for small trees to 21 inches for large ones.

¹ Taken from U. S. Forest Service Bull. 96.

² Volumes for trees under 9 inches diameter, breast high, are from measurements made in 1905 at Hyde Park, New York, by Mr. J. G. Peters.

TABLE XXVI.—RED, BLACK AND SCARLET OAKS¹ VOLUME
TABLE IN BOARD FEET, NEW LONDON COUNTY,
CONNECTICUT.

By International Log² Rule. Based on measurements of 175 trees.

Diameter, breast high.	Height of tree in feet.								Diameter (inside bark) of top.
	50		60		70		80		
	Volume.								
	Stem.	Top- wood.	Stem.	Top- wood.	Stem.	Top- wood.	Stem.	Top- wood.	
Inches.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Inches.
9	14	6.4	17	8.0	21	9.6	.....	.....	7
10	24	6.8	30	8.2	38	9.7	49	10.5	7
11	35	7.5	45	8.8	56	9.8	68	10.5	8
12	48	8.5	60	9.4	75	10.2	89	10.6	8
13	62	10.1	77	10.8	94	10.9	113	10.9	8
14	78	11.4	96	11.9	117	11.9	140	11.7	9
15	95	12.9	117	13.3	141	13.0	168	12.1	9
16	114	14.9	140	15.1	168	14.2	198	12.9	9
17	.....	.....	.....	.....	195	15.6	229	13.4	10
18	.....	.....	.....	.....	224	16.9	263	13.9	10
19	.....	.....	.....	.....	254	18.7	300	15.5	10

Note. — The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of tie logs to a minimum top diameter of 9 inches, outside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

¹ Taken from U. S. Forest Service Bull. 96.

² Ten per cent deducted for circular saw kerf.

TABLE XXVII.—RED, BLACK AND SCARLET OAKS¹ VOLUME
TABLE IN TIES.

Based on measurements of 150 trees.

Diameter, breast high.	Height of tree in feet.								Basis.
	50		60		70		80		
	Volume.								
	Ties.	Top-wood.	Ties.	Top-wood.	Ties.	Top-wood.	Ties.	Top-wood.	
Inches.	No.	Cu. ft.	No.	Cu. ft.	No.	Cu. ft.	No.	Cu. ft.	Trees.
10	1	8.4	1	10.8	1	12.9	1	15.0	24
11	1	9.0	1	10.8	2	12.6	2	14.2	35
12	2	9.8	2	11.1	2	12.6	3	13.1	33
13	2	11.1	2	12.2	3	12.7	4	12.5	30
14	2	12.3	4	13.0	5	13.1	5	12.4	13
15	4	13.7	4	14.0	5	13.5	7	12.2	12
16	4	15.7	4	15.3	6	14.2	7	12.1	5
17	.....	.....	.....	.....	7	14.6	8	12.1	4
18	.....	.....	.....	.....	8	14.8	10	11.5	2
19	.....	.....	.....	.....	8	15.2	11	11.8	1

All first-class ties — 6" × 8" × 8'.

Note. — The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of tie logs to a minimum top diameter of 9 inches, outside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

¹ Taken from U. S. Forest Service Bull. 96.

TABLE XXVIII.—SECOND-GROWTH WHITE OAK¹ VOLUME OF CORD WOOD IN CUBIC FEET, HYDE PARK, NEW YORK.²

Based on measurements of 349 trees.

Diameter, breast high, in inches.	Height of tree in feet.				
	20	30	40	50	60
	Volume of cord wood in cubic feet. ³				
2	0.2	0.5	.....	.....	.....
3	.5	.8	1.1	.....	.....
4	.9	1.4	1.8	.....	.....
5	.....	2.3	2.7	3.2	.....
6	.....	3.4	4.0	4.8	5.7
7	.....	4.8	5.7	6.6	7.9
8	.....	.....	7.7	9.0	10.6
9	.....	.....	.....	11.8	13.6
10	.....	.....	.....	15.3	17.3
11	.....	.....	.....	19.6	22.6
12	.....	.....	.....	24.6	28.0
13	.....	.....	.....	.....	32.2

¹ Measurements by J. G. Peters of the U. S. Forest Service in 1905.² This table may be used for other second-growth hardwoods to be cut into cord wood.³ These volumes include all the tree that may be utilized for cord wood down to 1 inch in diameter. A cord made up of mixed diameters of second-growth wood is considered to contain 80 cubic feet of solid wood, and this table can be reduced to cords by dividing by 80.

TABLE XXIX.—WHITE AND CHESTNUT OAKS¹ VOLUME
TABLE IN CUBIC FEET, NEW LONDON COUNTY,
CONNECTICUT; HYDE PARK, NEW YORK.²

Based on measurements of 293 trees.

Diameter, breast high, in inches.	Height of tree in feet.						
	20	30	40	50	60	70	80
	Volume in cubic feet.						
2	0.3	0.4	.....	.....	.....	.....	.....
3		.9	1.0	.....	.....	.....	.....
4		1.5	2.0	2.6	.....	.....	.....
5		2.4	2.9	3.6	.....	.....	.....
6			4.2	5.0	6.0	.....	.....
7			5.7	6.6	7.6	8.9	.....
8			7.4	8.7	10.3	12.2	.....
9			9.3	11.1	13.5	16.0	18.9
10			11.2	13.7	16.5	19.5	22.6
11			13.3	16.5	19.8	23.2	26.8
12			15.7	19.3	23.1	27.2	31.4
13				22.4	26.9	31.5	36.3
14				25.9	31.0	36.3	41.6
15					35.5	41.7	48.1
16					40.5	47.5	55.0

Volumes include stem and topwood, with bark, up to a minimum diameter of 2 inches. Average stump heights vary from 6 inches for small trees to 21 inches for large ones.

¹ Taken from U. S. Forest Service Bull. 96.

² Volumes for trees under 9 inches diameter, breast high, are from measurements made in 1905 at Hyde Park, New York, by Mr. J. G. Peters.

TABLE XXX.—WHITE AND CHESTNUT OAKS¹ VOLUME
TABLE IN BOARD FEET, LITCHFIELD COUNTY,
CONNECTICUT.

By International² Log Rule. Based on measurements of 26 trees.

Diameter, breast high.	Height of tree in feet.						Diameter (inside bark) of top.
	50		60		70		
	Volume.						
	Stem.	Topwood.	Stem.	Topwood.	Stem.	Topwood.	
Inches.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Inches.
9	18	6.3	23	7.7	30	9.2	7
10	29	6.3	36	7.8	47	9.4	8
11	41	6.3	50	8.1	66	9.4	8
12	56	6.3	66	8.2	85	9.5	8
13	72	6.1	84	8.5	107	9.7	9
14	90	6.1	104	8.6	130	9.9	9
15	.....	.....	126	8.9	156	10.3	9
16	.....	.....	149	9.4	180	10.8	9

Note. — The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of tie logs to a minimum top diameter of 9 inches, outside bark, from the total used volume of tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

¹ Taken from U. S. Forest Service Bull. 96.

² Ten per cent deducted for circular saw kerf.

TABLE XXXI.—WHITE AND CHESTNUT OAKS¹ VOLUME
TABLE IN TIES, NEW LONDON COUNTY, CONNECTICUT.

Based on measurements of 25 trees.

Diameter, breast high, in inches.	Height of tree in feet.					
	50		60		70	
	Ties.	Topwood.	Ties.	Topwood.	Ties.	Topwood.
	No.	Cu. ft.	No.	Cu. ft.	No.	Cu. ft.
10	1	9.7	1	11.7	1	14.1
11	1	9.2	1	11.5	2	13.5
12	2	8.9	2	10.9	3	12.7
13	2	7.2	2	9.7	3	11.7
14	4	5.6	4	8.7	5	11.1
15	.....	.....	4	8.0	6	10.6
16	.....	.....	5	7.8	6	10.3

All first-class ties — 6"×8"×8'.

Note. — The volume in "topwood" (top and branches) was obtained by subtracting the aggregate cubic volume of tie logs to a minimum top diameter of 9 inches, outside bark, from the total used volume of the tree, in cubic feet (to a minimum diameter of 2 inches, outside bark).

¹ Taken from U. S. Forest Service Bull. 96.

TABLE XXXII.—CORDWOOD CONVERTING FACTORS.¹

Converting factors for second-growth hardwoods, by D.B.H. classes, with corresponding diameters of the average four-foot stick in the tree or in the stack. With the aid of this table the volume in cords of single trees can be secured by dividing the volumes in cubic feet given in tables XXI, XXV and XXIX by the "cubic feet per cord" values given in this table for a tree of the same diameter, breast high. If it is desired to convert the contents in cubic feet of an entire stand into cords, the average diameter, breast high, of all the trees in the stand should be found, and the "cubic feet per cord" value corresponding to this diameter should be used.

While these converting factors are intended especially for chestnut and oaks they can be used safely with other hardwoods.

Diameter, breast high.	Chestnut.		Black Oaks.		White Oaks.	
	Diameter, average stick.	Cubic feet ² per cord.	Diameter, average stick.	Cubic feet per cord.	Diameter, average stick.	Cubic feet per cord.
1	0.9					
2	1.8	63	1.8	63	1.8	63
3	2.6	70	2.5	69	2.5	69
4	3.3	75	3.1	74	3.1	74
5	4.0	79	3.6	77	3.5	76
6	4.7	83	4.1	80	3.9	79
7	5.2	85	4.5	82	4.2	81
8	5.8	88	4.8	84	4.5	82
9	6.2	89	5.0	85	4.7	83
10	6.7	91	5.3	86	4.9	84
11	7.0	92	5.4	86	5.0	85
12	7.4	93	5.6	87	5.1	85
13	7.7	94	5.7	88	5.2	85
14	7.9	94	5.7	88	5.2	85
15	8.2	95	5.8	88	5.3	86
16	8.4	95	5.9	88	5.4	86
17	8.5	95	5.9	88		
18	8.7	95	6.0	89		
19	8.9	96	6.0	89		
20	9.0	96				
21	9.2	96				
22	9.3	96				
23	9.5	97				
24	9.6	97				
25	9.7	97				
26	9.8	97				
27	10.0	97				
28	10.1	97				
29	10.2	97				
30	10.3	97				
31	10.4	97				
32	10.6	98				

¹ Taken from U. S. Forest Service Bull. 96.² Solid cubic feet.

TABLE XXXIII.—HEMLOCK.¹ VOLUME IN BOARD FEET, SOUTHERN NEW HAMPSHIRE.

Diameter, breast high, in inches.	Height of tree in feet.					Board feet per 1 cubic foot of log.	Diameter of last log inside bark.	Basis.
	30	40	50	60	70			
	Volume in board feet. ²							
						Number.	Inches.	Trees.
6	5	.....	.....	.....	.....	4.5	4.4	4
7	10	20	30	42	.....	5.0	4.4	17
8	17	28	39	50	.....	5.3	5.1	40
9	26	36	49	60	.....	5.5	5.3	57
10	36	46	59	71	86	5.6	5.7	57
11	47	58	72	86	103	5.6	5.5	41
12	60	72	86	103	123	5.7	6.0	42
13	.....	88	104	124	148	5.7	6.7	17
14	.....	107	125	147	173	5.8	6.1	14
15	.....	126	148	172	204	5.9	6.4	14
16	.....	148	171	200	240	6.1	6.7	6
17	.....	.....	197	233	281	6.2	5.9	8
						5.7		317

¹ Measurements by L. Margolin, U. S. Forest Service in cooperation with the state of New Hampshire, New Hampshire Forestry Report, 1905-1906.

² Actually cut out with a circular saw. One-half of cut went into scantling and the other half into 1-inch boards.

TABLE XXXIV.—HEMLOCK. VOLUME IN BOARD FEET,
VERMONT RULE.

Based on 400 trees.

Diameter, breast high, in inches.	Total height of tree in feet.						
	40	50	60	70	80	90	100
8	<u>35</u> ¹	.....	.....	.....	.....	.....	.....
9	<u>42</u>	<u>51</u>	<u>60</u>	.....	.....	.....	.....
10	<u>53</u>	<u>66</u>	<u>76</u>	.....	.....	.....	.....
11	66	81	<u>94</u>	109	120	.....	.....
12	74	93	<u>113</u>	132	153	.....	.....
13	.....	118	132	<u>156</u>	180	.....	.....
14	.....	140	160	<u>182</u>	214	241	.....
15	.....	160	185	<u>217</u>	248	284	.....
16	.....	.....	214	<u>248</u>	282	320	.....
17	.....	.....	250	283	<u>317</u>	360	.....
18	.....	.....	293	330	<u>364</u>	405	454
19	.....	.....	335	372	<u>408</u>	450	500
20	.....	.....	380	415	<u>454</u>	498	545
21	.....	.....	.....	455	<u>497</u>	545	590
22	.....	.....	.....	491	<u>540</u>	594	650
23	.....	.....	.....	520	582	<u>650</u>	710
24	.....	.....	.....	.....	626	<u>712</u>	780
25	.....	.....	.....	.....	675	<u>777</u>	836
26	.....	.....	.....	.....	742	<u>840</u>	906
27	.....	.....	.....	.....	790	<u>897</u>	968
28	.....	.....	.....	.....	.....	<u>978</u>	1040
29	.....	.....	.....	.....	.....	<u>1040</u>	1100
30	.....	.....	.....	.....	.....	<u>1100</u>	1160

¹ The figures underscored indicate the average height of the trees in each diameter class.

TABLE XXXV.—WHITE PINE.¹ VOLUME IN BOARD FEET, SOUTHERN NEW HAMPSHIRE.

Diameter, breast high, in inches.	Height of tree in feet.										Basis.
	30	40	50	60	70	80	90	100	110	120	
	Volume in board feet. ²										
											Trees.
5	8	12	15	.....	.....	.....	.....	.....	.....	.....	7
6	13	20	23	27	29	.....	.....	.....	.....	.....	41
7	18	28	34	39	44	.....	.....	.....	.....	.....	75
8	24	36	45	53	62	.....	.....	.....	.....	.....	128
9	32	44	56	69	81	93	.....	.....	.....	.....	156
10	41	53	70	85	102	119	138	.....	.....	.....	177
11	...	63	84	103	126	147	168	.....	.....	.....	164
12	...	73	100	125	151	177	200	228	245	.....	146
13	...	84	117	148	180	210	238	270	293	.....	137
14	...	95	137	173	210	243	277	312	348	.....	91
15	...	105	158	200	241	282	321	362	406	.....	61
16	...	...	181	230	277	323	370	415	470	.....	88
17	...	...	209	261	313	368	421	471	540	.....	70
18	...	...	238	297	352	411	475	531	610	688	68
19	...	...	270	336	393	460	530	598	682	763	44
20	...	...	302	379	436	506	583	660	750	840	35
21	...	...	.....	425	480	553	634	720	820	918	23
22	...	...	.....	.....	522	597	681	779	887	990	16
23	...	...	.....	.....	566	639	727	834	958	1065	19
24	...	...	.....	.....	.....	674	769	899	1030	1135	9
25	...	...	.....	.....	.....	706	809	942	1105	.....	12
26	...	...	.....	.....	.....	737	846	994	1180	.....	11
27	...	...	.....	.....	.....	.....	.....	1046	.....	.....	.....
											1578

¹ Measurements by L. Margolin, U. S. Forest Service in coöperation with the state of New Hampshire, New Hampshire Forestry Report, 1905-1906. Stumps averaged about 1 foot in height.

² The volume given is actual saw cut. Sixty per cent was round-edged and forty per cent squared, 70 per cent 1-inch boards and 30 per cent 2½-inch plank.

TABLE XXXVI.—WHITE PINE.¹ VOLUME IN BOARD FEET, MASSACHUSETTS.

Scaled by rule made from mill tallies. Volume to 4-inch top. Stumps taken at $\frac{1}{2}$ foot.

Diameter, breast high, in inches.	Total height in feet.						
	30	40	50	60	70	80	90
	Board feet.						
5	10						
6	15	20	30				
7	20	30	40	50	65		
8	25	35	50	65	85		
9	30	45	60	80	105	115	
10	.....	55	75	95	125	145	
11	.....	65	90	115	145	170	200
12	.....	75	105	135	165	200	230
13	.....	90	120	155	190	235	260
14	.....	.....	135	175	215	265	300
15	.....	.....	155	195	245	300	340
16	.....	.....	175	215	270	335	380
17	.....	.....	.....	240	300	370	420
18	.....	.....	.....	260	325	405	465
19	.....	.....	.....	280	355	445	510
20	.....	.....	.....	305	385	485	555
21	.....	.....	.....	.....	420	525	605
22	.....	.....	.....	.....	450	570	650
23	.....	.....	.....	.....	480	620	700
24	.....	.....	.....	.....	515	665	750
25	.....	.....	.....	.....	550	715	800
26	.....	.....	.....	.....	.....	.....	855
27	.....	.....	.....	.....	.....	.....	905

¹ Taken from "Forest Mensuration of the White Pine in Massachusetts."

TABLE XXXVII.—WHITE PINE.¹ VOLUME IN CORDS,
MASSACHUSETTS.Volume to 4-inch top. Stumps taken at $\frac{1}{2}$ foot. Logs scaled by caliper rule.

Diameter, breast high, in inches.	Total height in feet.						
	30	40	50	60	70	80	90
	Cords.						
5	.03						
6	.03	.04	.05				
7	.04	.05	.07	.09			
8	.05	.07	.09	.11	.13		
9	.07	.09	.11	.13	.16		
10	.....	.11	.13	.16	.19	.22	
11	.....	.13	.16	.19	.23	.26	.30
12	.....	.15	.19	.22	.27	.31	.35
13	.....	.17	.22	.26	.31	.36	.40
14	.....	.....	.25	.30	.34	.41	.45
15	.....	.....	.28	.34	.40	.46	.51
16	.....	.....	.32	.38	.44	.52	.58
17	.....	.....	.....	.42	.49	.58	.64
18	.....	.....	.....	.47	.55	.64	.71
19	.....	.....	.....	.51	.60	.70	.79
20	.....	.....	.....	.55	.66	.77	.87
21	.....	.....	.....	.....	.72	.85	.95
22	.....	.....	.....	.....	.78	.92	1.04
23	.....	.....	.....	.....	.84	1.01	1.13
24	.....	.....	.....	.....	.90	1.08	1.22
25	.....	.....	.....	.....	.97	1.16	1.32
26	.....	.....	.....	.....	.....	.....	1.42
27	.....	.....	.....	.....	.....	.....	1.51

¹ Taken from "Forest Mensuration of the White Pine in Massachusetts."

TABLE XXXVIII.—WHITE PINE.¹ VOLUME IN CUBIC FEET, MASSACHUSETTS.Volume outside bark, up to a 4-inch top. Stumps taken at $\frac{1}{2}$ foot.

Diameter, breast high, in inches.	Total height in feet.						
	30	40	50	60	70	80	90
	Cubic feet.						
5	1.8						
6	2.6	3.3	4.3				
7	3.4	4.4	6.1	7.7			
8	4.5	6.0	7.8	9.8	12.0		
9	5.9	7.7	10.0	12.0	15.0		
10	.....	9.6	12.0	15.0	17.9	20.9	
11	.....	11.6	14.6	17.9	21.4	24.9	28.7
12	.....	13.9	17.6	21.1	25.3	29.8	33.7
13	.....	16.2	20.4	24.8	29.2	34.7	38.7
14	.....	.....	23.7	28.7	32.5	39.6	43.6
15	.....	.....	26.8	32.6	37.9	44.5	49.5
16	.....	.....	30.5	36.5	42.3	49.8	55.9
17	.....	.....	.....	40.3	47.2	56.7	62.3
18	.....	.....	.....	44.6	52.6	61.5	69.1
19	.....	.....	.....	49.0	57.9	67.8	76.9
20	.....	.....	.....	52.9	63.2	74.7	84.8
21	.....	.....	.....	.....	69.1	82.0	92.6
22	.....	.....	.....	.....	74.9	89.3	101.4
23	.....	.....	.....	.....	81.3	98.1	110.8
24	.....	.....	.....	.....	87.1	104.9	119.0
25	.....	.....	.....	.....	94.0	112.6	128.8

¹ Taken from "Forest Mensuration of the White Pine in Massachusetts."

TABLE XXXIX.—SPRUCE.¹ VOLUME IN BOARD FEET BY THE NEW HAMPSHIRE RULE,² GRAFTON COUNTY, N. H.

Diameter, breast high, in inches.	Height in feet.				
	40	50	60	70	80
	Volume in board feet.				
7	18	25	30	35	
8	29	38	45	53	
9	42	53	61	71	
10	58	67	78	91	
11	76	84	94	110	
12	96	100	112	130	
13	.....	113	130	151	
14	.....	129	148	172	194
15	.....	.....	166	195	219
16	.....	.....	186	219	245
17	.....	.....	208	244	275
18	.....	.....	.....	272	305
19	.....	.....	.....	308	343
20	.....	.....	.....	346	400

¹ Table by T. S. Woolsey, Jr., 1903, published in "The Woodsman's Handbook."² Cutting to a top diameter limit of 6 inches.

TABLE XL.—SPRUCE.¹ VOLUME IN BOARD FEET.²

Diameter, breast high, in inches.	Total height of tree in feet.									
	40	45	50	55	60	65	70	75	80	90
7	20	20	20	25	25					
8	20	25	30	35	40	45				
9	30	35	40	45	50	55				
10	40	45	50	60	65	70	80			
11	.....	55	65	70	80	90	105	115		
12	.....	65	75	85	100	110	120	135	150	
13	.....	75	90	100	115	125	140	155	170	
14	.....	.....	105	120	135	150	165	180	195	
15	.....	.....	120	135	155	170	190	205	220	
16	.....	.....	.....	155	170	185	205	225	250	315
17	.....	.....	.....	170	190	210	230	250	275	350
18	.....	.....	.....	185	210	235	255	280	310	390
19	.....	.....	.....	205	235	260	290	320	350	430
20	.....	.....	.....	235	265	295	325	355	385	470
21	.....	.....	.....	.....	300	330	360	390	425	510
22	.....	.....	.....	.....	330	360	395	430	465	550
23	.....	.....	.....	.....	360	400	435	470	510	600
24	.....	.....	.....	.....	400	440	480	515	555	650

¹ Taken from "A Manual for Northern Woodsmen." Mr. Austin Cary, the author, considers tables XL, XLI and XLII applicable to other coniferous species with certain modifications. For balsam fir he advises a deduction of 8 per cent.

² Based on 2500 trees scaled in 16-foot log lengths up to 6 inches in diameter by the Maine log rule and discounted from 5 to 10 per cent.

TABLE XLI.—SPRUCE.¹ VOLUME IN CUBIC FEET OF ENTIRE STEM INCLUDING BARK.²

Diameter, breast high, in inches.	Total height of tree in feet.									
	40	45	50	55	60	65	70	75	80	90
6	4.9	5.3	5.8	6.5						
7	6.3	6.9	7.6	8.5	9.6					
8	7.8	8.6	9.5	10.6	12.0	14				
9	9.8	10.8	12.0	13.4	15.0	17				
10	12.0	13.5	15.0	16.5	18.2	20	21			
11	.....	16.0	18.0	19.7	22	23	25	27		
12	.....	18.5	21	23	25	27	29	32	34	
13	.....	22	24	27	29	31	34	36	39	
14	.....	.....	28	30	33	36	38	41	44	
15	.....	.....	31	34	37	40	43	46	49	
16	.....	.....	.....	38	41	44	47	51	55	63
17	.....	.....	.....	43	46	49	52	56	61	70
18	.....	.....	.....	47	50	54	58	62	67	77
19	.....	.....	.....	52	55	59	64	69	74	85
20	.....	.....	.....	56	60	65	70	76	81	93
21	.....	.....	.....	.....	.....	72	77	82	87	98
22	.....	.....	.....	.....	.....	79	84	88	93	105
23	.....	.....	.....	.....	.....	87	92	95	100	114
24	.....	.....	.....	.....	.....	96	100	104	108	123

¹ Taken from "A Manual for Northern Woodsmen."² Based on 2500 trees. Bark is estimated to form about 12½ per cent of the total volume.TABLE XLII.—SPRUCE.¹ VOLUME IN CORDS.²

Diameter, breast high, in inches.	Total height of tree in feet.								
	40	45	50	55	60	65	70	75	80
6	.04	.05	.05	.06					
7	.06	.06	.07	.08	.09				
8	.07	.08	.09	.10	.12	.13			
9	.09	.10	.12	.13	.14	.16			
10	.11	.12	.14	.16	.17	.19	.20	.22	
11	.....	.15	.17	.19	.20	.22	.24	.26	.28
12	.....	.18	.20	.22	.24	.26	.28	.30	.32
13	.....	.21	.23	.25	.27	.30	.32	.34	.37
14	.....	.....	.26	.29	.31	.34	.36	.39	.42
15	.....	.....	.....	.32	.35	.38	.40	.43	.47
16	.....	.....	.....	.36	.39	.42	.45	.48	.52
17	.....	.....	.....	.40	.43	.46	.50	.54	.59
18	.....	.....	.....	.45	.48	.50	.55	.59	.64
19	.....	.....	.....	.49	.52	.56	.60	.65	.70
20	.....	.....	.....	.52	.57	.62	.66	.72	.77

¹ Taken from "A Manual for Northern Woodsmen."² Derived from Table XLI by deducting a fair allowance for waste in stump, also volume of top above 4 inches diameter, and dividing by 96, the usual number of cubic feet, solid wood, in a piled cord.

TABLE XLIII. — SPRUCE.¹ VOLUME OF UNPEELED PULP WOOD IN CUBIC FEET, SOUTHERN NEW HAMPSHIRE.²

Diameter, breast high, in inches.	Height of tree in feet.						Basis.
	40	50	60	70	80	90	
	Volume in cubic feet.						
							Trees.
5	1.0	2.5	3.0	.....	.....	.....	29
6	3.5	4.2	5.2	6.4	.....	.....	98
7	5.0	6.2	7.5	9.0	.....	.....	128
8	6.6	8.4	10.0	11.7	.....	.....	165
9	8.5	10.8	12.7	14.8	.....	.....	161
10	.....	13.5	15.6	18.0	.....	.....	113
11	.....	16.5	18.8	21.5	.....	.....	78
12	.....	19.5	22.3	25.4	.....	.....	63
13	.....	.....	26.0	29.5	34.5	.....	42
14	.....	.....	30.0	34.0	39.5	.....	55
15	.....	.....	34.5	38.5	44.0	.....	56
16	.....	.....	39.0	43.5	49.0	.....	49
17	.....	.....	43.5	49.0	55.0	63.5	38
18	.....	.....	48.0	54.5	61.0	70.0	44
19	.....	.....	53.0	60.5	67.5	77.0	30
20	.....	.....	58.0	67.0	74.5	83.5	21
21	.....	.....	.....	74.0	82.0	90.5	18
22	.....	.....	.....	81.5	89.0	98.0	16
23	.....	.....	.....	88.5	96.5	106.0	10
24	.....	.....	.....	95.5	104.5	114.0	5
25	.....	.....	.....	102.0	112.0	123.0	2
26	.....	.....	.....	109.0	120.0	131.5	2
27	.....	.....	.....	.....	128.0	140.0	2
28	.....	.....	.....	.....	135.5	148.5	1
							1226

¹ Taken from "The Woodsman's Handbook."² Stumps varying from $\frac{1}{2}$ to $1\frac{1}{2}$ feet and tops above 4-inch diameter point are excluded. To reduce to cords divide by 100 or point off two places. Some use 95 or 96 cubic feet per cord. Bark equals 11 per cent of total volume.

GROWTH OF INDIVIDUAL TREES.

TABLE XLIV.—ASPEN.¹ RATE OF GROWTH BASED ON QUALITY OF LOCALITY.

Based on measurements of 409 trees.

Age.	Diameter, breast high, outside bark.	Height.	Total volume, excluding bark.	Diameter, breast high, outside bark.	Height.	Total volume, excluding bark.	Diameter, breast high, outside bark.	Height.	Total volume, excluding bark.
Years.	Inches.	Ft.	Cu. ft.	Inches.	Ft.	Cu. ft.	Inches.	Ft.	Cu. ft.
5	1.3	11	.....	0.6	7	.....	0.2	4	
10	2.7	21	.....	1.6	15	.....	1.0	8	
20	5.3	40	1.0	3.8	32	.....	2.4	17	
30	8.0	55	7.5	5.8	45	2.0	3.6	28	
40	10.4	66	16.5	7.8	56	7.0	4.7	39	0.5
50	12.7	75	27.5	9.4	65	13.0	5.8	50	2.5
60	14.8	81	42.5	10.9	71	19.0	7.0	57	5.5
70	17.0	85	62.0	12.3	74	25.0	8.2	61	8.5
80	19.2	87	82.5	13.4	75	31.5	9.3	64	12.5
90	21.3	88	104.0	14.3	77	37.0	10.5	66	16.5
100	23.3	89	126.0	15.1	78	42.5	11.7	66	20.5

¹ Taken from U. S. Forest Service Bull. 93.TABLE XLV.—PAPER BIRCH.¹ HEIGHT AND DIAMETER GROWTH.

Age.	Height.		Diameter, breast high.	
	Seedlings. ²	Sprouts. ³	Seedlings.	Sprouts.
Years.	Feet.	Feet.	Inches.	Inches.
5	5	10	0.2	0.7
10	13	19	1.1	1.8
15	22	28	2.2	2.9
20	30	36	3.4	4.0
25	37	43	4.4	4.9
30	44	49	5.3	5.6
35	49	55	6.1	6.3
40	54	60	6.8	6.9
45	58	65	7.5	7.5
50	62	70	8.0	7.9
55	65	74	8.5	8.4
60	68	78	8.9	8.8
65	71	82	9.3	.....
70	74	.....	9.7	.....
75	76	.....	10.0	.....
80	78	.....	10.2	.....
85	80	.....	.....	.....
90	81	.....	.....	.....

¹ Taken from U. S. Forest Service Circular 163.² Based on measurements of 50 trees.³ Based on measurements of 30 trees.

TABLE XLVI.—PAPER BIRCH.¹ VOLUME GROWTH.

Age.	Total stem volume.		Volume, N. H. rule.	
	Seedlings. ²	Sprouts. ³	Seedlings.	Sprouts.
Years.	Cubic feet.	Cubic feet.	Board feet.	Board feet.
20	.....	1.8	.....	13
25	2.3	3.2	.....	19
30	3.6	4.6	16	26
35	5.2	6.1	22	34
40	6.9	7.7	29	43
45	8.6	9.5	37	52
50	10.5	11.4	46	61
55	12.3	13.5	55	71
60	14.1	15.5	64	.....
65	16.0	.....	73	.....
70	17.7	.....	82	.....
75	19.3	.....	90	.....
80	20.7	.....	97	.....

¹ Taken from U. S. Forest Service Circular 163.² Based on measurement of 50 trees.³ Based on measurement of 30 trees.TABLE XLVII.—WHITE PINE.¹ GROWTH IN VOLUME AND HEIGHT.

Age.	Rich lowland, 100 trees.		Upland pasture, 73 trees.		Sandy soil, 16 trees.		Wet swamp, 47 trees.	
	Volume.	Height.	Volume.	Height.	Volume.	Height.	Volume.	Height.
Years.	Cu. ft.	Ft.	Cu. ft.	Ft.	Cu. ft.	Ft.	Cu. ft.	Ft.
10	.8	8	.6	9	.4	5	.3	4
15	1.8	15	1.2	16	.5	14	.4	10
20	3.0	23	2.0	24	1.4	23	1.0	16
25	5.5	31	4.5	32	2.5	30	1.6	22
30	9.0	39	7.5	40	4.0	36	2.7	28
35	13.5	46	11.5	47	6.3	40	4.0	34
40	19.5	52	16.6	53	9.3	44	6.0	39
45	26.5	57	22.0	59	12.5	48	8.3	43
50	35.0	62	27.7	64	16.0	51	10.7	48
55	43.5	66	34.5	69	19.8	54	14.5	51
60	51.5	69	41.7	73	23.6	57	18.6	54
65	60.0	71	49.0	76	27.5	59	23.0	57
70	68.0	73	56.0	80	31.2	61	27.2	60
75	75.5	75	.....	82	35.3	63	31.2	62
80	84.0	77	.....	84	39.0	65	34.8	65
85	93.5	79	.....	87	42.8	.....	38.0	68
90	.....	80	.....	89	.....	.....	41.0	70
95	.....	.....	.....	90	.....	.....	43.5	.....
100	.....	.....	.....	91	.....	.....	.....	.....

¹ Taken from "Forest Mensuration of the White Pine in Massachusetts."

YIELD TABLES.

TABLE XLVIII.—PAPER BIRCH, YIELD PER ACRE. PURE
(100 PER CENT) BIRCH STANDS.

Penobscot, Piscataquis, Somerset and Franklin counties, Maine.

(Data gathered by R. L. Marston for Paper Birch Study, 1903-1907.)

Age.	Quality I.				Quality II.			
	Average diam-eter, breast high.	Average height.	Total yield.	Yield of trees 6 inches and over in per-centage of total yield.	Average diam-eter, breast high.	Average height.	Total yield.	Yield of trees 6 inches and over in per-centage of total yield.
Years.	Inches.	Ft.	Cu. ft.	Per cent.	Inches.	Ft.	Cu. ft.	Per cent.
15	2.3	24	710	0	1.8	21	410	0
20	3.4	33	1020	4	2.6	28	580	0
25	4.5	41	1340	27	3.4	34	770	18
30	5.6	48	1700	46	4.3	40	1010	35
35	6.4	54	2090	63	5.0	45	1290	50
40	7.2	58	2520	75	5.7	49	1580	63
45	7.8	62	2950	85	6.3	53	1890	73
50	8.4	65	3340	91	6.8	56	2220	82
55	8.8	68	3660	96	7.2	59	2530	89
60	9.2	70	3940	98	7.6	61	2810	94
65	9.6	72	4190	100	7.9	64	3060	97
70	10.0	74	4450	100	8.2	66	3300	100

Note.— These sample plots were taken in unmanaged stands. All plots with a density less than 50 per cent were discarded. All plots containing less than 40 per cent birch were discarded and the remainder reduced to 100 per cent birch by dividing the actual birch yield by the percentages of the total basal area formed by the birch. Hence the table applies only to pure birch stands of average density (quality I, 83 per cent and quality II, 75 per cent). For the yield of a mixed stand, containing, for example, 60 per cent of birch, a corresponding reduction would be made in the yield. The number of trees per acre was exceedingly irregular and was, therefore, excluded from the table.

The volume given is total stem volume, though the lowest measurement taken in the sample trees was at 4.5 feet, and this disregard for butt swelling makes the yield conservative.

Based on 20 quality I and 26 quality II, sample plots.

TABLE XLIX.—CHESTNUT TYPE,¹ GROWTH IN HEIGHT, DIAMETER AND NUMBER OF TREES FOR THREE QUALITIES OF SOIL,² CONNECTICUT.

Age.	Quality I.			Quality II.			Quality III.		
	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.
Years.	Feet.	Inches.	Trees.	Feet.	Inches.	Trees.	Feet.	Inches.	Trees.
15	38	3.2	1000	30	2.6	1160	21	2.0	1360
20	50	4.4	830	40	3.6	930	30	2.7	1180
25	58	5.4	680	48	4.5	800	37	3.5	990
30	64	6.4	550	54	5.3	675	44	4.3	790
35	70	7.3	460	60	6.1	560	50	5.0	670
40	74	8.1	400	64	6.8	490	55	5.6	580
45	77	8.9	350	68	7.5	425	59	6.2	500
50	80	9.6	310	71	8.2	370	62	6.8	450
55	83	10.3	280	74	8.8	335	64	7.3	400
60	85	10.9	260	76	9.4	300	67	7.8	360
65	87	11.6	235	77	9.9	280	68	8.3	330
70	88	12.2	220	79	10.5	255	70	8.7	310
75	90	12.8	200	80	11.0	240	71	9.2	290

¹ Taken from U. S. Forest Service Bull. 96.

² For trees over 2 inches in diameter, breast high; based on normally stocked plots, $\frac{1}{4}$ to $\frac{1}{2}$ acre in size. Quality classes based on height of dominant trees.

TABLE L. — OAK-CHESTNUT TYPE,¹ GROWTH IN HEIGHT, DIAMETER AND NUMBER OF TREES FOR THREE QUALITIES OF SOIL,² CONNECTICUT.

Age.	Quality I.			Quality II.			Quality III.		
	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.
Years.	Feet.	Inches.	Trees.	Feet.	Inches.	Trees.	Feet.	Inches.	Trees.
15	35	2.9	1130	28	2.5	1180	23	2.0	1500
20	46	4.0	910	38	3.3	950	31	2.8	1070
25	55	4.9	750	46	4.1	770	38	3.3	1000
30	62	5.8	610	52	4.8	675	43	3.9	855
35	68	6.6	525	57	5.5	610	48	4.4	755
40	73	7.4	455	61	6.1	530	52	4.8	700
45	77	8.2	400	65	6.7	470	55	5.3	620
50	80	8.9	360	68	7.3	425	58	5.7	570
55	83	9.6	320	71	7.8	390	60	6.1	525
60	85	10.3	290	73	8.4	355	62	6.5	475
65	87	10.9	270	75	8.9	325	64	6.9	445
70	89	11.5	250	77	9.4	305	66	7.2	420
75	90	12.1	235	78	9.8	285	67	7.6	390

¹ Taken from U. S. Forest Service Bull. 96.

² For trees over 2 inches in diameter, breast high; based on normally stocked plots, $\frac{1}{8}$ to $\frac{1}{2}$ acre in size. Quality classes based on height of dominant trees.

TABLE LI.—OAK TYPE.¹ GROWTH IN HEIGHT, DIAMETER AND NUMBER OF TREES FOR THREE QUALITIES OF SOIL,² CONNECTICUT.

Age.	Quality I.			Quality II.			Quality III.		
	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.	Height of dominant trees.	D.B.H. of average tree.	Number of trees per acre.
Years.	Feet.	Inches.	Trees.	Feet.	Inches.	Trees.	Feet.	Inches.	Trees.
15	25	2.5	1320	22	2.2	1400	18	1.9	1550
20	38	3.5	960	31	3.0	1060	25	2.5	1290
25	49	4.5	740	40	3.9	795	32	3.2	1000
30	57	5.5	575	47	4.6	675	37	3.7	880
35	63	6.4	475	53	5.3	575	42	4.2	770
40	68	7.2	405	57	6.0	485	46	4.7	650
45	72	8.0	350	61	6.6	430	49	5.1	560
50	75	8.7	310	64	7.1	390	52	5.5	515
55	78	9.4	280	67	7.6	355	54	5.8	480
60	80	10.0	260	68	8.1	325	56	6.2	450
65	82	10.6	240	70	8.5	300	58	6.5	400
70	84	11.1	220	72	8.9	280	60	6.6	375
75	86	11.6	210	73	9.4	255	61	7.1	345

¹ Taken from U. S. Forest Service Bull. 96.

² For trees over 2 inches in diameter, breast high; based on normally stocked plots, $\frac{1}{8}$ to $\frac{1}{2}$ acre in size. Quality classes based on height of dominant trees.

TABLE LII.—YIELD IN CORDS ¹ FOR THREE TYPES AND QUALITIES OF SOIL,² CONNECTICUT.

Age.	Chestnut type. ³ Quality.			Oak-chestnut type. ³ Quality.			Oak type. ³ Quality.		
	I.	II.	III.	I.	II.	III.	I.	II.	III.
Years.	Cords.								
15	16	12	9	12	10	8	9	8	6
20	23	18	13	19	16	12	15	12	10
25	30	24	18	28	22	17	23	18	14
30	37	30	23	36	28	20	30	24	17
35	43	35	27	41	33	24	36	28	21
40	48	40	31	46	36	27	40	32	24
45	53	43	34	49	40	30	44	35	26
50	57	46	37	53	42	32	48	38	29
55	61	49	39	56	45	33	51	40	30
60	63	51	41	59	47	35	53	43	32
65	66	53	42	62	49	37	55	45	34
70	68	55	44	64	51	38	58	47	35
75	70	57	45	66	53	39	60	48	36

¹ Taken from U. S. Forest Service Bull. 96.

² For trees over 2 inches in diameter, breast high. Based on selected, normally stocked plots $\frac{1}{8}$ to $\frac{1}{2}$ acre in size. Plots varying in basal area by not more than 10 per cent of the average were considered normally stocked. Quality classes based on average height of dominant trees. Yields computed in cubic feet by volume tables, to minimum diameters of 2 inches, outside bark, and reduced to cords by table of converting factors. Chestnut converting factors used for chestnut type, black oak factors for oak-chestnut type, and white oak factors for oak type.

³ A sub-type included in the mixed hardwoods type of the sprout hardwoods region.

TABLE LIIL.—CHESTNUT TYPE.¹ YIELD IN LUMBER AND ADDITIONAL CORDWOOD,² CONNECTICUT.By International Log Rule.³

Age.	Quality.					
	I.		II.		III.	
	Lumber.	Additional cordwood.	Lumber.	Additional cordwood.	Lumber.	Additional cordwood.
Years.	Board feet.	Cords.	Board feet.	Cords.	Board feet.	Cords.
20	300	21				
25	1,400	27				
30	2,850	30	900	27		
35	5,100	29	2,100	29	900	24
40	8,200	28	3,700	31	1,800	26
45	11,000	28	5,400	31	2,900	26
50	13,800	28	7,700	29	4,100	26
55	16,500	27	9,900	28	5,500	25
60	19,100	25	12,000	26	7,000	24
65	21,600	24	14,000	25	8,400	22
70	23,900	22	16,100	23	9,800	21
75	25,700	21	17,800	21	11,100	19

¹ Taken from U. S. Forest Service Bull. 96.² Based on 123 normally stocked plots, from $\frac{1}{8}$ to $\frac{1}{2}$ acre in size. Cordwood converting factor used = 80 cubic feet per cord.³ Ten per cent deducted for circular saw kerf.TABLE LIV.—CHESTNUT TYPE.¹ YIELD IN TIES² AND ADDITIONAL CORDWOOD.³

Age.	Quality.					
	I.		II.		III.	
	Ties.	Additional cordwood.	Ties.	Additional cordwood.	Ties.	Additional cordwood.
Years.	Number.	Cords.	Number.	Cords.	Number.	Cords.
25	25	29				
30	76	34	20	29		
35	140	37	55	33	20	25
40	225	38	100	36	45	28
45	320	37	150	36	75	30
50	435	35	215	35	110	31
55	565	32	290	33	145	31
60	710	29	365	30	190	30
65	855	26	440	28	235	29
70	975	25	510	26	280	28
75	1075	24	575	25	330	26

¹ Taken from U. S. Forest Service Bull. 96.² All first class — 6"×8"×8'.³ Based on 123 normally stocked sample plots, from $\frac{1}{8}$ to $\frac{1}{2}$ acre in size. Cordwood converting factor used = 80 cubic feet per cord.

TABLE LV.—WHITE PINE.¹ YIELD PER ACRE, SOUTHERN NEW HAMPSHIRE.

(Data gathered by L. Margolin for Graded Mill Tallies, 1906.)

Quality I.						
Age.	Number of trees.	Basal area.	Mean height.	Volume.	Current annual increment.	Mean annual increment.
Years.		Sq. ft.	Ft.	Cu. ft.	Cu. ft.	Cu. ft.
25	2430	190	33	3,100	124	124
30	1840	215	41	4,367	253	145
35	1250	230	48	5,850	296	167
40	870	238	56	7,033	236	176
45	640	243	64	8,000	193	177
50	510	246	70	8,767	153	175
55	430	249	75	9,475	141	172
60	380	252	80	10,100	125	168
65	340	255	84	10,633	106	164
70	310	258	87	11,100	93	158
75	280	261	90	11,567	93	154
80	260	263	93	12,000	86	150
85	240	266	95	12,383	76	146
90	220	268	97	12,767	76	142

Quality II.						
25	2430	163	31	2,700	108	108
30	1840	183	38	3,700	200	123
35	1250	195	45	4,850	230	139
40	870	212	52	5,800	190	145
45	640	221	59	6,600	160	147
50	510	228	65	7,300	140	146
55	430	233	71	7,925	125	144
60	380	236	76	8,500	115	142
65	340	238	80	9,000	100	138
70	310	241	84	9,450	90	135
75	280	244	87	9,900	90	132
80	260	247	89	10,300	80	129
85	240	250	91	10,650	70	125
90	220	253	93	11,000	70	122

Quality III.						
25	2430	150	28	2,300	.....	92
30	1840	165	35	3,033	146	101
35	1250	176	42	3,850	163	110
40	870	185	48	4,567	143	114
45	640	191	54	5,200	126	116
50	510	197	60	5,833	126	116
55	430	201	66	6,375	108	116
60	380	205	71	6,900	105	115
65	340	208	75	7,367	93	113
70	310	211	79	7,817	90	112
75	280	213	83	8,233	83	110
80	260	216	85	8,600	73	107
85	240	218	88	8,917	63	105
90	220	221	89	9,233	63	103

¹ Taken from "The Woodsman's Handbook."

TABLE LVI.—WHITE PINE.¹ YIELD TABLE IN BOARD FEET, CORDS AND CUBIC FEET.

Age, years.	1-inch boards.	Cords.	Cubic feet.	1-inch boards.	Cords.	Cubic feet.	1-inch boards.	Cords.	Cubic feet.
25	10,825	25.1	2080	6,750	16.4	1300	3,975	10.8	750
30	19,900	44.0	3750	12,500	31.2	2740	7,500	18.2	1400
35	31,150	60.4	5420	24,400	40.0	4375	16,050	35.8	3035
40	40,650	70.6	6590	32,800	58.0	5300	25,200	46.2	4080
45	49,350	78.0	7420	40,600	64.8	6075	32,100	51.8	4785
50	55,150	84.2	8035	46,500	70.0	6725	37,550	56.6	5475
55	59,650	89.2	8575	50,550	74.8	7200	42,100	60.8	6015
60	63,600	93.4	9075	53,200	79.2	7655	44,550	64.6	6340
65	67,050	97.2	9550	56,600	83.0	8050	46,150	68.4	6550

¹ Taken from "Forest Mensuration of the White Pine in Massachusetts."TABLE LVII.—WHITE PINE.¹ YIELD PER ACRE, SOUTHERN NEW HAMPSHIRE.

(Data gathered by L. Margolin for Graded Mill Tallies, 1906.)

Age.	Volume. ²			Age.	Volume.		
	Quality I.	Quality II.	Quality III.		Quality I.	Quality II.	Quality III.
Years.	Bd. ft.	Bd. ft.	Bd. ft.	Years.	Bd. ft.	Bd. ft.	Bd. ft.
20	4,600	3,150	1,700	60	57,300	47,400	37,500
25	8,400	5,900	3,450	65	61,850	51,850	41,850
30	15,100	10,800	6,550	70	65,900	55,800	45,700
35	24,050	18,050	11,200	75	69,750	59,500	49,250
40	33,550	25,000	16,450	80	73,300	62,850	52,400
45	40,750	31,450	22,150	85	76,700	66,000	55,300
50	47,450	37,800	27,650	90	80,050	69,000	57,950
55	52,350	42,550	32,750				

¹ Taken from "The Woodsman's Handbook."² Volume in board feet is round-edged boxboard material.

TABLE LVIII.—WHITE PINE.¹ YIELD PER ACRE OF THINNINGS,
SOUTHERN NEW HAMPSHIRE.

(Data gathered by L. Margolin for Graded Mill Tallies, 1906.)

Age.	Quality I.		Trees under 5 inches in diameter, breast high.	Quality II.		Trees under 5 inches in diameter, breast high.	Quality III.		Trees under 5 inches in diameter, breast high.
	Total thinning per acre.			Total thinning per acre.			Total thinning per acre.		
Years.	Cu. ft.	Bd. ft. ²	Cu. ft.	Cu. ft.	Bd. ft.	Cu. ft.	Cu. ft.	Bd. ft.	Cu. ft.
25	1350	2,000	830	900	750	750	600	.....	600
30	1730	4,500	660	1380	3,300	600	1090	2200	500
35	1980	6,800	480	1680	5,600	450	1440	4300	400
40	2120	8,700	270	1900	7,500	300	1640	5800	300
45	2240	10,100	60	2040	8,900	150	1750	6900	200
50	2280	11,200	.....	2100	9,900	.....	1800	7600	80
55	2280	12,000	.....	2100	10,400	.....	1780	8100	.....
60	2260	12,300	.....	2000	10,600	.....	1700	8300	.....
65	2200	12,300	.....	1850	10,300	.....	1590	8200	.....
70	2100	11,900	.....	1630	9,500	.....	1420	7800	.....
75	1950	11,100	.....	1300	8,000	.....	1200	6900	.....
80	1700	9,500	.....	860	5,000	.....	920	5600	.....
85	.....	.....	.....	200	1,200	.....	650	4000	.....
90	.....	.....	.....	.....	.....	.....	370	2300	.....

¹ Taken from "The Woodsman's Handbook."² Volume in board feet is round-edged boxboard material.

INDEX.

- Advance growth, 75.
Age, of trees, 172; of stands, 178.
Agriculture, 290.
Animals, injuries from, 97, 137; prevention of damage, 262, 293, 339, 371.
Aphid (pine bark), 103.
Arborvitæ, 52, 203, 246, 269.
Areas of New England forest regions, 197.
Ash, white, 58, 269, 276, 288, 298, 311, 313, 325, 346, 351, 355, 361, 364.
Aspen, *see* Poplar.
Assimilation, 4.
Austria, 177.
- Back fires, 152.
Baden, 178.
Balsam, 48, 184, 202, 222, 246, 269.
Basswood, 58, 246, 269, 276, 288, 346.
Beech, 57, 203, 246, 268, 271, 276, 288, 346.
Bibliography, 420.
Bingham purchase, 190.
Birch, black, 269, 346, 353.
Birch, gray, 56, 298, 304, 309, 311, 324, 345, 351, 352, 362.
Birch, yellow, 54, 203, 246, 268, 271, 276, 288, 298, 312, 325, 346, 351, 364.
Birch, paper or white, 55, 203, 231, 269; uses of, 248; tables, 440, 441, 442, 464, 465, 466.
Birds, damage by, 97, 113.
Black Hills national forest, 155.
Blight, white pine, 129.
Blister rust of white pine, 124, 341.
Bowdoin grants, 191.
Box industry, 329.
Brown-tail moth, 110, 340, 388, 391, 403.
Brush piling and burning, 260, 292, 338, 370, 380.
Calipers, 157.
Cambium, 105, 119, 172.
Cannon, Speaker, opposition to forestry, 375.
Cary, Austin, 162.
Cattle, damage by, 99.
Cedar, red, *see* Juniper.
Cedar, northern white, *see* Arborvitæ.
Cedar, southern white, 298, 301, 316, 346.
Chemical extinguishers, 147, 149.
Chemicals required by trees, 2, 5.
Cherry, black, 299, 311, 313, 325.
Chestnut, 60, 269, 298, 300, 311, 313, 325, 345, 347, 349, 355, 356, 364; tables, 435, 442, 443, 444, 445, 467, 468, 470, 471.
Chestnut bark disease, 118, 341, 355, 359, 372.
Cleanings, 34, 324.
Cleveland, President, 190.
Climate, influences of, 1.
Clinton, Dr. G. P., 121.
Codominant, 81.
Composite form, 16.
Connecticut, 379.
Connecticut Agricultural College, 380.
Cooperage staves, 249.
Coppice, simple, 12, 16, 32, 191; coppice with standards, 16, 33; polewood coppice, 35.
Cordwood converting factors, 453.
Cornell Forest School, 21.

- Cost of planting, 72.
 Crown class, 81.
 Crows, damage by, 98.
 Cubic contents of logs, solid, 436;
 stacked, 437.
 Currant rust, *see* Blister rust.
 Cutting, cost of, 168.

 Damage cutting, 91.
 Dartmouth grant, 190.
 Deer, damage by, 97.
 Defebaugh, history of the lumber in-
 dustry of America, 186, 190.
 Dominant, 91.
 Doyle log rule, 428.
 Driving logs, 240, 286.
 Duff, 30.
 Dwight, President of Yale, 191.

 Educational work, 349, 380, 385, 390,
 398, 402.
 Electricity for fuel, 258.
 Elm Leaf beetle, 113.
 England, 184, 186.
 Estimating fire damage, 152, 155.
 Estimating timber, 156; money value,
 165.
 Evelyn, John, 185.
 Even-aged forest, 14, 180, 309.
 Excelsior, 249.

 Final cutting, 29.
 Fir, *see* Balsam.
 Fires, causes, 136, 256, 291, 334, 369.
 crown, 131, 256, 333.
 extinguishing, 146, 261, 292, 339, 371.
 fire service, 379, 384, 389, 392, 396,
 400.
 ground, 133.
 lookout towers, 139, 257, 292, 337,
 390, 397, 400.
 northern hardwoods region, 291; pine
 region, 332; spruce region, 254;
 sprout hardwoods region, 367.
 patrol, 140, 257, 337, 397.
 prevention, 138, 257, 292, 335, 369.
 statistics, 417.
 surface, 132, 291, 333, 367.

 Fire lines, 142, 370.
 Forest regions, 196, 200.
 Forest tent caterpillar, 114, 295.
 Forestry associations, 381, 386, 394.
 Forestry, purpose of, 15; practice of,
 403, 404; net return from, 413; as
 an investment, 415.
 French method, 84.
 Fungi, 118, 263, 295, 340, 372.

 Gipsy moth, 108, 340, 388, 391, 403.
 Goats, damage by, 100.
 Gorges, Sir Ferdinando, 185.
 Grades of thinning, 82.
 Graves, H. S., 171.
 Growth, 171; annual, 408; diameter,
 174, 179; height, 175, 179; of indi-
 vidual trees, 464; volume, 176, 179.
 Guild, Gov. Curtis, conference called
 by, 375.

 Hardwoods, log rule for second growth,
 435.
 Harvard Forest School, 385.
 Hauling, cost of, 168.
 Hedge hogs, damage by, 262.
 Heeling in, 68.
 Heins, 125.
 Hemlock, 49, 203, 246, 269, 271, 288,
 298, 300, 314, 346, 349, 359, 364;
 tables, 454, 455.
 Hewitt, Dr. C. Gordon, 107, 112.
 Hickory, 184, 346, 347, 357, 364.
 High forests, 12.
 Hogs, damage by, 100; for killing grubs,
 118.
 Hopkins, Dr., 103, 105.
 Humus, 6.
 Hypsometer, 157, 175.

 Improvement cuttings, 74, 313; sched-
 ule of, 92; method of controlling,
 93.
 Income, *see* Revenue.
 Increment, *see* Growth.
 Industries, 243, 288, 329.
 Insects, 101, 262, 295, 340, 372.

- Intermediate, 81.
- International log rule, 433.
- Irregular forest, 15.
- June bugs, 116.
- Juniper, 52, 351, 362.
- Katahdin, elevation of, 291.
- Kearsarge station, 139.
- Lady bugs, 185.
- Larch, *see* Tamarack.
- Larch, European, 51, 276.
- Larch sawfly, 111, 262.
- Liberation cuttings, 76.
- Light, relation of light to tree growth, 2, 4.
- Lightning, as cause of fire, 138.
- Logging, cost of, 158; methods, 235, 285, 327, 362.
- Log rules, 159, 427.
- Lookout stations, 139.
- Lopping of branches, 141, 258.
- Lumbering, 235, 285, 327, 362.
- Lumber, 245; origin of word, 189.
- Lumber industry, 189, 245, 246, 288, 329, 364.
- Maine, 399.
- Maine Forestry District, 400.
- Maine log rule, 429.
- Manufacturing, 290, 329, 364.
- Map making, 162.
- Maps, forest regions, *facing* 197; railroad lines and forest regions, *facing* 199.
- Maple, red or soft, 54, 298, 301, 304, 309, 311, 312, 324, 325, 346, 347, 350, 353, 361, 364.
- Maple, sugar, 53, 203, 268, 271, 276, 288, 298, 346.
- Maple sugar industry, 289.
- Maple sugar orchard, management of, 279.
- Maple worm, *see* Forest tent caterpillar.
- Markets for forest products, 242, 287, 328, 364.
- Marking, 93.
- Massachusetts, 384.
- Massachusetts Agricultural College, 385.
- Mattock, 67.
- Maturity, 178.
- Mice, damage by, 97.
- Micheaux, 197.
- Mixed forests, 10, 11.
- Moles, damage by, 97.
- Naval stores, 187.
- New Hampshire, 396.
- New Hampshire log rule, 430.
- New Hampshire State College of Agriculture, 398.
- New Hampshire Timberland Owners Association, 397.
- Nitrogen, 6.
- Normal stands, 180.
- Northern hardwoods region, 197, 198, 265, 418.
- Novelties, 248.
- Oak, chestnut, 345, 347, 349; tables, 451, 452, 468, 469, 470.
- Oak, red, 62, 184, 269, 276, 298, 300, 311, 313, 325, 345, 347, 349, 355, 357, 364; tables, 446.
- Oak, white, 62, 184, 298, 311, 345, 347, 364; tables, 450, 451, 452, 468, 469, 470.
- Oaks, black, tables, 447, 448, 449, 468, 469, 470.
- Oil for fuel, 258.
- Ownership of lands, spruce region, 251; northern hardwoods region, 290; white pine region, 332; sprout hardwoods region, 366; state reserves, 404.
- Patrol, 189, 191.
- Pepys, Samuel, 184.
- Pinchot, 302.
- Pine, pitch, 42, 298, 301, 316, 325, 345; manufacture of naval stores, 187.

- Pine, red or Norway, 41, 202, 231, 314, 316, 325.
- Pine, Scotch, 43, 316, 325.
- Pine, white, 37, 183, 189, 192, 202, 231, 269, 276, 297, 303, 309, 311, 313, 317, 318, 324, 325, 345, 351, 355; tables, 434, 456, 457, 458, 459, 465, 472, 473, 474.
- Planting, opportunities for, 65, 231, 276, 313, 324, 325, 355, 359; methods, 67; heeling in plants, 68; size of plants, 69; pure versus mixed plantations, 70; spacing, 71; cost, 72.
- Polyporus schweinitzii, 123, 263.
- Poplar, 59, 203, 231, 269, 309, 324, 346, 353; tables, 438, 439, 464.
- Poplar, yellow, *see* Tulip tree.
- Porcupines, *see* Hedge hogs.
- Potash, 189, 191.
- Preparatory cutting, 30.
- Prices of lumber, 167.
- Pruning, 95.
- Pulpwood, 193, 243, 246.
- Pumps, spray, 147, 149.
- Punk, 127.
- Pure forests, 10, 11.
- Pure planting, 70.
- Quality, 10.
- Rabbits, damage by, 90.
- Railroads, logging, 241; as cause of fire, 136, 155.
- Regular form, 15.
- Removal cutting, 30.
- Reproduction cutting, 74.
- Reserve form, 16.
- Revenue of European forests, 414.
- Rhode Island, 389.
- Robinson, History of Vermont, 192.
- Root development, 5.
- Rossing bark, 260.
- Rot, white heart, 126.
- Rotation, 87.
- Saw mills, introduction of, 185; portable, 194, in spruce region, 239; in northern hardwoods region, 286; in white pine region, 328; in sprout hardwoods region, 363.
- Scandinavia, 184, 186.
- Scotland, 184.
- Scribner log rule, 427.
- Seed cutting, 29.
- Seed spots, 67; cost, 73.
- Seeding or sowing, 66.
- Selection forest, 15.
- Shakers, 98.
- Sheep, damage by, 100.
- Shifting sands, 326.
- Ship building, 187.
- Silvicultural systems, 17; *see also* Systems of reproduction.
- Silvicultural characteristics of trees, 37.
- Skidway, 166.
- "Snaking," 237.
- Soap solution, 105.
- Society for the Protection of New Hampshire Forests, 398.
- Soils, 5; chemical composition, 7.
- Spacing, 71.
- Spaulding, P., 124, 128.
- Spark arrester, 136.
- Spools, 248.
- Spores, 119.
- Sprout hardwoods region, 197, 198, 342, 418.
- Spruce destroying beetle, 105, 262.
- Spruce budworm, 106, 262.
- Spruce, red, 45, 184, 202, 216, 222, 223, 246, 269, 288; tables, 460, 461, 462, 463.
- Spruce region, 197, 200, 418.
- Spruce, Norway, 47, 231, 276.
- Squirrels, damage by, 81.
- Stand, 8.
- State administration, 379, 384, 389, 391, 396, 399.
- State forests, 381, 386, 391, 394, 398, 402.
- State nurseries, 383, 386, 395, 399.
- Stumpage, 166, 169.
- Summer resort business, 194, 249, 289.
- Suppressed, 81.

Systems of reproduction:

- clear cutting, 20, 21, 22, 24, 25, 26, 27, 217, 221, 222, 225, 226, 228, 283, 285, 314, 316, 318, 325, 327, 359, 360.
 - coppice, 31; simple coppice, 32, 283, 325, 356, 360; coppice with standards, 33.
 - pole-wood sprout, 35, 324, 357, 360.
 - selection, 17, 94, 217, 221, 222, 223, 277, 321, 359.
 - shelterwood, 27, 226, 266, 279, 284, 318, 320, 324.
- Tamarack, 50, 203.
- Taxation, 377, 383, 386, 391, 395, 399, 415.
- Thinnings, 79, 228, 278, 280, 321.
- Tolerant, 4.
- Tools, for fires, 147.
- Toothpicks, 248.
- Toys, 248.
- Traction engines, 240.
- Trails, 146.
- Trametes pini, 122, 263.
- Transplants, 72.
- Transpiration, 3.
- Tulip tree, 63, 346, 351, 361.
- Two-storied forests, 16, 309, 349.
- Types, definition, 7, 8.
- birch and poplar, 205, 211, 228, 269, 272, 283.
 - hardwood, 205, 207, 223, 269, 277.
 - hemlock, 299, 300, 314, 346, 348, 359.
 - how to identify, 199.
 - mixed hardwoods, 299, 311, 324, 346, 356, 467, 468, 469, 470, 471.
 - mixed hardwoods swamp, 346, 350, 360.
 - old field, 205, 215, 226, 269, 273, 274, 284, 285, 312, 325, 346, 351, 361.
 - permanent and temporary, 9.
 - pine and inferior hardwoods, 29, 308, 323.
 - pitch pine, 299, 301, 316.

- Types, pure white pine, 299, 303, 318, 346, 351, 361.
 - soft maple swamp, 299, 312, 325.
 - spruce flat, 205, 206, 220.
 - spruce slope, 205, 209, 217.
 - swamp, 205, 222, 269, 272, 283.
 - waste land, 299, 312, 325.
 - white cedar swamp, 299, 301, 316, 346, 351, 361.
- Uneven-aged forests, 14, 181, 202.
- University of Maine, 402.
- Valuation survey, 162.
- Vermont, 391.
- Vermont log rule, 432.
- Vermont University grants, 190.
- Volume tables, 158, 438.
- Von Schrenk, 122.
- Wagons for fires, 150.
- Washington, Mt., elevation of, 200.
- Waste, avoiding waste in woods, 232, 405.
- Water, relation of, to forests, 2.
- Waterflow, influence of forests on, 145.
- Watershed protection, 263, 295, 341, 372.
- Weeks Law, 140, 376, 380, 385, 393, 397.
- Weevil, white pine, 101, 340.
- West Indies, 184, 187, 189.
- White Mountains, 200, 207, 209, 217, 250, 253, 263, 375.
- White pine region, 197, 198, 296, 418.
- Whitewood, *see* Tulip tree.
- Winthrop, Governor of Connecticut, 186.
- Woodchucks, damage by, 188.
- Workwood per cent, 413.
- Württemberg, 178.
- Yale Forest School, 380.
- Yarding, 239.
- Yield from New England forests, 408.
- Yield tables, 180, 304, 321, 466.

SHORT-TITLE CATALOGUE

OF THE

PUBLICATIONS

OF

JOHN WILEY & SONS

NEW YORK

LONDON: CHAPMAN & HALL, LIMITED

ARRANGED UNDER SUBJECTS

Descriptive circulars sent on application. Books marked with an asterisk (*) are sold at *net* prices only. All books are bound in cloth unless otherwise stated.

AGRICULTURE—HORTICULTURE—FORESTRY.

Armsby's Principles of Animal Nutrition.....	8vo,	\$4 00
* Bowman's Forest Physiography.....	8vo,	5 00
Budd and Hansen's American Horticultural Manual:		
Part I. Propagation, Culture, and Improvement.....	12mo,	1 50
Part II. Systematic Pomology.....	12mo,	1 50
Elliott's Engineering for Land Drainage.....	12mo,	2 00
Practical Farm Drainage. (Second Edition, Rewritten.).....	12mo,	1 50
Fuller's Water Supplies for the Farm. (In Press.)		
Graves's Forest Mensuration.....	8vo,	4 00
* Principles of Handling Woodlands.....	Large 12mo,	1 50
Green's Principles of American Forestry.....	12mo,	1 50
Grotenfelt's Principles of Modern Dairy Practice. (Woll.).....	12mo,	2 00
* Hawley and Hawes's Forestry in New England.....	8vo,	3 50
* Herrick's Denatured or Industrial Alcohol.....	8vo,	4 00
* Kemp and Waugh's Landscape Gardening. (New Edition, Rewritten.)	12mo,	1 50
* McKay and Larsen's Principles and Practice of Butter-making.....	8vo,	1 50
Maynard's Landscape Gardening as Applied to Home Decoration.....	12mo,	1 50
Record's Identification of the Economic Woods of the United States. (In Press.)		
Sanderson's Insects Injurious to Staple Crops.....	12mo,	1 50
* Insect Pests of Farm, Garden, and Orchard.....	Large 12mo,	3 00
* Schwarz's Longleaf Pine in Virgin Forest.....	12mo,	1 25
* Solotaroff's Field Book for Street-tree Mapping.....	12mo,	0 75
In lots of one dozen.....		8 00
* Shade Trees in Towns and Cities.....	8vo,	3 00
Stockbridge's Rocks and Soils.....	8vo,	2 50
Winton's Microscopy of Vegetable Foods.....	8vo,	7 50
Woll's Handbook for Farmers and Dairymen.....	16mo,	1 50

ARCHITECTURE.

* Atkinson's Orientation of Buildings or Planning for Sunlight.....	8vo,	2 00
Baldwin's Steam Heating for Buildings.....	12mo,	2 50
Berg's Buildings and Structures of American Railroads.....	4to,	5 00

Birkmire's Architectural Iron and Steel.....	8vo.	\$3 50
Compound Riveted Girders as Applied in Buildings.....	8vo.	2 00
Planning and Construction of High Office Buildings.....	8vo.	3 50
Skeleton Construction in Buildings.....	8vo	3 00
Briggs's Modern American School Buildings.....	8vo.	4 00
Byrne's Inspection of Materials and Workmanship Employed in Construction.....	16mo.	3 00
Carpenter's Heating and Ventilating of Buildings.....	8vo.	4 00
* Corthell's Allowable Pressure on Deep Foundations.....	12mo.	1 25
* Eckel's Building Stones and Clays.....	8vo.	3 00
Freitag's Architectural Engineering.....	8vo.	3 50
Fire Prevention and Fire Protection. (In Press.).....		
Fireproofing of Steel Buildings.....	8vo.	2 50
Gerhard's Guide to Sanitary Inspections. (Fourth Edition, Entirely Revised and Enlarged.).....	12mo.	1 50
* Modern Baths and Bath Houses.....	8vo.	3 00
Sanitation of Public Buildings.....	12mo.	1 50
Theatre Fires and Panics.....	12mo.	1 50
* The Water Supply, Sewerage and Plumbing of Modern City Buildings.....	8vo.	4 00
Johnson's Statics by Algebraic and Graphic Methods.....	8vo	2 00
Kellaway's How to Lay Out Suburban Home Grounds.....	8vo.	2 00
Kidder's Architects' and Builders' Pocket-book.....	16mo, mor.	5 00
Merrill's Stones for Building and Decoration.....	8vo.	5 00
Monckton's Stair-building.....	4to.	4 00
Patton's Practical Treatise on Foundations.....	8vo.	5 00
Peabody's Naval Architecture.....	8vc.	7 50
Rice's Concrete-block Manufacture.....	8vo.	2 00
Richey's Handbook for Superintendents of Construction.....	16mo, mor.	4 00
Building Foreman's Pocket Book and Ready Reference.....	16mo, mor.	5 00
* Building Mechanics' Ready Reference Series:		
* Carpenters' and Woodworkers' Edition.....	16mo, mor.	1 50
* Cement Workers' and Plasterers' Edition.....	16mo, mor.	1 50
* Plumbers', Steam-Fitters', and Tinners' Edition.....	16mo, mor.	1 50
* Stone- and Brick-masons' Edition.....	16mo, mor.	1 50
Sabin's House Painting.....	12mo.	1 00
Siebert and Biggin's Modern Stone-cutting and Masonry.....	8vo.	1 50
Snow's Principal Species of Wood.....	8vo.	3 50
Wait's Engineering and Architectural Jurisprudence.....	8vo.	6 00
	Sheep	6 50
Law of Contracts.....	8vo.	3 00
Law of Operations Preliminary to Construction in Engineering and Architecture.....	8vo.	5 00
	Sheep.	5 50
Wilson's Air Conditioning.....	12mo.	1 50
Worcester and Atkinson's Small Hospitals, Establishment and Maintenance, Suggestions for Hospital Architecture, with Plans for a Small Hospital.....	12mo.	1 25

ARMY AND NAVY.

Bernadou's Smokeless Powder, Nitro-cellulose, and the Theory of the Cellulose Molecule.....	12mo.	2 50
Chase's Art of Pattern Making.....	12mo.	2 50
Screw Propellers and Marine Propulsion.....	8vo.	3 00
* Cloke's Enlisted Specialists' Examiner.....	8vo.	2 00
* Gunner's Examiner.....	8vo.	1 50
Craig's Azimuth.....	4to.	3 50
Crehore and Squier's Polarizing Photo-chronograph.....	8vo.	3 00
* Davis's Elements of Law.....	8vo.	2 50
* Treatise on the Military Law of United States.....	8vo.	7 00
* Dudley's Military Law and the Procedure of Courts-martial.....	Large 12mo.	2 50
Durand's Resistance and Propulsion of Ships.....	8vo.	5 00
* Dyer's Handbook of Light Artillery.....	12mo.	3 00

Bissler's Modern High Explosives.....	8vo	\$4 00
* Fieberger's Text-book on Field Fortification.....	Large 12mo,	2 00
Hamilton and Bond's The Gunner's Catechism.....	18mo,	1 00
* Hoff's Elementary Naval Tactics.....	8vo,	1 50
Ingalls's Handbook of Problems in Direct Fire.....	8vo,	4 00
* Interior Ballistics.....	8vo,	3 00
* Lissak's Ordnance and Gunnery.....	8vo,	6 00
* Ludlow's Logarithmic and Trigonometric Tables.....	8vo,	1 00
* Lyons's Treatise on Electromagnetic Phenomena. Vols. I. and II.....	8vo, each,	6 00
* Mahan's Permanent Fortifications. (Mercur.).....	8vo, half mor.	7 50
Manual for Courts-martial.....	16mo, mor.	1 50
* Mercur's Attack of Fortified Places.....	12mo,	2 00
* Elements of the Art of War.....	8vo,	4 00
Nixon's Adjutants' Manual.....	24mo,	1 00
Peabody's Naval Architecture.....	8vo,	7 50
* Phelps's Practical Marine Surveying.....	8vo,	2 50
Putnam's Nautical Charts.....	8vo,	2 00
Rust's Ex-meridian Altitude, Azimuth and Star-Finding Tables.....	8vo,	5 00
* Selkirk's Catechism of Manual of Guard Duty.....	24mo,	0 50
Sharpe's Art of Subsisting Armies in War.....	18mo, mor.	1 50
* Taylor's Speed and Power of Ships. 2 vols. Text 8vo, plates oblong 4to,		7 50
* Tupes and Poole's Manual of Bayonet Exercises and Musketry Fencing.	24mo, leather,	0 50
* Weaver's Military Explosives.....	8vo,	3 00
* Woodhull's Military Hygiene for Officers of the Line.....	Large 12mo,	1 50

ASSAYING.

Betts's Lead Refining by Electrolysis.....	8vo,	4 00
* Butler's Handbook of Blowpipe Analysis.....	16mo,	0 75
Fletcher's Practical Instructions in Quantitative Assaying with the Blowpipe.	16mo, mor.	1 50
Furman and Pardoe's Manual of Practical Assaying.....	8vo,	3 00
Lodge's Notes on Assaying and Metallurgical Laboratory Experiments.....	8vo,	3 00
Low's Technical Methods of Ore Analysis.....	8vo,	3 00
Miller's Cyanide Process.....	12mo,	1 00
Manual of Assaying.....	12mo,	1 00
Minet's Production of Aluminum and its Industrial Use. (Waldo.).....	12mo,	2 50
Ricketts and Miller's Notes on Assaying.....	8vo,	3 00
Robine and Lenglen's Cyanide Industry. (Le Clerc.).....	8vo,	4 00
* Seamon's Manual for Assayers and Chemists.....	Large 12mo,	2 50
Ulke's Modern Electrolytic Copper Refining.....	8vo,	3 00
Wilson's Chlorination Process.....	12mo,	1 50
Cyanide Processes.....	12mo,	1 50

ASTRONOMY.

Comstock's Field Astronomy for Engineers.....	8vo,	2 50
Craig's Azimuth.....	4to,	3 50
Crandall's Text-book on Geodesy and Least Squares.....	8vo,	3 00
Doolittle's Treatise on Practical Astronomy.....	8vo,	4 00
Hayford's Text-book of Geodetic Astronomy.....	8vo,	3 00
Hosmer's Azimuth.....	16mo, mor.	1 00
* Text-book on Practical Astronomy.....	8vo,	2 00
Merriman's Elements of Precise Surveying and Geodesy.....	8vo,	2 50
* Michie and Harlow's Practical Astronomy.....	8vo,	3 00
Rust's Ex-meridian Altitude, Azimuth and Star-Finding Tables.....	8vo,	5 00
* White's Elements of Theoretical and Descriptive Astronomy.....	12mo,	2 00

CHEMISTRY.

* Abderhalden's Physiological Chemistry in Thirty Lectures. (Hial and Defren.).....	8vo,	5 00
* Abegg's Theory of Electrolytic Dissociation. (von Ende.).....	12mo,	1 25
Alexeyeff's General Principles of Organic Syntheses. (Matthews.).....	8vo,	3 00
Allen's Tables for Iron Analysis.....	8vo,	3 00

Armsby's Principles of Animal Nutrition.....	8vo,	\$4 00
Arnold's Compendium of Chemistry. (Mandel.).....	Large 12mo,	3 50
Association of State and National Food and Dairy Departments, Hartford Meeting, 1906.....	8vo,	3 00
Jamestown Meeting, 1907.....	8vo,	3 00
Austen's Notes for Chemical Students.....	12mo,	1 50
Bernadou's Smokeless Powder.—Nitro-cellulose, and Theory of the Cellulose Molecule.....	12mo,	2 50
* Biltz's Introduction to Inorganic Chemistry. (Hall and Phelan.).....	12mo,	1 25
Laboratory Methods of Inorganic Chemistry. (Hall and Blanchard.).....	8vo,	3 00
* Bingham and White's Laboratory Manual of Inorganic Chemistry.....	12mo,	1 00
* Blanchard's Synthetic Inorganic Chemistry.....	12mo,	1 00
* Bottler's German and American Varnish Making. (Sabin.).....	Large 12mo,	3 50
Browne's Handbook of Sugar Analysis. (In Press.).....		
* Browning's Introduction to the Rarer Elements.....	8vo,	1 50
* Butler's Handbook of Blowpipe Analysis.....	16mo,	0 75
* Claassen's Beet-sugar Manufacture. (Hall and Rolfe.).....	8vo,	3 00
Classen's Quantitative Chemical Analysis by Electrolysis. (Boltwood.).....	8vo,	3 00
Cohn's Indicators and Test-papers.....	12mo,	2 00
Tests and Reagents.....	8vo,	3 00
Cohnheim's Functions of Enzymes and Ferments. (In Press.).....		
* Danneel's Electrochemistry. (Merriam.).....	12mo,	1 25
Dannerth's Methods of Textile Chemistry.....	12mo,	2 00
Duhem's Thermodynamics and Chemistry. (Burgess.).....	8vo,	4 00
Effront's Enzymes and their Applications. (Prescott.).....	8vo,	3 00
Eissler's Modern High Explosives.....	8vo,	4 00
* Ekeley's Laboratory Manual of Inorganic Chemistry.....	12mo,	1 00
* Fischer's Oedema.....	8vo,	2 00
* Physiology of Alimentation.....	Large 12mo,	2 00
Fletcher's Practical Instructions in Quantitative Assaying with the Blowpipe.....	16mo, mor,	1 50
Fowler's Sewage Works Analyses.....	12mo,	2 00
Fresenius's Manual of Qualitative Chemical Analysis. (Wells.).....	8vo,	5 00
Manual of Qualitative Chemical Analysis. Part I. Descriptive. (Wells.).....	8vo,	3 00
Quantitative Chemical Analysis. (Cohn.) 2 vols.....	8vo,	12 50
When Sold Separately, Vol. I, \$6. Vol. II, \$8.		
Fuertes's Water and Public Health.....	12mo,	1 50
Furman and Pardoe's Manual of Practical Assaying.....	8vo,	3 00
* Getman's Exercises in Physical Chemistry.....	12mo,	2 00
Gill's Gas and Fuel Analysis for Engineers.....	12mo,	1 25
Gooch's Summary of Methods in Chemical Analysis. (In Press.).....		
* Gooch and Browning's Outlines of Qualitative Chemical Analysis.....	Large 12mo,	1 25
Grotenfelt's Principles of Modern Dairy Practice. (Woll.).....	12mo,	2 00
Groth's Introduction to Chemical Crystallography (Marshall).....	12mo,	1 25
* Hammarsten's Text-book of Physiological Chemistry. (Mandel.).....	8vo,	4 00
Hanausek's Microscopy of Technical Products. (Winton.).....	8vo,	5 00
* Haskins and Macleod's Organic Chemistry.....	12mo,	2 00
* Herrick's Denatured or Industrial Alcohol.....	8vo,	4 00
Hinds's Inorganic Chemistry.....	8vo,	3 00
* Laboratory Manual for Students.....	12mo,	1 00
* Holleman's Laboratory Manual of Organic Chemistry for Beginners. (Walker.).....	12mo,	1 00
Text-book of Inorganic Chemistry. (Cooper.).....	8vo,	2 50
Text-book of Organic Chemistry. (Walker and Mott.).....	8vo,	2 50
* (Ekeley) Laboratory Manual to Accompany Holleman's Text-book of Inorganic Chemistry.....	12mo,	1 00
Holley's Analysis of Paint and Varnish Products. (In Press.).....		
* Lead and Zinc Pigments.....	Large 12mo,	3 00
Hopkins's Oil-chemists' Handbook.....	8vo,	3 00
Jackson's Directions for Laboratory Work in Physiological Chemistry.....	8vo,	1 25
Johnson's Rapid Methods for the Chemical Analysis of Special Steels, Steel-making Alloys and Graphite.....	Large 12mo,	3 00
Landauer's Spectrum Analysis. (Tingle.).....	8vo,	3 00
Lassar-Cohn's Application of Some General Reactions to Investigations in Organic Chemistry. (Tingle.).....	12mo,	1 00

Leach's Inspection and Analysis of Food with Special Reference to State Control.....	8vo,	\$7 50
Löb's Electrochemistry of Organic Compounds. (Lorenz.).....	8vo,	3 00
Lodge's Notes on Assaying and Metallurgical Laboratory Experiments.....	8vo,	3 00
Low's Technical Method of Ore Analysis.....	8vo,	3 00
Lowe's Paint for Steel Structures.....	12mo,	1 00
Lunge's Techno-chemical Analysis. (Cohn.).....	12mo,	1 00
* McKay and Larsen's Principles and Practice of Butter-making.....	8vo,	1 50
Maire's Modern Pigments and their Vehicles.....	12mo,	2 00
Mandel's Handbook for Bio-chemical Laboratory.....	12mo,	1 50
* Martin's Laboratory Guide to Qualitative Analysis with the Blowpipe.....	12mo,	0 60
Mason's Examination of Water. (Chemical and Bacteriological.).....	12mo,	1 25
Water-supply. (Considered Principally from a Sanitary Standpoint.).....	8vo,	4 00
* Mathewson's First Principles of Chemical Theory.....	8vo,	1 00
Matthews's Laboratory Manual of Dyeing and Textile Chemistry.....	8vo,	3 50
Textile Fibres. 2d Edition, Rewritten.....	8vo,	4 00
* Meyer's Determination of Radicles in Carbon Compounds. (Tingle.).....	12mo,	1 25
Third Edition.....	12mo,	1 00
Miller's Cyanide Process.....	12mo,	1 00
Manual of Assaying.....	12mo,	1 00
Miner's Production of Aluminum and its Industrial Use. (Waldo.).....	12mo,	2 50
* Mittelstaedt's Technical Calculations for Sugar Works. (Bourbakis.).....	12mo,	1 50
Mixer's Elementary Text-book of Chemistry.....	12mo,	1 50
Morgan's Elements of Physical Chemistry.....	12mo,	3 00
* Physical Chemistry for Electrical Engineers.....	12mo,	1 50
* Moore's Experiments in Organic Chemistry.....	12mo,	0 50
* Outlines of Organic Chemistry.....	12mo,	1 50
Morse's Calculations used in Cane-sugar Factories.....	16mo, mor,	1 50
* Muir's History of Chemical Theories and Laws.....	8vo,	4 00
Mulliken's General Method for the Identification of Pure Organic Compounds.....		
Vol. I. Compounds of Carbon with Hydrogen and Oxygen. Large 8vo,		5 00
Vol. II. Nitrogenous Compounds. (In Preparation.).....		
Vol. III. The Commercial Dyestuffs.....	Large 8vo,	5 00
* Nelson's Analysis of Drugs and Medicines.....	12mo,	5 00
Ostwald's Conversations on Chemistry. Part One. (Ramsey.).....	12mo,	1 50
Part Two. (Turnbull.).....	12mo,	2 00
* Introduction to Chemistry. (Hall and Williams.).....	Large 12mo,	1 50
Owen and Standage's Dyeing and Cleaning of Textile Fabrics.....	12mo,	2 00
* Palmer's Practical Test Book of Chemistry.....	12mo,	1 00
* Pauli's Physical Chemistry in the Service of Medicine. (Fischer.).....	12mo,	1 25
Penfield's Tables of Minerals, Including the Use of Minerals and Statistics of Domestic Production.....	8vo,	1 00
Pictet's Alkaloids and their Chemical Constitution. (Biddle.).....	8vo,	5 00
Poole's Calorific Power of Fuels.....	8vo,	3 00
Prescott and Winslow's Elements of Water Bacteriology, with Special Reference to Sanitary Water Analysis.....	12mo,	1 50
* Reisig's Guide to Piece-Dyeing.....	8vo,	25 00
Richards and Woodman's Air, Water, and Food from a Sanitary Standpoint.....	8vo,	2 00
Ricketts and Miller's Notes on Assaying.....	8vo,	3 00
Rideal's Disinfection and the Preservation of Food.....	8vo,	4 00
Riggs's Elementary Manual for the Chemical Laboratory.....	8vo,	1 25
Robine and Lenglen's Cyanide Industry. (Le Clerc.).....	8vo,	4 00
Ruddiman's Incompatibilities in Prescriptions.....	8vo,	2 00
Whys in Pharmacy.....	12mo,	1 00
* Ruer's Elements of Metallography. (Mathewson.).....	8vo,	3 00
Sabin's Industrial and Artistic Technology of Paint and Varnish.....	8vo,	3 00
Salkowski's Physiological and Pathological Chemistry. (Orndorff.).....	8vo,	2 50
* Schimpf's Essentials of Volumetric Analysis.....	Large 12mo,	1 50
Manual of Volumetric Analysis. (Fifth Edition, Rewritten).....	8vo,	5 00
* Qualitative Chemical Analysis.....	8vo,	1 25
* Seamon's Manual for Assayers and Chemists.....	Large 12mo,	2 50
Smith's Lecture Notes on Chemistry for Dental Students.....	8vo,	2 50
Spencer's Handbook for Cane Sugar Manufacturers.....	16mo, mor,	3 00
Handbook for Chemists of Beet-sugar Houses.....	16mo, mor,	3 00

* Ogden and Cleveland's Practical Methods of Sewage Disposal for Residences, Hotels, and Institutions.....	8vo,	\$1 50
Parsons's Disposal of Municipal Refuse.....	8vo,	2 00
Patton's Treatise on Civil Engineering.....	8vo, half leather,	7 50
Reed's Topographical Drawing and Sketching.....	4to,	5 00
Riemer's Shaft-sinking under Difficult Conditions. (Corning and Peele.)	8vo,	3 00
Siebert and Biggin's Modern Stone-cutting and Masonry.....	8vo,	1 50
Smith's Manual of Topographical Drawing. (McMillan.).....	8vo,	2 50
Soper's Air and Ventilation of Subways.....	12mo,	2 50
* Tracy's Exercises in Surveying.....	12mo, mor.	1 00
Tracy's Plane Surveying.....	16mo, mor.	3 00
Venable's Garbage Crematories in America.....	8vo,	2 00
Methods and Devices for Bacterial Treatment of Sewage.....	8vo,	3 00
Wait's Engineering and Architectural Jurisprudence.....	8vo,	6 00
	Sheep,	6 50
Law of Contracts.....	8vo,	3 00
Law of Operations Preliminary to Construction in Engineering and Architecture.....	8vo,	5 00
	Sheep,	5 50
Warren's Stereotomy—Problems in Stone-cutting.....	8vo,	2 50
* Waterbury's Vest-Pocket Hand-book of Mathematics for Engineers.	2½ × 5¾ inches, mor.	1 00
* Enlarged Edition, Including Tables.....	n. o.	1 50
Webb's Problems in the Use and Adjustment of Engineering Instruments.	16mo, mor.	1 25
Wilson's Topographic, Trigonometric and Geodetic Surveying.....	8vo,	3 50

BRIDGES AND ROOFS.

Boller's Practical Treatise on the Construction of Iron Highway Bridges.	8vo,	2 00
* Thames River Bridge.....	Oblong paper,	5 00
Burr and Falk's Design and Construction of Metallic Bridges.....	8vo,	5 00
Influence Lines for Bridge and Roof Computations.....	8vo,	3 00
Du Bois's Mechanics of Engineering. Vol. II.....	Small 4to,	10 00
Poster's Treatise on Wooden Trestle Bridges.....	4to,	5 00
Fowler's Ordinary Foundations.....	8vo,	3 50
Greene's Arches in Wood, Iron, and Stone.....	8vo,	2 50
Bridge Trusses.....	8vo,	2 50
Roof Trusses.....	8vo,	1 25
Grimm's Secondary Stresses in Bridge Trusses.....	8vo,	2 50
Heller's Stresses in Structures and the Accompanying Deformations.....	8vo,	3 00
Howe's Design of Simple Roof-trusses in Wood and Steel.....	8vo,	2 00
Symmetrical Masonry Arches.....	8vo,	2 50
Treatise on Arches.....	8vo,	4 00
* Hudson's Deflections and Statically Indeterminate Stresses....	Small 4to,	3 50
* Plate Girder Design.....	8vo,	1 50
* Jacoby's Structural Details, or Elements of Design in Heavy Framing,	8vo,	2 25
Johnson, Bryan and Turneure's Theory and Practice in the Designing of Modern Framed Structures.....	Small 4to,	10 00
* Johnson, Bryan and Turneure's Theory and Practice in the Designing of Modern Framed Structures. New Edition. Part I.....	8vo,	3 00
* Part II. New Edition.....	8vo,	4 00
Merriman and Jacoby's Text-book on Roofs and Bridges:		
Part I. Stresses in Simple Trusses.....	8vo,	2 50
Part II. Graphic Statics.....	8vo,	2 50
Part III. Bridge Design.....	8vo,	2 50
Part IV. Higher Structures.....	8vo,	2 50
Ricker's Design and Construction of Roofs. (In Press.)		
Sondericker's Graphic Statics, with Applications to Trusses, Beams, and Arches.....	8vo,	2 00
Waddell's De Pontibus, Pocket-book for Bridge Engineers.....	16mo, mor.	2 00
* Specifications for Steel Bridges.....	12mo,	50

HYDRAULICS.

Barnes's Ice Formation.....	8vo,	3 00
Bazin's Experiments upon the Contraction of the Liquid Vein Issuing from an Orifice. (Trautwine.).....	8vo,	2 00

Bovey's Treatise on Hydraulics.....	8vo,	\$5 00
Church's Diagrams of Mean Velocity of Water in Open Channels.		
	Oblong 4to, paper,	1 50
Hydraulic Motors	8vo,	2 00
Mechanics of Fluids (Being Part IV of Mechanics of Engineering)	8vo,	3 00
Coffin's Graphical Solution of Hydraulic Problems.....	16mo, mor.	2 50
Plather's Dynamometers, and the Measurement of Power.....	12mo,	3 00
Polwell's Water-supply Engineering.....	8vo,	4 00
Prizell's Water-power.....	8vo,	5 00
Puertes's Water and Public Health.....	12mo,	1 50
Water-filtration Works.....	12mo,	2 50
Ganguillet and Kutter's General Formula for the Uniform Flow of Water in Rivers and Other Channels. (Hering and Trautwine.).....	8vo,	4 00
Hazen's Clean Water and How to Get It.....	Large 12mo,	1 50
Filtration of Public Water-supplies.....	8vo,	3 00
Hazelhurst's Towers and Tanks for Water-works.....	8vo,	2 50
Herschel's 115 Experiments on the Carrying Capacity of Large, Riveted, Metal Conduits.....	8vo,	2 00
Hoyt and Grover's River Discharge.....	8vo,	2 00
Hubbard and Kiersted's Water-works Management and Maintenance.		
	8vo,	4 00
* Lyndon's Development and Electrical Distribution of Water Power.		
	8vo,	3 00
Mason's Water-supply. (Considered Principally from a Sanitary Stand-point.).....	8vo,	4 00
* Merriman's Treatise on Hydraulics. 9th Edition, Rewritten.....	8vo,	4 00
* Molitor's Hydraulics of Rivers, Weirs and Sluices.....	8vo,	2 00
* Morrison and Brodie's High Masonry Dam Design.....	8vo,	1 50
* Richards's Laboratory Notes on Industrial Water Analysis.....	8vo,	50
Schuyler's Reservoirs for Irrigation, Water-power, and Domestic Water-supply. Second Edition, Revised and Enlarged.....	Large 8vo,	6 00
* Thomas and Watt's Improvement of Rivers.....	4to,	6 00
Turneure and Russell's Public Water-supplies.....	8vo,	5 00
* Wegmann's Design and Construction of Dams. 6th Ed., enlarged.....	4to,	6 00
Water-Supply of the City of New York from 1658 to 1895.....	4to,	10 00
Whipple's Value of Pure Water.....	Large 12mo,	1 00
Williams and Hazen's Hydraulic Tables.....	8vo,	1 50
Wilson's Irrigation Engineering.....	8vo,	4 00
Wood's Turbines.....	8vo,	2 50

MATERIALS OF ENGINEERING.

Baker's Roads and Pavements.....	8vo,	5 00
Treatise on Masonry Construction.....	8vo,	5 00
Black's United States Public Works.....	Oblong 4to,	5 00
* Blanchard and Drown's Highway Engineering, as Presented at the Second International Road Congress, Brussels, 1910.....	8vo,	2 00
Bleining's Manufacture of Hydraulic Cement. (In Preparation.)		
* Bottler's German and American Varnish Making. (Sabin.)	Large 12mo,	3 50
Burr's Elasticity and Resistance of the Materials of Engineering.....	8vo,	7 50
Byrne's Highway Construction.....	8vo,	5 00
Inspection of the Materials and Workmanship Employed in Construction.		
	16mo,	3 00
Church's Mechanics of Engineering.....	8vo,	6 00
Mechanics of Solids (Being Parts I, II, III of Mechanics of Engineering).....	8vo,	4 50
Du Bois's Mechanics of Engineering.		
Vol. I. Kinematics, Statics. Kinetics.....	Small 4to,	7 50
Vol. II. The Stresses in Framed Structures, Strength of Materials and Theory of Flexures.....	Small 4to,	10 00
* Eckel's Building Stones and Clays.....	8vo,	3 00
* Cements, Limes, and Plasters.....	8vo,	6 00
Fowler's Ordinary Foundations.....	8vo,	3 50
* Greene's Structural Mechanics.....	8vo,	2 50
Holley's Analysis of Paint and Varnish Products. (In Press.)		
* Lead and Zinc Pigments.....	Large 12mo,	3 00

* Hubbard's Dust Preventives and Road Binders.....	8vo,	\$3 00
Johnson's (C. M.) Rapid Methods for the Chemical Analysis of Special Steels, Steel-making Alloys and Graphite.....	Large 12mo,	3 00
Johnson's (J. B.) Materials of Construction.....	Large 8vo,	6 00
Keep's Cast Iron.....	8vo,	2 50
Lanza's Applied Mechanics.....	8vo,	7 50
Lowe's Paints for Steel Structures.....	12mo,	1 00
Maire's Modern Pigments and their Vehicles.....	12mo,	2 00
* Martin's Text Book on Mechanics. Vol. I. Statics.....	12mo,	1 25
* Vol. II. Kinematics and Kinetics.....	12mo,	1 50
* Vol. III. Mechanics of Materials.....	12mo,	1 50
Maurer's Technical Mechanics.....	8vo,	4 00
Merrill's Stones for Building and Decoration.....	8vo,	5 00
Merriman's Mechanics of Materials.....	8vo,	5 00
* Strength of Materials.....	12mo,	1 00
Metcalf's Steel. A Manual for Steel-users.....	12mo,	2 00
Morrison's Highway Engineering.....	8vo,	2 50
* Murdock's Strength of Materials.....	12mo,	2 50
Patton's Practical Treatise on Foundations.....	8vo,	5 00
Rice's Concrete Block Manufacture.....	8vo,	2 00
Richardson's Modern Asphalt Pavement.....	8vo,	3 00
Richey's Building Foreman's Pocket Book and Ready Reference.....	16mo, mor.	5 00
* Cement Workers' and Plasterers' Edition (Building Mechanics' Ready Reference Series).....	16mo, mor.	1 50
Handbook for Superintendents of Construction.....	16mo, mor.	4 00
* Stone and Brick Masons' Edition (Building Mechanics' Ready Reference Series).....	16mo, mor.	1 50
* Ries's Clays: Their Occurrence, Properties, and Uses.....	8vo,	5 00
* Ries and Leighton's History of the Clay-working Industry of the United States.....	8vo,	2 50
Sabin's Industrial and Artistic Technology of Paint and Varnish.....	8vo,	3 00
* Smith's Strength of Material.....	12mo,	1 25
Snow's Principal Species of Wood.....	8vo,	3 50
Spalding's Hydraulic Cement.....	12mo,	2 00
Text-book on Roads and Pavements.....	12mo,	2 00
* Taylor and Thompson's Concrete Costs.....	Small 8vo,	5 00
* Extracts on Reinforced Concrete Design.....	8vo,	2 00
Treatise on Concrete, Plain and Reinforced.....	8vo,	5 00
Thurston's Materials of Engineering. In Three Parts.....	8vo,	8 00
Part I. Non-metallic Materials of Engineering and Metallurgy.....	8vo,	2 00
Part II. Iron and Steel.....	8vo,	3 50
Part III. A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.....	8vo,	2 50
Tillson's Street Pavements and Paving Materials.....	8vo,	4 00
Turneure and Maurer's Principles of Reinforced Concrete Construction. Second Edition, Revised and Enlarged.....	8vo,	3 50
Waterbury's Cement Laboratory Manual.....	12mo,	1 00
* Laboratory Manual for Testing Materials of Construction.....	12mo,	1 50
Wood's (De V.) Treatise on the Resistance of Materials, and an Appendix on the Preservation of Timber.....	8vo,	2 00
Wood's (M. P.) Rustless Coatings: Corrosion and Electrolysis of Iron and Steel.....	8vo,	4 00

RAILWAY ENGINEERING.

Andrews's Handbook for Street Railway Engineers.....	3×5 inches, mor.	1 25
Berg's Buildings and Structures of American Railroads.....	4to,	5 00
Brooks's Handbook of Street Railroad Location.....	16mo, mor.	1 50
* Burt's Railway Station Service.....	12mo,	2 00
Butts's Civil Engineer's Field-book.....	16mo, mor.	2 50
Crandall's Railway and Other Earthwork Tables.....	8vo,	1 50
Crandall and Barnes's Railroad Surveying.....	16mo, mor.	2 00
* Crockett's Methods for Earthwork Computations.....	8vo,	1 50
Dredge's History of the Pennsylvania Railroad. (1879).....	Paper,	5 00
Fisher's Table of Cubic Yards.....	Cardboard,	25
* Gilbert Wightman and Saunders's Subways and Tunnels of New York.....	8vo,	4 00
Godwin's Railroad Engineers' Field-book and Explorers' Guide.....	16mo, mor.	2 50

Hudson's Tables for Calculating the Cubic Contents of Excavations and Embankments.....	8vo,	\$1 00
Ives and Hilt's Problems in Surveying, Railroad Surveying and Geodesy.....	16mo, mor.	1 50
Molitor and Beard's Manual for Resident Engineers.....	16mo,	1 00
Nagle's Field Manual for Railroad Engineers.....	16mo, mor.	3 00
* Orrock's Railroad Structures and Estimates.....	8vo,	3 00
Philbrick's Field Manual for Engineers.....	16mo, mor.	3 00
Raymond's Railroad Field Geometry.....	16mo, mor.	2 00
Elements of Railroad Engineering.....	8vo,	3 50
Railroad Engineer's Field Book. (In Preparation.)		
Roberts' Track Formule and Tables.....	16mo, mor.	3 00
Searles's Field Engineering.....	16mo, mor.	3 00
Railroad Spiral.....	16mo, mor.	1 50
Taylor's Prismoidal Formulæ and Earthwork.....	8vo,	1 50
Webb's Economics of Railroad Construction.....	Large 12mo,	2 50
Railroad Construction.....	16mo, mor.	5 00
Wellington's Economic Theory of the Location of Railways.....	Large 12mo,	5 00
Wilson's Elements of Railroad-Track and Construction.....	12mo,	2 00

DRAWING.

Barr and Wood's Kinematics of Machinery.....	8vo,	2 50
* Bartlett's Mechanical Drawing.....	8vo,	3 00
Abridged Ed.....	8vo,	1 50
* Bartlett and Johnson's Engineering Descriptive Geometry.....	8vo,	1 50
Blessing and Darling's Descriptive Geometry. (In Press.)		
Elements of Drawing. (In Press.)		
Coolidge's Manual of Drawing.....	8vo, paper,	1 00
Coolidge and Freeman's Elements of General Drafting for Mechanical Engineers.....	Oblong 4to,	2 50
Durley's Kinematics of Machines.....	8vo,	4 00
Emch's Introduction to Projective Geometry and its Application.....	8vo,	2 50
Hill's Text-book on Shades and Shadows, and Perspective.....	8vo,	2 00
Jamison's Advanced Mechanical Drawing.....	8vo,	2 00
Elements of Mechanical Drawing.....	8vo,	2 50
Jones's Machine Design:		
Part I. Kinematics of Machinery.....	8vo,	1 50
Part II. Form, Strength, and Proportions of Parts.....	8vo,	3 00
* Kimball and Barr's Machine Design.....	8vo,	3 00
MacCord's Elements of Descriptive Geometry.....	8vo,	3 00
Kinematics; or, Practical Mechanism.....	8vo,	5 00
Mechanical Drawing.....	4to,	4 00
Velocity Diagrams.....	8vo,	1 50
McLeod's Descriptive Geometry.....	Large 12mo,	1 50
* Mahan's Descriptive Geometry and Stone-cutting.....	8vo,	1 50
Industrial Drawing. (Thompson.).....	8vo,	3 50
Moyer's Descriptive Geometry.....	8vo,	2 00
Reed's Topographical Drawing and Sketching.....	4to,	5 00
* Reid's Mechanical Drawing. (Elementary and Advanced.).....	8vo,	2 00
Text-book of Mechanical Drawing and Elementary Machine Design.....	8vo,	3 00
Robinson's Principles of Mechanism.....	8vo,	3 00
Schwamb and Merrill's Elements of Mechanism.....	8vo,	3 00
Smith (A. W.) and Marx's Machine Design.....	8vo,	3 00
Smith's (R. S.) Manual of Topographical Drawing. (McMillan.).....	8vo,	2 50
* Titsworth's Elements of Mechanical Drawing.....	Oblong 8vo,	1 25
Tracy and North's Descriptive Geometry. (In Press.)		
Warren's Elements of Descriptive Geometry, Shadows, and Perspective.....	8vo,	3 50
Elements of Machine Construction and Drawing.....	8vo,	7 50
Elements of Plane and Solid Free-hand Geometrical Drawing.....	12mo,	1 00
General Problems of Shades and Shadows.....	8vo,	3 00
Manual of Elementary Problems in the Linear Perspective of Forms and Shadow.....	12mo,	1 00
Manual of Elementary Projection Drawing.....	12mo,	1 50
Plane Problems in Elementary Geometry.....	12mo,	1 25
Weisbach's Kinematics and Power of Transmission. (Hermann and Klein.).....	8vo,	5 00
Wilson's (H. M.) Topographic Surveying.....	8vo,	3 50

* Wilson's (V. T.) Descriptive Geometry.....	8vo,	\$1 50
Free-hand Lettering.....	8vo,	1 00
Free-hand Perspective.....	8vo,	2 50
Woolf's Elementary Course in Descriptive Geometry.....	Large 8vo,	3 00

ELECTRICITY AND PHYSICS.

* Abegg's Theory of Electrolytic Dissociation. (von Ende).....	12mo,	1 25
Andrews's Hand-book for Street Railway Engineers.....	3×5 inches mor.	1 25
Anthony and Ball's Lecture-notes on the Theory of Electrical Measure- ments.....	12mo,	1 00
Anthony and Brackett's Text-book of Physics. (Magie)....	Large 12mo,	3 00
Benjamin's History of Electricity.....	8vo,	3 00
Betts's Lead Refining and Electrolysis.....	8vo,	4 00
* Burgess and Le Chatelier's Measurement of High Temperatures. Third Edition.....	8vo,	4 00
Classen's Quantitative Chemical Analysis by Electrolysis. (Boltwood).....	8vo,	3 00
* Collins's Manual of Wireless Telegraphy and Telephony.....	12mo,	1 50
Crehore and Squier's Polarizing Photo-chronograph.....	8vo,	3 00
* Danneel's Electrochemistry. (Merriam).....	12mo,	1 25
Dawson's "Engineering" and Electric Traction Pocket-book....	16mo, mor.	5 00
Dolezalek's Theory of the Lead Accumulator (Storage Battery). (von Ende.)	12mo,	2 50
Duhem's Thermodynamics and Chemistry. (Burgess).....	8vo,	4 00
Flather's Dynamometers, and the Measurement of Power.....	12mo,	3 00
* Getman's Introduction to Physical Science.....	12mo,	1 50
Gilbert's De Magnete. (Mottelay).....	8vo,	2 50
* Hanchett's Alternating Currents.....	12mo,	1 00
Hering's Ready Reference Tables (Conversion Factors).....	16mo, mor.	2 50
* Hobart and Ellis's High-speed Dynamo Electric Machinery.....	8vo,	6 00
Holman's Precision of Measurements.....	8vo,	2 00
Telescope-Mirror-scale Method, Adjustments, and Tests....	Large 8vo,	0 75
* Hutchinson's High-Efficiency Electrical Illuminants and Illumination.	Large 12mo,	2 50
* Jones's Electric Ignition.....	8vo,	4 00
Karapetoff's Experimental Electrical Engineering: * Vol. I.....	8vo,	3 50
* Vol. II.....	8vo,	2 50
Kinzbrunner's Testing of Continuous-current Machines.....	8vo,	2 00
* Koch's Mathematics of Applied Electricity.....	Small 8vo,	3 00
Landauer's Spectrum Analysis. (Tingle).....	8vo,	3 00
* Lauffer's Electrical Injuries.....	16mo,	0 50
Löb's Electrochemistry of Organic Compounds. (Lorenz).....	8vo,	3 00
* Lyndon's Development and Electrical Distribution of Water Power.....	8vo,	3 00
* Lyons's Treatise on Electromagnetic Phenomena. Vols. I. and II. 8vo, each,	8vo,	6 00
* Michie's Elements of Wave Motion Relating to Sound and Light.....	8vo,	4 00
* Morgan's Physical Chemistry for Electrical Engineers.....	12mo,	1 50
* Norris's Introduction to the Study of Electrical Engineering.....	8vo,	2 50
Norris and Dennison's Course of Problems on the Electrical Characteristics of Circuits and Machines. (In Press.)		
* Parshall and Hobart's Electric Machine Design.....	4to, half mor.	12 50
Reagan's Locomotives: Simple, Compound, and Electric. New Edition.	Large 12mo,	3 50
* Rosenberg's Electrical Engineering. (Haldane Gee—Kinzbrunner).....	8vo,	2 00
* Ryan's Design of Electrical Machinery: * Vol. I. Direct Current Dynamos.....	8vo,	1 50
Vol. II. Alternating Current Transformers.....	8vo,	1 50
Vol. III. Alternators, Synchronous Motors, and Rotary Converters. (In Preparation.)		
Ryan, Norris, and Hoxie's Text Book of Electrical Machinery.....	8vo,	2 50
Schapper's Laboratory Guide for Students in Physical Chemistry.....	12mo,	1 00
* Tillman's Elementary Lessons in Heat.....	8vo,	1 50
* Timbie's Elements of Electricity.....	Large 12mo,	2 00
* Answers to Problems in Elements of Electricity.....	12mo, Paper	0 25
Tory and Pitcher's Manual of Laboratory Physics.....	Large 12mo,	2 00
Ulke's Modern Electrolytic Copper Refining.....	8vo,	3 00
* Waters's Commercial Dynamo Design.....	8vo,	2 00

LAW.

* Brennan's Hand-book of Useful Legal Information for Business Men.	16mo, mor.	\$5 00
* Davis's Elements of Law.	8vo,	2 50
*Treatise on the Military Law of United States.	8vo,	7 00
* Dudley's Military Law and the Procedure of Courts-martial.	Large 12mo,	2 50
Manual for Courts-martial.	16mo, mor.	1 50
Wait's Engineering and Architectural Jurisprudence.	8vo,	6 00
	Sheep,	6 50
Law of Contracts.	8vo,	3 00
Law of Operations Preliminary to Construction in Engineering and Architecture.	8vo,	5 00
	Sheep,	5 50

MATHEMATICS.

Baker's Elliptic Functions.	8vo,	1 50
Briggs's Elements of Plane Analytic Geometry. (Böcher.)	12mo,	1 00
* Buchanan's Plane and Spherical Trigonometry.	8vo,	1 00
Byerly's Harmonic Functions.	8vo,	1 00
Chandler's Elements of the Infinitesimal Calculus.	12mo,	2 00
* Coffin's Vector Analysis.	12mo,	2 50
Compton's Manual of Logarithmic Computations.	12mo,	1 50
* Dickson's College Algebra.	Large 12mo,	1 50
* Introduction to the Theory of Algebraic Equations.	Large 12mo,	1 25
Emch's Introduction to Projective Geometry and its Application.	8vo,	2 50
Fiske's Functions of a Complex Variable.	8vo,	1 00
Halsted's Elementary Synthetic Geometry.	8vo,	1 50
Elements of Geometry.	8vo,	1 75
* Rational Geometry.	12mo,	1 50
Synthetic Projective Geometry.	8vo,	1 00
* Hancock's Lectures on the Theory of Elliptic Functions.	8vo,	5 00
Hyde's Grassmann's Space Analysis.	8vo,	1 00
* Johnson's (J. B.) Three-place Logarithmic Tables: Vest-pocket size, paper.		0 15
	* 100 copies,	5 00
	* Mounted on heavy cardboard, 8×10 inches,	0 25
	* 10 copies,	2 00
Johnson's (W. W.) Abridged Editions of Differential and Integral Calculus.		
	Large 12mo, 1 vol.	2 50
Curve Tracing in Cartesian Co-ordinates.	12mo,	1 00
Differential Equations.	8vo,	1 00
Elementary Treatise on Differential Calculus.	Large 12mo,	1 50
Elementary Treatise on the Integral Calculus.	Large 12mo,	1 50
* Theoretical Mechanics.	12mo,	3 00
Theory of Errors and the Method of Least Squares.	12mo,	1 50
Treatise on Differential Calculus.	Large 12mo,	3 00
Treatise on the Integral Calculus.	Large 12mo,	3 00
Treatise on Ordinary and Partial Differential Equations.	Large 12mo,	3 50
Karapetoff's Engineering Applications of Higher Mathematics:		
* Part I. Problems on Machine Design.	Large 12mo,	0 75
* Koch's Mathematics of Applied Electricity.	8vo,	3 00
Laplace's Philosophical Essay on Probabilities. (Truscott and Emory.)	12mo,	2 00
* Le Messurier's Key to Professor W. W. Johnson's Differential Equations.		
	Small 8vo,	1 75
* Ludlow's Logarithmic and Trigonometric Tables.	8vo,	1 00
* Ludlow and Bass's Elements of Trigonometry and Logarithmic and Other Tables.	8vo,	3 00
* Trigonometry and Tables published separately.	Each,	2 00
Macfarlane's Vector Analysis and Quaternions.	8vo,	1 00
McMahon's Hyperbolic Functions.	8vo,	1 00
Manning's Irrational Numbers and their Representation by Sequences and Series.	12mo,	1 25
* Martin's Text Book on Mechanics. Vol. I. Statics.	12mo,	1 25
* Vol. II. Kinematics and Kinetics.	12mo,	1 50
* Vol. III. Mechanics of Materials.	12mo,	1 50

Mathematical Monographs. Edited by Mansfield Merriman and Robert S. Woodward.			Octavo, each \$1 00
No. 1. History of Modern Mathematics, by David Eugene Smith.			
No. 2. Synthetic Projective Geometry, by George Bruce Halsted.			
No. 3. Determinants, by Laenas Gifford Weld.	No. 4. Hyperbolic Functions, by James McMahon.	No. 5. Harmonic Functions, by William E. Byerly.	No. 6. Grassmann's Space Analysis, by Edward W. Hyde.
No. 7. Probability and Theory of Errors, by Robert S. Woodward.	No. 8. Vector Analysis and Quaternions, by Alexander Macfarlane.	No. 9. Differential Equations, by William Woolsey Johnson.	No. 10. The Solution of Equations, by Mansfield Merriman.
No. 11. Functions of a Complex Variable, by Thomas S. Fiske.			
Maurer's Technical Mechanics.	8vo,	4 00	
Merriman's Method of Least Squares.	8vo,	2 00	
Solution of Equations.	8vo,	1 00	
* Moritz's Elements of Plane Trigonometry.	8vo,	2 00	
Rice and Johnson's Differential and Integral Calculus. 2 vols. in one.			
	Large 12mo,	1 50	
Elementary Treatise on the Differential Calculus.	Large 12mo,	3 00	
Smith's History of Modern Mathematics.	8vo,	1 00	
* Veblen and Lennes's Introduction to the Real Infinitesimal Analysis of One Variable.	8vo,	2 00	
* Waterbury's Vest Pocket Hand-book of Mathematics for Engineers			
	2 $\frac{3}{8}$ $\times$ 5 $\frac{1}{2}$ inches, mor.	1 00	
* Enlarged Edition, Including Tables	mor.	1 50	
Weld's Determinants.	8vo,	1 00	
Wood's Elements of Co-ordinate Geometry.	8vo,	2 00	
Woodward's Probability and Theory of Errors.	8vo,	1 00	

MECHANICAL ENGINEERING.

MATERIALS OF ENGINEERING, STEAM-ENGINES AND BOILERS.

Bacon's Forge Practice.	12mo,	1 50
Baldwin's Steam Heating for Buildings.	12mo,	2 50
Barr and Wood's Kinematics of Machinery.	8vo,	2 50
* Bartlett's Mechanical Drawing.	8vo,	3 00
* " " " Abridged Ed.	8vo,	1 50
* Bartlett and Johnson's Engineering Descriptive Geometry.	8vo,	1 50
* Burr's Ancient and Modern Engineering and the Isthmian Canal.	8vo,	3 50
Carpenter's Heating and Ventilating Buildings.	8vo,	4 00
* Carpenter and Diederichs's Experimental Engineering.	8vo,	6 00
* Clerk's The Gas, Petrol and Oil Engine.	8vo,	4 00
Compton's First Lessons in Metal Working.	12mo,	1 50
Compton and De Groodt's Speed Lathe.	12mo,	1 50
Coolidge's Manual of Drawing.	8vo, paper,	1 00
Coolidge and Freeman's Elements of General Drafting for Mechanical Engineers.	Oblong 4to,	2 50
Cromwell's Treatise on Belts and Pulleys.	12mo,	1 50
Treatise on Toothed Gearing.	12mo,	1 50
Dingey's Machinery Pattern Making.	12mo,	2 00
Durley's Kinematics of Machines.	8vo,	4 00
Flanders's Gear-cutting Machinery.	Large 12mo,	3 00
Plath's Dynamometers and the Measurement of Power.	12mo,	3 00
Rope Driving.	12mo,	2 00
Gill's Gas and Fuel Analysis for Engineers.	12mo,	1 25
Goss's Locomotive Sparks.	8vo,	2 00
* Greene's Pumping Machinery.	8vo,	4 00
Hering's Ready Reference Tables (Conversion Factors).	16mo, mor.	2 50
* Hobart and Ellis's High Speed Dynamo Electric Machinery.	8vo,	6 00
Hutton's Gas Engine.	8vo,	5 00
Jamison's Advanced Mechanical Drawing.	8vo,	2 00
Elements of Mechanical Drawing.	8vo,	2 50
Jones's Gas Engine.	8vo,	4 00
Machine Design:		
Part I. Kinematics of Machinery.	8vo,	1 50
Part II. Form, Strength, and Proportions of Parts.	8vo,	3 00

* Kaup's Machine Shop Practice.....	Large 12mo	\$1 25
* Kent's Mechanical Engineer's Pocket-Book.....	16mo, mor.	5 00
Kerr's Power and Power Transmission.....	8vo,	2 00
* Kimball and Barr's Machine Design.....	8vo,	3 00
* King's Elements of the Mechanics of Materials and of Power of Transmission.....	8vo,	2 50
* Lanza's Dynamics of Machinery.....	8vo,	2 50
Leonard's Machine Shop Tools and Methods.....	8vo,	4 00
* Levin's Gas Engine.....	8vo,	4 00
* Lorenz's Modern Refrigerating Machinery. (Pope, Haven, and Dean).....	8vo,	4 00
MacCord's Kinematics; or, Practical Mechanism.....	8vo,	5 00
Mechanical Drawing.....	4to,	4 00
Velocity Diagrams.....	8vo,	1 50
MacFarland's Standard Reduction Factors for Gases.....	8vo,	1 50
Mahan's Industrial Drawing. (Thompson.).....	8vo,	3 50
Mehrtens's Gas Engine Theory and Design.....	Large 12mo,	2 50
Miller, Berry, and Riley's Problems in Thermodynamics and Heat Engineering.....	8vo, paper,	0 75
Oberg's Handbook of Small Tools.....	Large 12mo,	2 50
* Parshall and Hobart's Electric Machine Design. Small 4to, half leather,		12 50
* Peele's Compressed Air Plant. Second Edition, Revised and Enlarged.	8vo,	3 50
* Perkins's Introduction to General Thermodynamics.....	12mo,	1 50
Poole's Calorific Power of Fuels.....	8vo,	3 00
* Porter's Engineering Reminiscences, 1855 to 1882.....	8vo,	3 00
Randall's Treatise on Heat. (In Press.)		
* Reid's Mechanical Drawing. (Elementary and Advanced.).....	8vo,	2 00
Text-book of Mechanical Drawing and Elementary Machine Design.....	8vo,	3 00
Richards's Compressed Air.....	12mo,	1 50
Robinson's Principles of Mechanism.....	8vo,	3 00
Schwamb and Merrill's Elements of Mechanism.....	8vo,	3 00
Smith (A. W.) and Marx's Machine Design.....	8vo,	3 00
Smith's (O.) Press-working of Metals.....	8vo,	3 00
Sorel's Carbureting and Combustion in Alcohol Engines. (Woodward and Preston.).....	Large 12mo,	3 00
Stone's Practical Testing of Gas and Gas Meters.....	8vo,	3 50
Thurston's Animal as a Machine and Prime Motor, and the Laws of Energetics.....	12mo,	1 00
Treatise on Friction and Lost Work in Machinery and Mill Work.....	8vo,	3 00
* Tillson's Complete Automobile Instructor.....	16mo,	1 50
* Tittsworth's Elements of Mechanical Drawing.....	Oblong 8vo,	1 25
Warren's Elements of Machine Construction and Drawing.....	8vo,	7 50
* Waterbury's Vest Pocket Hand-book of Mathematics for Engineers.....	2 $\frac{1}{8}$ × 5 $\frac{3}{8}$ inches, mor.	1 00
* Enlarged Edition, Including Tables.....		1 50
Weisbach's Kinematics and the Power of Transmission. (Herrmann—Klein.).....	8vo,	5 00
Machinery of Transmission and Governors. (Herrmann—Klein.).....	8vo,	5 00
Wood's Turbines.....	8vo,	2 50

MATERIALS OF ENGINEERING.

Burr's Elasticity and Resistance of the Materials of Engineering.....	8vo,	7 50
Church's Mechanics of Engineering.....	8vo,	6 00
Mechanics of Solids (Being Parts I, II, III of Mechanics of Engineering).....	8vo,	4 50
* Greene's Structural Mechanics.....	8vo,	2 50
Holley's Analysis of Paint and Varnish Products. (In Press.)		
* Lead and Zinc Pigments.....	Large 12mo,	3 00
Johnson's (C. M.) Rapid Methods for the Chemical Analysis of Special Steels, Steel-Making Alloys and Graphite.....	Large 12mo,	3 00
Johnson's (J. B.) Materials of Construction.....	8vo,	6 00
Keep's Cast Iron.....	8vo,	2 50
* King's Elements of the Mechanics of Materials and of Power of Transmission.....	8vo,	2 50
Lanza's Applied Mechanics.....	8vo,	7 50
Lowe's Paints for Steel Structures.....	12mo,	1 00
Maire's Modern Pigments and their Vehicles.....	12mo,	2 00

Maurer's Technical Mechanics.	8vo,	\$4 00
Merriman's Mechanics of Materials.	8vo,	5 00
* Strength of Materials.	12mo,	1 00
Metcalf's Steel. A Manual for Steel-users.	12mo,	2 00
* Murdock's Strength of Materials.	12mo,	2 00
Sabin's Industrial and Artistic Technology of Paint and Varnish.	8vo,	3 00
Smith's (A. W.) Materials of Machines.	12mo,	1 00
* Smith's (H. E.) Strength of Material.	12mo,	1 25
Thurston's Materials of Engineering.	3 vols., 8vo,	8 00
Part I. Non-metallic Materials of Engineering.	8vo,	2 00
Part II. Iron and Steel.	8vo,	3 50
Part III. A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.	8vo,	2 50
* Waterbury's Laboratory Manual for Testing Materials of Construction.	12mo,	1 50
Wood's (De V.) Elements of Analytical Mechanics.	8vo,	3 00
Treatise on the Resistance of Materials and an Appendix on the Preservation of Timber.	8vo,	2 00
Wood's (M. F.) Rustless Coatings Corrosion and Electrolysis of Iron and Steel.	8vo,	4 00

STEAM-ENGINES AND BOILERS.

Berry's Temperature-entropy Diagram. Third Edition Revised and En- larged.	12mo,	2 50
Carnot's Reflections on the Motive Power of Heat. (Thurston).	12mo,	1 50
Chase's Art of Pattern Making.	12mo,	2 50
Creighton's Steam-engine and other Heat Motors.	8vo,	5 00
Dawson's "Engineering" and Electric Traction Pocket-book.	16mo, mor,	5 00
* Gebhardt's Steam Power Plant Engineering.	8vo,	6 00
Goss's Locomotive Performance.	8vo,	5 00
Hemenway's Indicator Practice and Steam-engine Economy.	12mo,	2 00
Hirshfeld and Barnard's Heat Power Engineering. (In Press.)		
Hutton's Heat and Heat-engines.	8vo,	5 00
Mechanical Engineering of Power Plants.	8vo,	5 00
Kent's Steam Boiler Economy	8vo,	4 00
Kneass's Practice and Theory of the Injector.	8vo,	1 50
MacCord's Slide-valves.	8vo,	2 00
Meyer's Modern Locomotive Construction.	4to,	10 00
Miller, Berry, and Riley's Problems in Thermodynamics.	8vo, paper,	0 75
Moyer's Steam Turbine.	8vo,	4 00
Peabody's Manual of the Steam-engine Indicator.	12mo,	1 50
Tables of the Properties of Steam and Other Vapors and Temperature- Entropy Table.	8vo,	1 00
Thermodynamics of the Steam-engine and Other Heat-engines.	8vo,	5 00
* Thermodynamics of the Steam Turbine.	8vo,	3 00
Valve-gears for Steam-engines.	8vo,	2 50
Peabody and Miller's Steam-boilers.	8vo,	4 00
* Perkins's Introduction to General Thermodynamics.	12mo,	1 50
Pupin's Thermodynamics of Reversible Cycles in Gases and Saturated Vapors. (Osterberg.).	12mo,	1 25
Reagan's Locomotives: Simple, Compound, and Electric. New Edition. Large	12mo,	3 50
Sinclair's Locomotive Engine Running and Management.	12mo,	2 00
Smart's Handbook of Engineering Laboratory Practice.	12mo,	2 50
Snow's Steam-boiler Practice.	8vo,	3 00
Spangler's Notes on Thermodynamics.	12mo,	1 00
Valve-gears.	8vo,	2 50
Spangler, Greene, and Marshall's Elements of Steam-engineering.	8vo,	3 00
Thomas's Steam-turbines.	8vo,	4 00
Thurston's Handbook of Engine and Boiler Trials, and the Use of the Indi- cator and the Prony Brake.	8vo,	5 00
Manual of Steam-boilers, their Designs Construction, and Operation	8vo,	5 00
Manual of the Steam-engine.	2 vols., 8vo,	10 00
Part I. History, Structure, and Theory	8vo,	6 00
Part II. Design, Construction, and Operation.	8vo,	6 00

Wehrenfennig's Analysis and Softening of Boiler Feed-water. (Patterson)	8vo, \$4 00
Weisbach's Heat, Steam, and Steam-engines. (Du Bois.)	8vo, 5 00
Whitham's Steam-engine Design.	8vo, 5 00
Wood's Thermodynamics, Heat Motors, and Refrigerating Machines.	8vo, 4 00

MECHANICS PURE AND APPLIED.

Church's Mechanics of Engineering.	8vo, 6 00
Mechanics of Fluids (Being Part IV of Mechanics of Engineering).	8vo, 3 00
* Mechanics of Internal Work.	8vo, 1 50
Mechanics of Solids (Being Parts I, II, III of Mechanics of Engineering).	8vo, 4 50
Notes and Examples in Mechanics.	8vo, 2 00
Dana's Text-book of Elementary Mechanics for Colleges and Schools.	12mo, 1 50
Du Bois's Elementary Principles of Mechanics:	
Vol. I. Kinematics.	8vo, 3 50
Vol. II. Statics.	8vo, 4 00
Mechanics of Engineering. Vol. I.	Small 4to, 7 50
Vol. II.	Small 4to, 10 00
* Greene's Structural Mechanics.	8vo, 2 50
* Hartmann's Elementary Mechanics for Engineering Students.	12mo, 1 25
James's Kinematics of a Point and the Rational Mechanics of a Particle.	Large 12mo, 2 00
* Johnson's (W. W.) Theoretical Mechanics.	12mo, 3 00
* King's Elements of the Mechanics of Materials and of Power of Transmission.	8vo, 2 50
Lanza's Applied Mechanics.	8vo, 7 50
* Martin's Text Book on Mechanics, Vol. I, Statics.	12mo, 1 25
* Vol. II. Kinematics and Kinetics.	12mo, 1 50
* Vol. III. Mechanics of Materials.	12mo, 1 50
Maurer's Technical Mechanics.	8vo, 4 00
* Merriman's Elements of Mechanics.	12mo, 1 00
Mechanics of Materials.	8vo, 5 00
* Michie's Elements of Analytical Mechanics.	8vo, 4 00
Robinson's Principles of Mechanism.	8vo, 3 00
Sanborn's Mechanics Problems.	Large 12mo, 1 50
Schwamb and Merrill's Elements of Mechanism.	8vo, 3 00
Wood's Elements of Analytical Mechanics.	8vo, 3 00
Principles of Elementary Mechanics.	12mo, 1 25

MEDICAL.

* Abderhalden's Physiological Chemistry in Thirty Lectures. (Hall and Defren.)	8vo, 5 00
von Behring's Suppression of Tuberculosis. (Bolduan.)	12mo, 1 00
* Bolduan's Immune Sera.	12mo, 1 50
Bordet's Studies in Immunity. (Gay.)	8vo, 6 00
* Chapin's The Sources and Modes of Infection.	Large 12mo, 3 00
Davenport's Statistical Methods with Special Reference to Biological Variations.	16mo, mor., 1 50
Ehrlich's Collected Studies on Immunity. (Bolduan.)	8vo, 6 00
* Fischer's Nephritis.	Large 12mo, 2 50
* Oedema.	8vo, 2 00
* Physiology of Alimentation.	Large 12mo, 2 00
* de Fursac's Manual of Psychiatry. (Rosanoff and Collins.)	Large 12mo, 2 50
* Hammarsten's Text-book on Physiological Chemistry. (Mandel.)	8vo, 4 00
Jackson's Directions for Laboratory Work in Physiological Chemistry.	8vo, 1 25
Lassar-Cohn's Praxis of Urinary Analysis. (Lorenz.)	12mo, 1 00
* Lauffer's Electrical Injuries.	16mo, 0 50
Mandel's Hand-book for the Bio-Chemical Laboratory.	12mo, 1 50
* Nelson's Analysis of Drugs and Medicines.	12mo, 3 00
* Pauli's Physical Chemistry in the Service of Medicine. (Fischer.)	12mo, 1 25
* Pozzi-Escot's Toxins and Venoms and their Antibodies. (Cohn.)	12mo, 1 00
Rostoski's Serum Diagnosis. (Bolduan.)	12mo, 1 00
Ruddiman's Incompatibilities in Prescriptions.	8vo, 2 00
Whys in Pharmacy.	12mo, 1 00
Salkowski's Physiological and Pathological Chemistry. (Orndorff.)	8vo, 2 50

* Satterlee's Outlines of Human Embryology.	12mo,	\$1 25
Smith's Lecture Notes on Chemistry for Dental Students.	8vo,	2 50
* Whipple's Typhoid Fever.	Large 12mo,	3 00
* Woodhull's Military Hygiene for Officers of the Line.	Large 12mo,	1 50
* Personal Hygiene.	12mo,	1 00
Worcester and Atkinson's Small Hospitals Establishment and Maintenance, and Suggestions for Hospital Architecture, with Plans for a Small Hospital.	12mo,	1 25

METALLURGY.

Betts's Lead Refining by Electrolysis.	8vo,	4 00
Bolland's Encyclopedia of Founding and Dictionary of Foundry Terms used in the Practice of Moulding.	12mo,	3 00
Iron Founder.	12mo,	2 50
" " Supplement.	12mo,	2 50
* Borchers's Metallurgy. (Hall and Hayward.)	8vo,	3 00
* Burgess and Le Chatelier's Measurement of High Temperatures. Third Edition.	8vo,	4 00
Douglas's Untechnical Addresses on Technical Subjects.	12mo,	1 00
Goesel's Minerals and Metals: A Reference Book.	16mo, mor.	3 00
* Iles's Lead-smelting.	12mo,	2 50
Johnson's Rapid Methods for the Chemical Analysis of Special Steels, Steel-making Alloys and Graphite.	Large 12mo,	3 00
Keep's Cast Iron.	8vo,	2 50
Metcalf's Steel. A Manual for Steel-users.	12mo,	2 00
Minet's Production of Aluminum and its Industrial Use. (Waldo.)	12mo,	2 50
* Palmer's Foundry Practice.	Large 12mo,	2 00
* Price and Meade's Technical Analysis of Brass.	12mo,	2 00
* Ruer's Elements of Metallography. (Mathewson.)	8vo,	3 00
Smith's Materials of Machines.	12mo,	1 00
Tate and Stone's Foundry Practice.	12mo,	2 00
Thurston's Materials of Engineering. In Three Parts.	8vo,	8 00
Part I. Non-metallic Materials of Engineering, see Civil Engineering, page 9.		
Part II. Iron and Steel.	8vo,	3 50
Part III. A Treatise on Brasses, Bronzes, and Other Alloys and their Constituents.	8vo,	2 50
Ulke's Modern Electrolytic Copper Refining.	8vo,	3 00
West's American Foundry Practice.	12mo,	2 50
Moulders' Text Book.	12mo.	2 50

MINERALOGY.

* Browning's Introduction to the Rarer Elements.	8vo,	1 50
Brush's Manual of Determinative Mineralogy. (Penfield.)	8vo,	4 00
Butler's Pocket Hand-book of Minerals.	16mo, mor.	3 00
Chester's Catalogue of Minerals.	8vo, paper,	1 00
Cloth,	1 25	
* Crane's Gold and Silver.	8vo,	5 00
Dana's First Appendix to Dana's New "System of Mineralogy".	Large 8vo,	1 00
Dana's Second Appendix to Dana's New "System of Mineralogy."	Large 8vo,	1 50
Manual of Mineralogy and Petrography.	12mo,	2 00
Minerals and How to Study Them.	12mo,	1 50
System of Mineralogy.	Large 8vo, half leather,	12 50
Text-book of Mineralogy.	8vo,	4 00
Douglas's Untechnical Addresses on Technical Subjects.	12mo,	1 00
Eakle's Mineral Tables.	8vo,	1 25
* Eckel's Building Stones and Clays.	8vo,	3 00
Goesel's Minerals and Metals: A Reference Book.	16mo, mor.	3 00
* Groth's The Optical Properties of Crystals. (Jackson.)	8vo,	3 50
Groth's Introduction to Chemical Crystallography (Marshall).	12mo,	1 25
* Hayes's Handbook for Field Geologists.	16mo, mor.	1 50
Iddings's Igneous Rocks.	8vo,	5 00
Rock Minerals.	8vo,	5 00

Johannsen's Determination of Rock-forming Minerals in Thin Sections. 8vo.	
With Thumb Index	\$5 00
* Martin's Laboratory Guide to Qualitative Analysis with the Blow-pipe.	12mo, 0 60
Merrill's Non-metallic Minerals: Their Occurrence and Uses.	8vo, 4 00
Stones for Building and Decoration.	8vo, 5 00
* Penfield's Notes on Determinative Mineralogy and Record of Mineral Tests.	8vo, paper, 0 50
Tables of Minerals, Including the Use of Minerals and Statistics of Domestic Production.	8vo, 1 00
* Pirsson's Rocks and Rock Minerals.	12mo, 2 50
* Richards's Synopsis of Mineral Characters.	12mo, mor. 1 25
* Ries's Clays: Their Occurrence, Properties and Uses.	8vo, 5 00
* Ries and Leighton's History of the Clay-working Industry of the United States.	8vo, 2 50
* Rowe's Practical Mineralogy Simplified.	12mo, 1 25
* Tillman's Text-book of Important Minerals and Rocks.	8vo, 2 00
Washington's Manual of the Chemical Analysis of Rocks.	8vo, 2 00

MINING.

* Beard's Mine Gases and Explosions.	Large 12mo, 3 00
* Crane's Gold and Silver.	8vo, 5 00
* Index of Mining Engineering Literature.	8vo, 4 00
	* 8vo, mor. 5 00
* Ore Mining Methods.	8vo, 3 00
* Dana and Saunders's Rock Drilling.	8vo, 4 00
Douglas's Untechnical Addresses on Technical Subjects.	12mo, 1 00
Eissler's Modern High Explosives.	8vo, 4 00
* Gilbert Wightman and Saunders's Subways and Tunnels of New York.	8vo, 4 00
Goesel's Minerals and Metals: A Reference Book.	16mo, mor. 3 00
Ihlseng's Manual of Mining.	8vo, 5 00
* Iles's Lead Smelting.	12mo, 2 50
* Peele's Compressed Air Plant.	8vo, 3 50
Riemer's Shaft Sinking Under Difficult Conditions. (Corning and Peele.)	8vo, 3 00
* Weaver's Military Explosives.	8vo, 3 00
Wilson's Hydraulic and Placer Mining. 2d edition, rewritten.	12mo, 2 50
Treatise on Practical and Theoretical Mine Ventilation.	12mo, 1 25

SANITARY SCIENCE.

Association of State and National Food and Dairy Departments, Hartford Meeting, 1906.	8vo, 3 00
Jamestown Meeting, 1907.	8vo, 3 00
* Bashore's Outlines of Practical Sanitation.	12mo, 1 25
Sanitation of a Country House.	12mo, 1 00
Sanitation of Recreation Camps and Parks.	12mo, 1 00
* Chapin's The Sources and Modes of Infection.	Large 12mo, 3 00
Folwell's Sewerage. (Designing, Construction, and Maintenance.)	8vo, 3 00
Water-supply Engineering.	8vo, 4 00
Fowler's Sewage Works Analyses.	12mo, 2 00
Fuertes's Water-filtration Works.	12mo, 2 50
Water and Public Health.	12mo, 1 50
Gerhard's Guide to Sanitary Inspections.	12mo, 1 50
* Modern Baths and Bath Houses.	8vo, 3 00
Sanitation of Public Buildings.	12mo, 1 50
* The Water Supply, Sewerage, and Plumbing of Modern City Buildings.	8vo, 4 00
Hazen's Clean Water and How to Get It.	Large 12mo, 1 50
Filtration of Public Water-supplies.	8vo, 3 00
* Kinnicutt, Winslow and Pratt's Sewage Disposal.	8vo, 3 00
Leach's Inspection and Analysis of Food with Special Reference to State Control.	8vo, 7 50
Mason's Examination of Water. (Chemical and Bacteriological).	12mo, 1 25
Water-supply. (Considered principally from a Sanitary Standpoint).	8vo, 4 00
* Mast's Light and the Behavior of Organisms.	Large 12mo, 2 50

* Merriman's Elements of Sanitary Engineering.	8vo,	\$2 00
Ogden's Sewer Construction	8vo,	3 00
Sewer Design.	12mo,	2 00
* Ogden and Cleveland's Practical Methods of Sewage Disposal for Res-		
idences, Hotels and Institutions.	8vo,	1 50
Parsons's Disposal of Municipal Refuse.	8vo,	2 00
Prescott and Winslow's Elements of Water Bacteriology, with Special Refer-		
ence to Sanitary Water Analysis.	12mo,	1 50
* Price's Handbook on Sanitation.	12mo,	1 50
Richards's Conservation by Sanitation.	8vo,	2 50
Cost of Cleaness.	12mo,	1 00
Cost of Food. A Study in Diaries.	12mo,	1 00
Cost of Living as Modified by Sanitary Science.	12mo,	1 00
Cost of Shelter.	12mo,	1 00
Richards and Woodman's Air, Water, and Food from a Sanitary Stand-		
point.	8vo,	2 00
* Richey's Plumbers', Steam-fitters', and Tinnners' Edition (Building		
Mechanics' Ready Reference Series).	16mo, mor,	1 50
Rideal's Disinfection and the Preservation of Food.	8vo,	4 00
Soper's Air and Ventilation of Subways.	12mo,	2 50
Turneaure and Russell's Public Water-supplies.	8vo,	5 00
Venable's Garbage Crematories in America.	8vo,	2 00
Method and Devices for Bacterial Treatment of Sewage.	8vo,	3 00
Ward and Whipple's Freshwater Biology. (In Press.)		
Whipple's Microscopy of Drinking-water.	8vo,	3 50
* Typhoid Fever.	Large 12mo,	3 00
Value of Pure Water.	Large 12mo,	1 00
Winslow's Systematic Relationship of the Coccaceæ.	Large 12mo,	2 50

MISCELLANEOUS.

* Burt's Railway Station Service.	12mo,	2 00
* Chapin's How to Enamel.	12mo,	1 00
Emmons's Geological Guide-book of the Rocky Mountain Excursion of the		
International Congress of Geologists.	Large 8vo,	1 50
Ferrel's Popular Treatise on the Winds.	8vo,	4 00
Fitzgerald's Boston Machinist.	18mo,	1 00
* Fritz, Autobiography of John.	8vo,	2 00
Gannett's Statistical Abstract of the World.	24mo,	0 75
Haines's American Railway Management.	12mo,	2 50
Hanausek's The Microscopy of Technical Products. (Winton).	8vo,	5 00
Jacobs's Betterment Briefs. A Collection of Published Papers on Or-		
ganized Industrial Efficiency.	8vo,	3 50
Metcalfe's Cost of Manufactures, and the Administration of Workshops. 8vo,		5 00
* Parkhurst's Applied Methods of Scientific Management.	8vo,	2 00
Putnam's Nautical Charts.	8vo,	2 00
Ricketts's History of Rensselaer Polytechnic Institute 1824-1894.		
	Large 12mo,	3 00
* Rotch and Palmer's Charts of the Atmosphere for Aeronauts and Aviators.		
	Oblong 4to,	2 00
Rotherham's Emphasised New Testament.	Large 8vo,	2 00
Rust's Ex-Meridian Altitude, Azimuth and Star-finding Tables.	8vo,	5 00
Standage's Decoration of Wood, Glass, Metal, etc.	12mo,	2 00
Westermaier's Compendium of General Botany. (Schneider).	8vo,	2 00
Winslow's Elements of Applied Microscopy.	12mo,	1 50

HEBREW AND CHALDEE TEXT-BOOKS.

Gesenius's Hebrew and Chaldee Lexicon to the Old Testament Scriptures.		
(Tregelles).	Small 4to, half mor,	5 00
Green's Elementary Hebrew Grammar.	12mo,	1 25

NORTH CAROLINA STATE UNIVERSITY LIBRARIES

S01944732 U

Cooley