

UNIVERSITY OF TORONTO



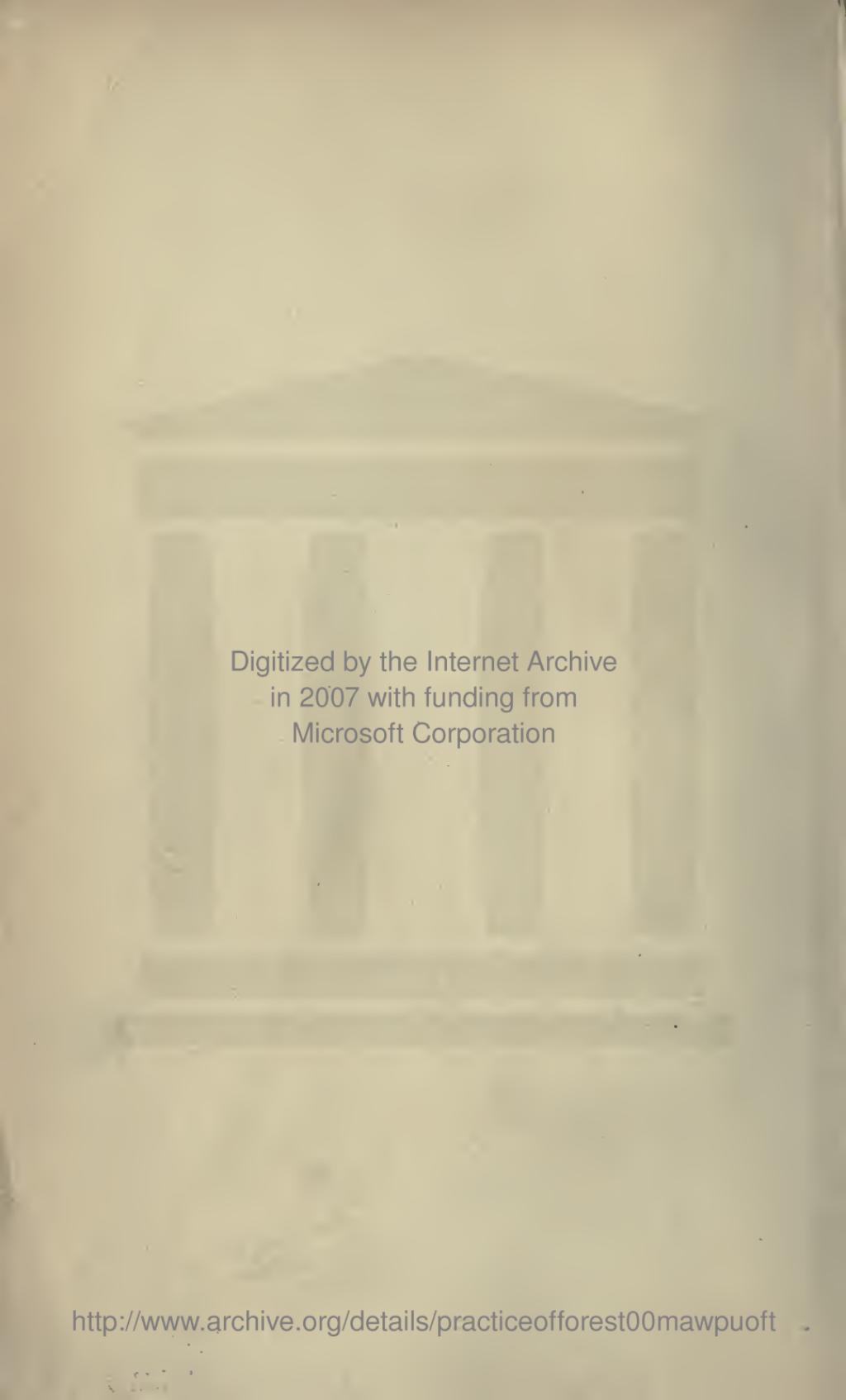
3 1761 01538306 0

A

24

THE PRACTICE OF FORESTRY
CONCERNING ALSO
THE FINANCIAL ASPECT OF AFFORESTATION

{ FORESTRY
EVER }

A very faint, light gray watermark-style illustration of a classical building with four prominent columns supporting a triangular pediment. The building appears to be made of stone or concrete.

Digitized by the Internet Archive
in 2007 with funding from
Microsoft Corporation

THE PRACTICE OF FORESTRY

CONCERNING ALSO
THE FINANCIAL ASPECT OF
AFFORESTATION

BY

PERCIVAL TRENTHAM MAW

LATE PROFESSOR OF FORESTRY AT THE ROYAL AGRICULTURAL COLLEGE, CIRENCESTER
PROFESSIONAL ASSOCIATE OF THE SURVEYORS INSTITUTION
MEMBER OF THE LAND AGENTS SOCIETY
HONORARY JOINT-EXAMINER IN FORESTRY AT THE SURVEYORS INSTITUTION
FORMERLY LAND AGENT TO THE LATE A. C. PASS, ESQ., DEVON AND DORSET ESTATE

LIBRARY
FACULTY OF FORESTRY
UNIVERSITY OF TORONTO

100-142
95 / 2 / 10

T. FISHER UNWIN

LONDON
ADELPHI TERRACE

1909

LEIPSIC

INSELSTRASSE 20

MICROFORMED BY
PRESERVATION
SERVICES
OCT 25 1991
DATE.....

SD
409
M3

P R E F A C E

IN the following pages I have endeavoured to write such a treatise on Forestry as will be found of universal use to Landowners, Land Agents, and all Students of the science of Forestry.

It is very necessary to realise that a complete knowledge of the correct practice of Forestry can only be obtained by approaching the subject from a scientific attitude.

There are many able foresters whose only school has been that of the lonely woodlands, but their ability is, nevertheless, the result of an unconscious scientific study.

There is, however, a species of humanity—a class of self-styled experts—who advertise as being practical authorities on Forestry matters, and who boast that they eschew all that is scientific, but whose only passport is, in reality, that of garrulous ignorance, and an overweening confidence in their own inability. I cannot too strongly warn my readers against attaching any importance to the remarks or advice of such men as these.

Now, whereas in the cultivation of field crops, a considerable degree of proficiency may be acquired in an empiric manner, by merely watching the results of one's own practice, and without availing oneself of the lessons learnt by others, yet, in the case of Forestry, such would be impossible, for the life of mankind is far too short to admit of acquiring a complete knowledge of Forestry without studying the results of the actions of others, both of the present and past generations, and endeavouring to draw correct conclusions from observations so made.

Knowledge acquired in this way can only be the result of scientific study; and this study may be greatly facilitated by a perusal of the current literature thereon.

As regards Forestry education, I should like to express my opinion that British foresters can only learn their Forestry in this country.

I scout any idea that a complete training in any continental school can act other than most prejudiciously upon those who take such a course. For the practice in foreign countries is governed by different economic laws. And, although the main principles of correct continental practice are also applicable to this country, yet to pursue, in this country, much of the detail of such practice, would usually result in disaster, even if not in ridicule.

Nevertheless, those who have had considerable experience in this country will find it an inestimable advantage to pay short visits to various continental forests.

As regards the present volume, I have emphasised in black type a considerable number of words and sentences, as I feel that such a course will be of great benefit to a certain section of my readers.

I would direct especial attention to that which I have said with regard to the choice of tree seeds (pp. 37, 38, 39, 194), the occurrence of and the susceptibility of trees to spring and autumn frosts (pp. 36, 37, 72, 73, 89); the preparation of land by ploughing, and subsequently planting with a planting spike (pp. 67, 68, 118, 119, 132); and as to the partial clearance and underplanting of crops of timber (pp. 163 to 175). So, also, on pp. 317 to 322, I have endeavoured to show the fairness or otherwise of the railway rates charged for the carriage of timber—at present such a debated point.

In Chapter XI. I have stated what I believe to be the average yield of crops of timber upon certain qualities of soil.

In Chapter XII. I have dealt, in as simple a manner as possible, with the complex technicalities of the financial

aspect of Afforestation, and on pp. 246, 247, 248 I have shown the maximum present-day rental equivalents that may be expected to accrue from planting land of a given quality with trees, provided a particular price can be obtained for the timber ; whilst in Chapter I. I have dealt, in a general way, concerning the advisability or otherwise of the afforestation of land. Also, I direct especial attention to the data (on pp. 235 to 237) showing the enormous debt per acre that exists upon any normally stocked area of forest land. The whole question of the financial results of afforestation has hitherto received but little consideration ; and the majority of those who are responsible for woodland management are entirely ignorant of the subject. And yet, reduced to its lowest terms, is not economic forestry merely a question of £ S. D. ?

That the yields of crops of timber and the prices that will be obtained therefor are factors of great uncertainty, no one will deny. Yet such is no defence for the failure to adopt correct actuarial principles when considering questions of Forestry finance. Rather is it a reason why a high rate of interest should be looked for instead of a low rate, which latter so many seem to think is justifiable.

I have no hesitation in saying that a study of the finances of Forestry is of far more importance to those responsible for woodland management, than is the study of any of the Natural History sciences allied to Forestry, such as Entomology, or Botany, or the study of Fungi, interesting and important though these be.

In another volume I hope to deal shortly with some of these subjects, and also with certain extraneous matter, such as the conversion and the technical qualities of timber ; and, so also, concerning the utilisation of coppice produce, and woodland industries connected therewith.

But such subjects are beyond the scope of the present volume.

PREFACE

Lastly, I wish to express my thanks to Professor Pritchard of the Royal Agricultural College, Cirencester, for having read through all my manuscripts (except Chapters I. and XII.), and for the many valuable suggestions which he has offered to me in connection with this work.

And I thank M. Johannes Rafn, Seed Merchant, of Copenhagen, for much valuable information with regard to tree seeds and their germinative capacity.

PERCIVAL T. MAW.

NUTFIELD, SURREY,
1st January 1909.

TABLE OF CONTENTS

x CHAPTER I.

AN INTRODUCTION.

CONCERNING THE NATIONAL ECONOMIC IMPORTANCE OF WOODLANDS AND OF THE AFFORESTATION OF LAND.

	PAGE
The Effects upon Climatic Conditions and upon the Locality	1-6
As regards the Temperature of the Air and Soil	1
As regards the Moisture in the Atmosphere	2
As regards Soil Moisture	4
As regards Protection against Erosion and Denudation	4
As regards Shelter and Protection from Storms	4
As regards the Salubrity of the Atmosphere	5
Conclusion	5
The Effects upon the Labour Market	6-9
As to the Direct Effects of Afforestation with respect to Labour	6
As regards Afforestation as a Means of affording Work for the Unemployed	8
The Financial Returns which Afforestation is likely to yield	9-20
As to the Possibility of Permanent Advances in the Price of Timber	13
Considerations in favour of General Afforestation Schemes	14
Considerations which point to the Inadvisability of General Afforestation Schemes in this Country	15
ix	α 2

TABLE OF CONTENTS

CHAPTER II.

FOREST SYSTEMS.

	PAGE
Simple Coppice	21
Coppice with Standards	22
High Forest Systems	22-27
(1) The Selection System	23
(2) The Group System	23
(3) The Compartment System	24
(a) Compartments of Even-aged High Forest	
(b) Two-storied High Forest	
(c) High Forest with Coppice	
(d) High Forest with Standards	
The Choice of Systems	27-31

CHAPTER III.

THE NURSERY.

Advantages of a Home Nursery	32
Formation of a Nursery	33-35
(1) Choice of Site	33
(2) Size of Nursery	34
(3) Laying out a Nursery	34
Nursery Management	35-55
(1) Seed Beds	36
(2) Liability to Frosts	36
(3) Choice of Seed	37
(4) The Storage of Seed	39
(5) The Sowing of Seeds	40
(6) Treatment of Seedlings	47
(7) Other Methods of Raising Trees	52
(8) Stocking a Nursery with Purchased Plants	53
(9) The Pruning of Nursery Stock	54
(10) Lifting the Plants for Planting Out	55
Insect and Fungoid and other Enemies in the Nursery	55-57

TABLE OF CONTENTS

xi

CHAPTER IV.

PLANTING.

FENCING AND PRELIMINARY OPERATIONS.

	PAGE
Fencing of Land	58-64
Rabbit Fences	58
Fences against Stock	61
Cost per acre of a Rabbit Fence	61
Drainage of Land	64-66
Other Preliminary Operations	66-69
Cleaning and Preparing the Land	66
The great Advantages of Ploughing the Land	68
The Laying Out of Rides and Compartments	69

CHAPTER V.

PLANTING—*continued.*

AS TO THE CHOICE OF TREES TO PLANT.

CONCERNING ALSO THE SPECIAL DEMANDS OF TIMBER TREES, AND THEIR HABITS, AND THE CONDITIONS SUITED TO THEIR GROWTH, AND THEIR FINANCIAL RETURNS.

The Individual Demands of Trees as to Locality and Soil	70-89
The Aspect	71
The Influence of Aspect and Altitude on Frosts	72
Aspect and Altitude in reference to Gales	73
Altitude in reference to Tree Growth	73
1. The Demands of Trees as to Moisture	74
2. The Demands of Trees as to Shelter and Protection from Gales and Frosts	76
3. The Demands of Trees as to Depth of Soil	78
4. The Demands of Trees as to the Mechanical Condition of the Soil	79
As to Food requirements	80
As to Floods	86
As to Fire.	87
Summary . . . . .	. 88, 89

TABLE OF CONTENTS

	PAGE
The Peculiarities of Growth and the Conditions suited to the Growth of Trees	89-113
A. Concerning the Growth peculiar to Individual Trees :—	
(1) The Shape of the Crowns	90
(2) The Relative Height Growth	91
(3) The Persistency and Vigour of Side Branches	92
(4) The Shade-bearing or Light-demanding Qualities of Trees	95
B. As regards the Conditions under which Trees may best be Grown :—	
(1) The Age and Distance apart at which Trees should be Planted	96
(2) The Merits and Demerits of Pure and Mixed Woods, and the Methods of Mixing	97
(a) Even-aged Woods	100
(b) Uneven-aged Woods Good or Fair Mixtures	103
Bad and Inferior Mixtures	103
Summary	105
(3) The Choice of System	108
(4) The Advisability or otherwise of a Rotation of Crop-ping	109
(5) The Season for Planting	110
As to the Financial Returns that may be anticipated by Planting one Species in preference to another	114-115

CHAPTER VI.

PLANTING—*continued.*

PLANTING OPERATIONS.

CONCERNING ALSO THE ARTIFICIAL SOWING OF CROPS OF TREES.

The Different Methods of Planting Trees	116-126
(1) Planting in Pits	116
(2) Planting in Holes made with a Planting Spike	118
(3) Planting with a Curved Planting Spade	119
(4) Notching or Slitting	120
(5) Dibbling	122
As to the Choice of Methods	122
The Number of Trees per Acre	123
Sundry matters relative to the Control of Planting Operations	124

TABLE OF CONTENTS

xiii

	PAGE
Some Notes on the Methods of Planting in Particular Cases	126-130
On Heather Land	126
On Wet Peat Land	127
On Clay Soils	127
On Exposed Land	128
Planting Frost Localities	128
Planting Shifting Sand and Sand Dunes	128
Planting Ornamental Trees	130
Estimates for Planting and Establishing	131-136
The Artificial Sowing of Crops of Trees	136-141

CHAPTER VII.

THE TENDING OF YOUNG HIGH FOREST AND PRUNING.

Cleaning and Tending Young Crops	142-145
Thinning	145-152
Pruning Trees	153-158
(1) The Pruning of Green Branches	153
(2) Method of Pruning	155
(3) Season for Pruning	156
(4) The Effects of Pruning	157
(5) The Pruning of Dead Branches	158
Tables of Thinnings	158-162

CHAPTER VIII.

PARTIAL CLEARANCES AND UNDERPLANTING.

Partial Clearances and Stimulation of Increment	163
Necessity for Underplanting	166
Trees used for Underplanting	167
Financial Result of Underplanting	169
Benefits resulting from the Retention of Humus owing to Under- planting	170
Notes and Tables for Partial Clearances of Particular Species	172-175

TABLE OF CONTENTS

CHAPTER IX.

NATURAL REGENERATION OF HIGH FOREST.

	PAGE
The Selection System	176-179
The Group System	179-181
Natural Regeneration of Whole Compartments of Even-aged High Forest	182-187
(1) Preparatory Fellings	182
(2) "Seed" or Regeneration Felling	183
(3) Gradual Clearance of Mother Trees	184
The Natural Regeneration of Beech	187-191
Under the Selection System	188
Regeneration of Whole Compartments	189
The Natural Regeneration of Oak and other Trees	191-193
Oak	191
Ash	191
Sycamore and Norway Maple	192
Corsican and Scots Pines	192
Larch	193
The Natural Regeneration of the Shade-bearing Conifers	193-195
The Comparative Merits and Demerits of the Systems	195-196

CHAPTER X.

TREATMENT OF COPPICE SYSTEMS.

Simple Coppice	197-202
Length of Rotations	197
Reproductive Power from Stools	198
General Management	199
(1) Planting up the Land	199
(2) Layering or Plashing	201
Coppice with Standards	202-210
Tables of Fellings	204
Expenses of Management	208
The Conversion of Coppice, or Coppice with Standards, into High Forest	210
High Forest with Coppice	211-214
Table of Fellings	212

TABLE OF CONTENTS

xv

CHAPTER XI.

AVERAGE YIELDS FROM FOREST LAND.

	PAGE
Yield from High Forest	215-225
Qualities of Soil	215
Oak	216
Beech	217
Silver Fir and Norway Spruce	218
Scots Pine and Corsican Pine	219
Weymouth Pine	220
Ash	221
Larch	222, 223
Douglas Fir	224
Sitka Spruce, <i>Cupressus macrocarpa</i> , Willows and Poplars	225
Yield from Standards over Coppice	226
Yield from Coppice	227-230

CHAPTER XII.

THE FINANCIAL ASPECT OF AFFORESTATION.

Fallacious Methods of Presenting Financial Statements	232-234
Initial Outlay Credited with the Income which is Receivable only after a Period of Years	232
Correct Methods of Presenting Financial Statements	234-263
Statement of Income obtained on Average Accumulated Capital Sunk in Normally Stocked Areas	234
Statement of Gain in Capital after charging Compound Interest	238
Statement of Rate of Compound Interest	239
Statement of Yearly Rental Principle	244
Tables of Rentals yielded by different Crops in High Forest	246
Advantages of Annual Rental Principle	251
The Financial Aspect of Underplanting	252-257
The Financial Aspect of Coppice with Standards	257-261
Comparison of Actual Land Rentals with the Net Returns from Normally Stocked Areas	261-262
Conclusion	263

TABLE OF CONTENTS

CHAPTER XIII.

TIMBER MEASURING.

	PAGE
Square of Quarter Girth Measurement	264-276
(i) Measurement of Felled Timber	265
Fraudulent Girthing	268
Booking Measurements	270
(2) Measurement of Standing Timber	272
Booking Measurements	273
Other Methods of Computing Contents	276-283
True Contents	276
Calliper Measure	277
Die Square Measure	278
Board Measure	278
Table of Percentage Comparison of Contents computed by Various Methods	282

CHAPTER XIV.

THE MARKETING, SALE, AND TRANSPORT OF WOODLAND
PRODUCE.

Coppice Areas	284-289
Conditions of Sale of Coppice	286
Uses to which Coppice Produce is put	287
High Forest Areas	289-304
(i) The Marketing of Thinnings	289
(ii) The Marketing of Mature Timber	290
The Sale of Timber	290
The Choice between Sales by Auction, Tender, and Private Contract	295
Conditions of Sale of Timber	298
The Marking and Lotting of Timber	302

TABLE OF CONTENTS

xvii

	PAGE
The Felling of Timber	304-311
Season for Felling . . . . .	. 307
Barking Trees . . . . .	. 307
Extraction and Transportation of Timber	311-323
Cost of Haulage by Horses . . . . .	. 312
Cost of Steam Traction . . . . .	. 312
Forest Roads . . . . .	. 313
Forest Tramway . . . . .	. 314
Timber Slides . . . . .	. 316
Transportation by Canals . . . . .	. 316
Railway Carriage of Timber . . . . .	. 317
The Uses and Prices of Timber	323-333

CHAPTER XV.

SYLVICULTURAL NOTES ON TIMBER TREES—
BROAD-LEAVED TREES.

Acacia	334
Alder	336
Ash	338
Beech	342
Birch	346
Cherry	348
Elm	349
Hawthorn	352
Hazel	353
Hornbeam	354
Horse Chestnut	356
Lime or Linden Trees	357
Oak	359
Plane Trees	365
Poplars	367
Spanish Chestnut	372
Sycamore and Norway Maple	375
Tulip Tree	377
Walnut	379
Willows	381

CHAPTER XVI.

SYLVICULTURAL NOTES ON TIMBER TREES—*continued.*

CONIFEROUS TREES.

<i>Cupressus</i>	386
Douglas Fir	389
Larch	392
Pines	400
Silver Fir	414
Spruce	418
<i>Thuya</i>	424

CHAPTER XVII.

MEASUREMENTS FOR PURPOSES OF FOREST MANAGEMENT.

Height of Trees	426
Basal Area	427
Form Factor	428
(1) Measurement of Sample Trees	429
Weise's method	430
Other methods	431
(2) Measurement of Sample Plots	432
(3) Estimation by Reference to Average Yield Tables	434

CHAPTER XVIII.

ESTIMATION OF INCREMENT ON CROPS OF TIMBER.

1. Increment in Cubic Contents	437
Increment on Standing Timber	441
Pressler's Formula	443
Schneider's Formula	444
Maw's Formula	446
Increment on Felled Timber	448
Current Annual Increment	459
Average Annual Increment	451
2. Increment in Quality	451
3. Total Increment on Invested Capital	452

TABLE OF CONTENTS

xix

APPENDICES.

	PAGE
APPENDIX A.—Height Tables	459
APPENDIX B.—Tables of Contents by Quarter Girth Measurement	467
APPENDIX C.—Compound Interest Tables	477
APPENDIX D.—Tables of Basal Areas for given Diameters	485
APPENDIX E.—Tables of Basal Areas for given Quarter Girths	487
INDEX	489

ERRATA

Page 49, last line.—*Read “culls” instead of “calls.”*

„ 138, line 36.—*Read “ditissima” instead of “ditissina.”*

THE PRACTICE OF FORESTRY

CONCERNING ALSO

THE FINANCIAL ASPECT OF AFFORESTATION

CHAPTER I.

AN INTRODUCTION

CONCERNING THE NATIONAL ECONOMIC IMPORTANCE OF
WOODLAND AREAS AND OF THE AFFORESTATION OF
LAND.

WITHIN recent years the study of Forestry in this country has received no little attention. Many landowners have displayed a lively interest in the welfare of their woodlands; and not a few politicians and other public men have seriously considered the possibility and advisability of adopting, on behalf of the public, certain schemes of afforestation on a large scale.

The economic importance of woodlands, and the desirability of the adoption of works of afforestation in this country, may be considered under three main headings, namely :—

- (1) The Effects of Woodland Areas upon Local Climatic Conditions, and upon the Locality.
- (2) The Effects upon the Labour Market.
- (3) The Financial Returns which Afforestation is likely to Yield.

THE EFFECTS UPON CLIMATIC CONDITIONS, AND UPON THE LOCALITY.

As regards the Temperature of the Air and Soil.—The existence of large areas of woodland has an appreciable effect upon the temperature of the atmosphere within such

areas, when compared to the temperature of the atmosphere in the open country. As a general rule, it may be stated that the **average** temperature **throughout the year** is less within woodlands than that which obtains in the open. And furthermore, that the **average summer temperature** is considerably less in woodlands than in the open; whereas the **average winter temperature** is usually about the same or very slightly lower than in the open.

Then again, extremes of heat and cold are lessened within woodland areas. It has been found that during the hottest days in the year, the maximum temperatures registered within woodlands are always far below those registered in the open; and conversely, the minimum temperatures registered within woodlands during the coldest days of the year are never so low as those registered in the open; especially is this so in the case of woodlands consisting of ever-green trees.

So also, there are daily variations in the temperature of the air within woodlands, when compared to the temperature of the air in the open.

Within woodland areas, the night temperature is practically always warmer than, and never falls so low as, the temperature in the open; whereas, during the daytime, the average atmospheric temperature within woodlands is always less than the average temperature in the open.

The chief reason for these differences can be ascribed to the fact that the canopy of the trees prevents the soil from being rapidly warmed by the sun's rays; and also, when once the soil has become warmed, the canopy of the trees prevents any rapid radiation of heat from the soil.

And so, also, in the case of **woodland soils**, it has been found that the average temperature of such soils is always less than that of soils in the open country. The greatest difference is observed in the summer months, whereas in the winter the difference is practically nil.

As regards the Moisture in the Atmosphere.—The presence of woodlands probably does not materially affect the **absolute humidity** of the atmosphere if the neighbouring

EFFECTS OF FORESTS UPON LOCALITY 3

country consist of pasture land, or if it be under cultivated crops, though the absolute humidity would be increased, if the neighbouring country were a dry, more or less barren, waste. Now, inasmuch as the average temperature of the air is less in woodlands than in the open country, it follows that the **relative humidity** of the atmosphere is much increased by the presence of woodlands; especially does this increase take place in the summer and early autumn, when the difference in the air temperatures is at its greatest.

Hence, on account of this increase in the relative humidity, there is always, *ceteris paribus*, a greater likelihood of rain or mists occurring in a well-wooded area than in a treeless country. This tendency to an increased rainfall is usually only noticed at very high altitudes, or in dry, barren countries; for in the former case the extremes of temperature by day and night are nearly always far greater than at low latitudes,¹ and in the latter case the absolute humidity in the summer months, as well as the relative humidity, is generally much increased. Furthermore, when the surrounding country is dry and somewhat barren, the summer rainfall is more regular. So also, an increased dewfall may always be expected on grass-land or on crops in the neighbourhood of woodlands. Then again, as air rises and gets more rarified, it becomes cooled, and, if its relative humidity were already near the saturation point, the moisture contained therein will consequently be precipitated either as mist, dew, or rain. On the other hand, at low altitudes in fertile districts large unbroken stretches of woodland may actually tend to lessen the rainfall, for although the **average** relative humidity is generally greater, yet the relative humidity at **night-time**, in the summer months, is usually less in woodlands than in

¹ However, at the lowest altitudes, or those relatively lowest in a locality, there are often greater extremes of temperature by day and by night, than are experienced at medium altitudes. Especially is this the case in the spring and autumn, when, in the lowlands and coombes, frosts are often experienced at night; whereas, at somewhat higher altitudes, these frosts do not occur.

open ground, since the temperature by night in woodlands is higher.

As regards Soil Moisture.—Woodlands exert a considerable influence upon soil moisture. For the canopy of the trees and the layer of humus prevent rapid evaporation of soil moisture ; and the layer of humus, which is hygroscopic, also absorbs moisture, as it were, like a sponge. On account of this latter property, the layer of humus, assisted also by the obstruction afforded by the roots and crowns of the trees, prevents the rapid disappearance of any rainfall ; and it prevents the consequent flooding of streams and rivers ; and it prevents also the washing away and denudation of the soil. Consequently, the duration of the beneficial effects of rainfall is prolonged ; especially is this the case in the early spring, before active transpiration has begun.

It should be noted that in the summer months, an area covered by trees will utilise a far greater quantity of water than is lost by evaporation from the surface of bare land. For although soil evaporation is less in woodlands than on bare, open land, an enormous quantity of water is transpired by the trees. Another effect produced by trees is that the water table is lowered ; and, for this reason alone, the liability to floods is lessened ; for a greater quantity of water must be absorbed before flooding can take place.

As regards Protection against Erosion and Denudation.—The beneficial effect which trees exert with respect to any direct erosion by rainfall has just been noticed. But losses sustained by erosion and denudation from other causes, such as that characterised by landslips and caused by the action of underground water or other agencies, can often be avoided, or at any rate lessened, by the judicious planting of trees and shrubs ; for their roots will help to bind the soil together. In this connection, the planting of stoloniferous shrubs, or trees which shall afterwards be kept coppiced, will generally be more advantageous than if an attempt be made to grow mature timber.

As regards Shelter and Protection from Storms.—The presence of woodland is often of the greatest value, in exposed

EFFECTS OF FORESTS UPON LOCALITY 5

localities, to agricultural interests. It is most advisable that as much shelter as is possible should be provided for farms in exposed districts.

As regards the Salubrity of the Atmosphere.—The atmosphere in woodlands is always more free from impurities than the atmosphere in more thickly populated districts. It usually shows a remarkable absence of bacteria and of carbonic acid gas; and on the other hand, it usually contains more oxygen and ozone than the atmosphere near towns. Then again, in the neighbourhood of Pine woods or forests of Silver Fir or Douglas Fir, it is probable that the atmosphere will contain more ozone than is found in other forest areas, and there will usually be found also appreciable quantities of hydrogen peroxide (H_2O_2), owing to the oxidation of turpentine.

Conclusion.—Now, with reference to the foregoing, it is evident that afforestation may sometimes be judiciously carried out, even though there be no direct pecuniary returns by the sale of timber. For instance, the planting of **water catchment areas** is in practically all cases desirable, not only on account of any probable increase in the rainfall, but chiefly because any sudden floods are largely avoided and the water is more gradually drained from the land, and the supply is thus more constant. And inasmuch as this is so, smaller reservoirs will suffice for any given supply; and thereby the expenses of the whole undertaking can usually be greatly reduced.

And then again, the planting of trees will often be advisable in order to provide shelter for farms or houses in exposed localities. And so, also, afforestation may often advisedly be embarked upon in order to render the adjoining country fit for agricultural purposes. And though such opportunities are not very frequent in this country, partly on account of the moist climate which already naturally prevails, yet they do exist.

In this connection, it may be well to note that in Belgium, and in other places in Europe, certain tracts of land, formerly useless for agriculture, have been rendered fertile in conse-

quence of the shelter afforded, and of the increased rainfall and humidity of the atmosphere, resulting from the afforestation of a part of the area.

And on the other hand, the evil effects of the destruction of forests have in places been very evident. Districts which once were very fertile have become almost barren ; the rainfall in the growing season has almost vanished ; and the summer temperature has become greatly increased. Such examples are to be found in parts of Austria, in Cyprus, and the Russian Steppes.

THE EFFECTS UPON THE LABOUR MARKET.

As to the Direct Effects of Afforestation with respect to Labour.—When considering this aspect of the question, it is necessary to have regard to the annual cost of labour which a normally stocked forest area involves.

This of course will vary a great deal, according to the cost of labour per day, the length of rotation under which the timber is grown, the kind of timber grown, etc., etc. But, on an average, it may be taken that normally stocked areas under high forest, which are regenerated artificially (by planting), will involve a **minimum** expenditure per acre per annum of 8s. 6d.¹ for labour only ; and that normally stocked areas under coppice with standards, or high forest with coppice, will involve a minimum expenditure per acre per annum of 11s. 9d. for labour only. This latter price includes the "making up" of the underwood.

In neither case, however, do these sums include the cost

¹ The labour expenses in high forest are made up as follows :—

General expenses in respect of ditches, roads, fences,

thinning and pruning (labour only), etc.

£
o
2
3

Labour on planting, fencing, and cleaning young crops

o
1
0

Felling timber and making up cordwood and faggots

o
5
3

Equals	£ o 8 6
--------	------------------

Add, for Haulage

o
4
0

Total cost

£
o
12
6

of labour spent in raising young nursery plants, nor the average labour cost per acre per annum, of hauling the produce to the merchants' yards or to the railway station, etc. Such extra cost for **manual labour** only would probably average about 4s. per acre per annum, if the average distance along which the timber, etc., had to be hauled were from $3\frac{1}{2}$ to $4\frac{1}{2}$ miles.

Hence the minimum **cost of all manual labour expenses** incurred on nominally stocked areas of forest land (including haulage to market) may be reckoned at **from 12s. 6d. to 15s. 6d. per acre per annum**. Now these labour expenses per acre are very much below those which are incurred on an ordinary "mixed" farm, or even on a purely "grass" farm. And hence any afforestation of land (other than mere "sheep runs") which is at all adapted to farming, would result in diminishing the amount of labour that could otherwise be directly employed in the district.

And on the other hand, the afforestation of purely waste land, or land used merely for sheep runs, would necessitate the permanent employment of additional labour.

However, notwithstanding that a permanent loss of employment is incurred if afforestation be carried out on land now farmed in the ordinary manner, it may be advisable, if there be only a small area of woodlands in any neighbourhood, to afforest a portion of such land. For, whereas the demand for labour on a farm is usually greatest during the summer months, and is very small during the winter months, the greater part of the work required to be done on forest areas can be executed in the winter, late autumn, and early spring. Hence regular employment all the year round, could be found for a given number of men; and this condition of affairs is infinitely preferable to that of having a considerable number of men out of employment during the winter months, even though a somewhat greater number might find employment during the summer.

However, the financial aspect of afforestation will usually have to be considered before such side issues as the effect upon the labour market.

As regards Afforestation as a Means of affording Work for the Unemployed.—Within recent years there has been some considerable discussion as to the advisability of adopting schemes of afforestation as a means of providing work in the winter months for those who may be out of employment.

It has been urged that even if such schemes did not pay financially, they are justified and advisable, inasmuch as “relief works” of some sort must be embarked upon, and the planting up of land gives employment in the winter months.

Now, apart from the financial losses which will probably result from most schemes of afforestation embarked upon in order to provide “relief works,” a careful consideration of the whole matter should convince even the most enthusiastic supporter of such schemes, that the afforestation of land is singularly unsuited as a means of affording winter employment for those who may be seeking work.

Among the more important reasons why afforestation “relief works” cannot be considered advisable, may be mentioned the facts that the cost of the manual labour required in the winter months, in order to establish a crop on maiden land (including cleaning for the first few years), represents only about one-third¹ of the total outlay expended in planting, fencing, cleaning, etc. ; and that about an acre of land must be acquired for every £2² that can be distributed as wages in the winter months.

Hence, supposing that land could be acquired for £8 an acre, and that the cost of planting, fencing, and cleaning the young crop, etc., were £6 per acre, then, for every £2 that can be distributed as wages in the winter months, a capital of £14 is required. So that, in order to provide 100 men with winter work for 16 weeks, at £1 per week, it would be

¹ This, however, must vary a great deal.

² This depends upon whether planting be done in pits or by notching, etc. ; 1 acre to £2 in wages has been taken as an average, though if the notching of seedlings were adopted, a greater acreage would be required. On ordinary waste land trees should seldom be planted in pits.

necessary to acquire 800 acres of land, and to expend a total sum of £11,200. And although ultimately some return on this money may be looked for, yet many years must elapse before any revenue is derived from the money thus expended.

It is a *sine quâ non* that the expenditure on any more or less unnecessary work, undertaken in the nature of "relief work," should be almost entirely on behalf of the cost of the manual labour required for such work.

There are, moreover, several other objections to any schemes of afforestation undertaken in the nature of relief works, amongst the more important of which may be mentioned the following:—

- (1) In frosty weather, when the distress arising from unemployment is most severe, all planting operations must be suspended.
- (2) There is usually no suitable land for afforestation near the big cities and towns; and if land be acquired at a distance, all expenses will be greatly increased, as, for instance, the cost of railway fares, living and sleeping accommodation, etc., etc.
- (3) If somewhat high-priced agricultural land be acquired in the vicinity of the cities or towns, the chances of obtaining any ultimate profit will be very much lessened; and the amount of the annual labour, at present employed on such land, will be much reduced, thereby increasing rural depopulation and lack of employment for the doubtful benefit of providing employment for others for a few weeks in the winter months.
- (4) Planting requires considerable skill, and the casual labour of inexperienced "hands" can only be beneficially made use of to a slight extent.

THE FINANCIAL RETURNS WHICH AFFORESTATION IS LIKELY TO YIELD.

The Financial Aspect of Afforestation, on the assumption that the prices obtainable for timber will remain at their

present levels, is fully considered in another portion of this book (*vide* Chapter XII). It is there shown that if money be borrowed at 4 per cent. interest, a direct loss will usually be incurred by planting land, the soil and situation of which may be classed as Quality II., with such trees as Beech, Norway Spruce, Silver Fir, Scots Pine, Oak, and Weymouth Pine, and this even though the land could be acquired rent free. The losses are greatest in the case of the first mentioned trees. If, however, money could be borrowed at $3\frac{1}{2}$ per cent. interest, the losses would not be so great, and, in the case of Weymouth Pine, a small rental equivalent of 1s. 2d. per acre per annum would be returned for the land, if the cost of establishing the crop, including fencing and cleaning for the first few years, were £8 an acre.

If, however, the cost of establishing the crops could be reduced to £5 an acre, small rentals could be earned by all the crops, except Beech.

So, also, if money could be borrowed at 3 per cent. interest, still better results would be achieved.

On the other hand, it is shown that such crops as Douglas Fir, Larch, and Ash, will, if all goes well, not only pay 4 per cent. interest on the cost of establishing the crops, but will yield in addition a handsome rental for the land.

Other trees which pay well in most cases to grow at present prices are Black and White Poplars, Willows, for cricket bats, and Spanish Chestnut. Also, although their value in this country has not been proved, such trees as Black Walnut, Sitka Spruce, Tulip Tree, *Thuya gigantea*, *Cupressus macrocarpa*, Oregon Ash, and the White Ash, will probably yield excellent results; although any planting of such trees must, at present, be looked upon in the light of an experiment.

Furthermore, with reference to the yearly rents which crops of timber may be expected to return, as shown in Chapter XII., it should be noticed that these data have reference, for the most part, to crops grown on land, the soil and situation of which is classed as Quality II. If the soil and situation were Quality I., the crops would yield much

better yearly rentals; but if the soil and situation were Quality III. or IV., the yearly rentals yielded would be much less, and any losses sustained would be much greater. And therefore, when contemplating afforestation, it is most important to accurately gauge the quality of the soil and situation.

In this connection it may be stated that there is very little land which can be classed as Quality I. for any of the valuable trees, except the Pines, which is not already profitably employed for farming or otherwise.

There are of course vast areas of "waste lands" in Great Britain; but these, for the most part, are only suitable for the growth of **coniferous** trees, and must generally be classed as Quality II., or III., or IV. The total area of waste lands in this country which is at all suitable for tree growth, is purely a matter of conjecture. One writer¹ suggests about $2\frac{1}{2}$ million acres in Great Britain, and $\frac{3}{4}$ of a million acres in Ireland. But whatever the amount may be, **any attempt at afforestation of waste lands** on any large scale, **must, if the present prices** which are obtainable for timber **remain unaltered, result in a colossal failure**, unless indeed money can be borrowed at a very much lower rate of interest than is at present possible. Financed at 3 per cent. or $3\frac{1}{2}$ per cent. interest, such schemes can never pay with trees such as Scots Pine, Norway Spruce, Silver Fir, Weymouth Pine, Beech, or Oak.

However, there are certain areas of waste land, especially on the northern aspects, which may often be profitably planted with Douglas Fir, Larch, Poplars, or Ash. Indeed, the Douglas Fir, along perhaps with Sitka Spruce or *Thuya gigantea*, may prove most valuable for planting extensively on waste lands, and will, in all probability, often render advisable the afforestation of land which could otherwise only be afforested at a great monetary loss.

But, of the utility of these trees on the poorer classes of land, it is as yet too soon to speak; though it is certain that, unless indeed the atmosphere be continually very

¹ Nisbet, in the *Forester*, vol. i., p. 95.

moist, they will only succeed on fairly deep soil containing plenty of moisture.

As regards the choice¹ of trees that may be planted on waste lands, it may be accepted as a general rule that land which is covered with heather, or at any rate on which the heather has long been established, is almost always too acid for the growth of any valuable broad-leaved trees; and therefore the choice must be confined to the conifers.

However, apart from the afforestation of waste lands, it will nearly always pay well, even at present prices, to replant any land from which a crop of timber has just been removed. For such land will generally be suitable for planting some of those species of trees which are very profitable, even though an unprofitable species may have just been cleared. And even if it be necessary to replant with a species which is not at present profitable if planted on maiden land, yet, if the land be clean, a profit may often be realised owing to the decreased cost of establishing the crop.

Land from which a crop has been removed is usually practically worthless except for replanting; for the cost of converting it into farming land is nearly always prohibitive.

So also, there are large areas of land now let to farmers at low rents of about 5s. to 7s. an acre, which are very inferior for farming purposes, but which, if afforested, should easily return rentals equivalent to 9s. or 10s. an acre, or considerably more, if suitable for the growth of Douglas Fir or Black Poplars.

Considerable quantities of such land exist on most estates on the **northern aspects**, on which, it should be noted, tree growth usually flourishes best; whereas land with a northern aspect is always inferior for farming purposes. Such land, also, usually exists in considerable quantities in districts where the surface soil is shallow, but where there is a very disintegrated subsoil rock. However, unless a rise in the price of home grown timber be assured, it is hardly likely that any considerable number of landowners will deem it expedient to sacrifice an existing present rental for the

¹ This matter is fully dealt with in Chapter V.

equivalent of a small increased rental, the accumulated value of which can only be realised after the lapse of a considerable number of years; since, until such time, a considerable capital must be locked up, without any yearly income being received. Furthermore, the profitable production of timber is penalised by the present incidence of local taxation; the ever growing tendency to a rise in rates; and the levying of charges for "extraordinary traffic," occasioned by the removal of timber.

A consideration of the foregoing leaves little doubt that, generally speaking, there is little inducement from a financial point of view to afforest land on any large scale, except when such crops as Douglas Fir or Poplars, or (in many cases) Larch or Ash can be grown, unless, indeed, substantial rises in the prices of timber should occur and be maintained.

As to the Possibility of Permanent Advances in the Price of Timber.—Inasmuch as any great schemes, relative to the general afforestation of waste lands, must end in failure unless greater prices for timber be realised in the future than at present prevail, almost all advocates of such schemes have persuaded themselves, and endeavour to persuade others, that a timber famine is imminent, or at any rate a famine in coniferous timber; and that, in the near future, the prices realised for home-grown timber will be infinitely greater than those which have prevailed for the last few years. Now, that there is some possibility of a general rise in prices, it is impossible to deny. But the whole question is such a very complicated one, and depends upon so many widely different circumstances, that it is at present impossible to arrive at any definite conclusion upon the subject.

Nevertheless, this matter concerning the probable trend of prices and the available timber supply in the future, should receive the earnest attention of all who may be interested in the welfare of British Forestry.

Stated briefly, the following are some of the chief considerations which may be urged on behalf of, and against,

the adoption of general schemes of afforestation, from a purely financial point of view:—

Considerations in favour of General Afforestation Schemes in this Country:—

- (1) The climate of this country is admirably suited for tree growth.
- (2) This country at present imports enormous quantities of coniferous timber, which, if grown at home, would represent the yearly production of about 10 million acres of land.
- (3) The easily available supplies for export, in the chief exporting countries in Europe, are rapidly diminishing; and European countries do not at present supply the total requirements of the whole of Europe; and these requirements are continually increasing.
- (4) The prices of timber will probably rise when the produce of virgin forests is no longer forthcoming.
- (5) In the advent of a change in the fiscal policy of Great Britain, prices of home-grown timber would advance if an import duty were levied upon foreign timber.
- (6) As areas become afforested, so, it is asserted, will new local industries, utilising wood as their raw material, be established; and thus, better prices should be obtained for timber.

This, however, is very problematical, for it has not occurred in many well-wooded districts where there is a difficulty in marketing the timber.

- (7) Improved methods could be adopted to some extent in the marketing of timber; thereby securing to the grower a better price. Such methods would include the semi-conversion of timber in the locality where grown.
- (8) The price of certain kinds of timber will probably rise considerably owing to special circumstances. For instance, Poplar wood,¹ on account of its fire-

¹ The non-inflammability of Poplar wood has long been recognised by land agents in hop districts, and used, in consequence, for the

resisting properties, should be largely used for all internal boarding in house building—*e.g.* boards for flooring, lining, sarking, etc. Hence an increase in the price of the timber may be anticipated.

Considerations which point to the Inadvisability of General Afforestation Schemes in this Country:—

- (1) The present forest area in Europe is far greater than is necessary to supply the amount of timber annually required in Europe; and a small advance in present prices would enable the timber on immense areas to be profitably marketed. The same result would follow if increased facilities for transport were provided in districts from which it is impossible, at present, to profitably export timber.

And moreover, apart from such industries as the manufacture of wood pulp, a woodland area of $\frac{3}{4}$ of an acre, of average quality, per head of population will easily provide enough timber for all domestic requirements—the requirements of Great Britain are about one-half of this amount—and, on the basis of $\frac{3}{4}$ of an acre per head of population, the forest area of Europe, exclusive of Russia and Finland, is more than sufficient. Furthermore, the forest area of Russia and Finland shows a surplus of 400 million acres of forest land, after deducting $\frac{3}{4}$ of an acre per head of population of these countries; however, much of this forest in Russia and Finland is practically worthless, and must always remain inaccessible.

- (2) The forest area of Canada, producing, or capable of producing, good marketable timber, is about 300 million acres. This area, if properly managed and exploited, could perpetually supply, according to

battens of the floors of hop oasts. It is greatly to be desired that the model bye-laws of the Local Government Board, and also the bye-laws of the Local Authorities of all big towns and cities, should specify the compulsory utilisation of Poplar wood, in preference to Deal and Fir, for use, wherever possible, in building construction.

present demands, all the timber required by the whole of Europe, in addition to Canada's domestic requirements.

- (3) The forest area of Siberia is immense, and must in future generations help to prevent any shortage in the world's timber supply.
- (4) The majority of waste lands in this country are far removed from all consuming centres, and, owing to the fact that the transport of timber must generally be by rail or road, the cost of marketing home-grown timber will, in many cases, exceed the cost of marketing in Great Britain that which is grown in foreign countries. For instance, Swedish timber, grown within two miles of the banks of one of the rivers flowing into the Baltic, will probably not have cost in transportation, from the place where the log was felled to any large British port, more than about 4d. to 5d. a cubic foot, and sometimes even less. But on the other hand, British grown timber will often have cost twice or thrice that amount before it can be delivered at a large consuming centre. For, often, the British grown timber has to be hauled 6 to 8 miles to a station, and then perhaps 50 to 60¹ miles to some large town; whereas the Swedish grown timber, as instanced, would be taken on sleighs to the river's edge, or perhaps shot down a timber slide into the river, and then it would be floated down the river to the saw-mills, at an almost infinitesimal cost, and then shipped direct to a British port.²

So again, timber can be felled near the coast of British Columbia, or in parts of Vancouver Island, and can be delivered at a British port at a cost for

¹ It should be noted that if large areas were afforested, any small local markets would soon be glutted, and the large consuming centres at a greater distance would have to be sought.

² Timber can be shipped from a Baltic port to London at about 2½d. to 2¾d. per cubic foot.

transportation¹ which will not exceed that which is often incurred in the case of British grown timber. Furthermore, with reference to the cost of the importation of Canadian timber, there is every probability that, on the completion of the Panama Canal, the rates from the Pacific coast to Great Britain will be less than they are now. So also, much timber may, in the future, find its way to this country *via* Hudson's Bay, at a very low rate.

- (5) Even if a timber famine were certain, it would often be preferable, from a financial point of view, to re-afforest easily accessible areas in foreign countries than to afforest waste land at home. For, apart from the question of transportation already referred to, it will often be possible, especially in countries with a cold winter climate and a short growing season, or wherever the surface of old forest land is clean, to raise crops from seed at a minimum expense; whereas, owing to the warm, moist winter climate in this country and the long growing season for most vegetation, it is usually very expensive, and often almost impossible, especially on maiden land, to raise crops from seed. And then again, in foreign countries there is often no necessity to fence a young crop from rabbits, whereas in this country it is practically always necessary. Now, a sum of 30s. per acre spent on fencing, will, at 4 per cent. interest, represent a debt on the crop of over £50 at the end of a 90-years rotation; this is equal to a tax of about 3d. per cubic foot on the final yield obtained from a crop of Scots Pine.
- (6) The growing popularity of the use of creosote as a preservative for timber, will tend to lessen the quantity of timber used for fencing, weather boarding, etc., etc.; and it will also tend to raise the prices of inferior timber, or to reduce the prices

¹ Timber can be shipped from Vancouver City to London at a cost of about 8½d. a cubic foot.

AN INTRODUCTION

of the more valuable timber. For instance, a creosoted fence of Poplar wood would last longer than, and for most purposes be as valuable as, an Oak fence made of untreated timber.

- (7) Except as already indicated, afforestation cannot pay unless the prices of timber advance substantially. But, as there is no guarantee that prices will advance, money spent in afforestation may only too often prove to be a very bad investment.
- (8) There is an ever-growing tendency for the rates and burdens on land to increase.

The above represent a few of the facts relating to afforestation upon which it is possible to base an opinion upon the subject. But in view of the great uncertainty which prevails, and of the long period which must elapse before any returns can be anticipated, it would seem impossible to deny that afforestation, dismantled of its sentimental clothing, is other than an hideous gamble in "futures"; for, apart from fluctuations in the prices of timber, forests are liable to destruction by hidden dangers, such as insects, fungi, and fire, the number of which is legion.

No doubt a fairly strong case, based merely upon statistics of the acreages under forest and of the imports and exports of timber into, and out of, various countries, can be made out in favour of afforestation. But such hastily formed advice, based upon a portion only of the facts of the case, is about comparable with the advice of those so-called "poultry experts" who rashly assert that egg production on a large scale must pay in this country; and, to lend colour to their assertions, they never tire of quoting, with the greatest accuracy, statistics showing the imports of eggs from foreign countries; and this, too, in spite of the fact that few, if any, have ever succeeded in making such a business, carried out upon a large scale, a commercial success.

Advocates of afforestation maintain that the Government have a national duty to perform in aiding private and public enterprise in this direction.

Schemes have been suggested whereby it is proposed that the Government should lend money to landowners for planting, at a lower rate of interest, payable yearly, than they can borrow in the open market, and that a mortgage should be created upon any land so planted. But why, it may be asked, should the credit of the community be mortgaged in order to foster a private industry of a very risky nature?

Others, again, suggest that the Government should advance money, the interest on which should be deferred and payable only after (say) fifty years, but that, as additional security, a sufficient mortgage be granted on land used for farming purposes only. If such a scheme were set on foot and largely made use of, it would, in all likelihood, result in the cry of the socialists, for the State ownership of Land, being at last realised, in respect of a considerable area.

Similar schemes have been propounded, whereby county councils, municipal councils, and other corporate bodies could provide money to undertake works of afforestation on more favourable terms than is at present possible.

Now, if in the future schemes are instituted for thus financing public bodies, it is earnestly to be hoped that no schemes, involving the deferred payment of all interest, be ever sanctioned. It will doubtless be urged that such are justifiable, inasmuch as the "profits" will be realised in the future. But supposing that, as is highly probable in so many cases, a direct loss were sustained, then a future generation must, *nolens volens*, inherit an undertaking in respect of which a heavy debt has accrued, and for which they are in no way responsible. What a legacy for one generation to leave another!

In conclusion, it may be pointed out that, if it be the duty of the Government to take steps to anticipate a possible timber famine, it would be far preferable for the Government to acquire extensive timber "limits" in Canada, in close proximity to the coast, instead of fostering and favouring schemes of afforestation in Great Britain.

By such means an investment would be made which would be immediately profitable, and which, if American history is going to repeat itself, would show an enormous capital appreciation in years to come. Would not a scheme such as this be infinitely more profitable than sinking large sums of money in works of afforestation at home?

And finally, it should always be remembered that, generally speaking, agriculture or husbandry is far more profitable at the present time than forestry, and also that husbandry necessitates a greater amount of labour per acre than can ever be profitably employed on forest areas.

CHAPTER II.

FOREST SYSTEMS.

IN a general way, woods may be classified in three main classes, viz.:—

- (1) Simple Coppice,
- (2) Coppice with Standards,
- (3) High Forest,

according to the methods adopted in bringing any area of forest land into a state of production. The system of high forest is capable of many variations, and can be still further subdivided into many distinct classes or systems.

SIMPLE COPPICE.

This system consists in growing trees and periodically cutting them over close to the ground at short intervals, usually of from 5 to 20 years. The growing stock thus found on the ground is often referred to as "underwood." The trees when thus cut over close to the ground are known as "stools," and the regeneration is said to be by "stool shoots."

It is a method that can seldom, if ever, be conducted at a profit in the present day; but it was formerly much in vogue for pure Oak coppice, which was grown for the bark it produced.

Simple coppice of Ash and Spanish Chestnut is, however, grown for hop poles in hop districts, and also in the potteries district for "crate" wood.

COPPICE WITH STANDARDS.

Under this system a combination of simple coppice and of high forest is produced. There is an overwood of "standards" or "stores," which are grown for mature timber, and an underwood which is produced by the periodic coppicing of a portion of the trees.

The standards are not all of the same age, for a certain number are planted and others grow from seed at each time that the stools are coppiced; hence the standards are distributed in age classes varying from each other by the number of years that elapse between each cutting of the underwood.

The number of trees of each age class should vary according to their age; being more numerous the younger the age class. Trees belonging to different age classes should be evenly distributed over the whole area; there will therefore never be a clear felling of the standards over any large area.

Where this system is adopted, **only thinly foliaged trees can be grown as standards;** for instance, Oak, Ash, Larch, Black Poplars, Black Walnut, and Acacia.

For the underwood, the most suitable trees to grow are Spanish Chestnut, Ash, Hazel, Hornbeam, Sycamore, Norway Maple, and Alder.

HIGH FOREST SYSTEMS.

These embrace :—

- (1) The Selection System.
- (2) The Group System.
- (3) The Compartment System.

And again, the compartment system may be further subdivided; thus, there may be compartments of :—

- (a) Even-Aged High Forest.
- (b) Two-Storied High Forest.
- (c) High Forest with Coppice.
- (d) High Forest with Standards.

1. The Selection System.

To all intents and purposes, this is the system as adopted by nature. There are trees of practically all ages over the entire area; and as they become marketable they are cut; regeneration is practically continuous, and is almost always brought about by natural agencies.

It is a system that should never be practised except in the case of **shade-bearing trees**; and it is more suited for the growth of Beech than for any other kind of timber. Inasmuch as the area is never clear cut, the system has much to recommend it on poor soils or in exposed situations, where the laying bare of the soil is avoided. Again, when sporting is a consideration, it will perpetually afford a certain amount of somewhat inferior covert for game preservation. It is, however, absolutely essential that rabbits should be exterminated, otherwise natural regeneration cannot take place.

It is the system under which Beech are grown on the Chiltern Hills.

In practice, mature timber will only be cut on the same area about once in every 10 to 20 years.

2. The Group System.

This system is an expansion as it were of the selection system. It derives its name from the fact that fellings and regeneration are started in groups or patches.

These groups or patches vary in size from about 20 yards diameter up to $\frac{1}{2}$ to 1 acre. Its derivation from the selection system is very evident, for under the selection system, wherever a big tree is felled, a vacant patch is left; and, for the greater part, the young trees that will cover this patch will all be of the same age. When one group or patch is regenerated, another is then felled and regenerated in its turn; and so on, until the whole area is regenerated. The groups are seldom of similar shape, and usually they are seen as strips or bands encircling the various centres where the regeneration was begun. There is always a period of years

between the felling of one group and its neighbour ; by this means only a small area is laid bare at a time, and the young trees are protected from wind and sun by the other trees adjoining. The regeneration is almost always brought about by natural agencies, and takes place from seed shed from the neighbouring trees. If the groups are large, it is advisable to leave a few trees on any group that is being felled, so as to insure a more even seeding.

When dealing with any area under this system the usual plan is to endeavour to bring about the complete regeneration of the whole area in a period of from 30 to 45 years, after which it will be some 50 to 60 years, according to the length of the rotation, before the timber on the original group will be ready for the axe.

It is a system that is **only suitable to shade-enduring trees**, which are fairly storm-proof. On the Continent, Silver Fir is often regenerated in this way, but the possibility of regenerating Silver Fir naturally in this country, seems to be confined to a few localities.

The method should give good results with Douglas Fir or Sitka Spruce or *Thuya gigantea*.

3. The Compartment System.

This system of high forest is capable of many variations, and will be considered under the subdivisions as already indicated. But there is a broad distinction between this system, including all its variations, and the two former systems described, which is evidenced by the fact that under the compartment system, fellings and regenerations are referable to compartments or large blocks of land of 5, 10, 20, or even 50 acres in extent ; whereas under the group system fellings and regenerations take place only on small groups or patches at a time, and under the selection system the operations are still more sporadic.

These compartments are preferably made rectangular in shape, with sides in the proportion of 3:2. The long side should always be at right angles to the direction of the prevailing winds, for by this means the danger from windfall in

neighbouring compartments, owing to the felling of any particular compartment, will be much lessened.

The compartments should be separated from each other by grass rides or roads. Narrow rides about 12 to 15 feet wide should run parallel to the longer side, and should be cut more or less at right angles by broad rides or roads 24 to 30 feet wide. However, from sporting considerations alone, it may be advisable to make the rides broader than this.

(a) **Compartments of Even-aged High Forest.**—This is the most usual system adopted in growing timber, and the method practically explains itself. At the end of the rotation, the area is generally clear cut and replanted. Sometimes, however, regeneration is brought about naturally, either by a seeding from a light canopy of mother trees left standing over the area, which method is specially suited for the regeneration of beech, or else by a seeding from neighbouring trees, on to a cleared area, in which case the seed should be light and easily carried by the wind. This latter method is suited for the natural regeneration of Scotch Pine or Corsican Pine; and in countries where the seed ripens sufficiently, Larch may be regenerated in this manner.

These even-aged compartments may be either mixed or pure. All **thickly foliaged shade-enduring trees** may be grown pure, but **thinly foliaged trees** should not usually be grown pure, because as they approach maturity the canopy always becomes too thin, which results in an abundant growth of rank grass, brambles, bracken, and the like. However, under the following conditions, pure crops of thinly foliaged trees are admissible, namely, when—

- (1) High exposed elevations are being planted and shade-enduring trees would not be advisable;
- (2) The rotation is very short;
- (3) They are afterwards underplanted with shade-enduring trees.

(b) **Two-Storied High Forest.**—Under this system there are, towards the end of the rotation, two crops of trees, of widely different ages, growing on the same land.

It is brought about by underplanting or undersowing an

existing crop, which has been heavily thinned. Only thinly foliated trees, such as Oak, Ash, and Larch, should be underplanted, and the trees used for the undercrop should only be shade-bearing trees. Silver Fir, Beech, and Hornbeam will bear the greatest amount of shade, and then perhaps *Thuya gigantea* (*T. plicata*). These trees will usually form the undercrop.

If, however, the canopy is thin, Douglas Fir or Weymouth Pine, or Spanish Chestnut may be used. Norway Spruce cannot be recommended, as, in this country, it is not tolerant of much shade, and it robs the overwood of too much moisture.

Under the orthodox method the two crops are harvested at the same time; but there is no necessity for such a course. If desired, the older crop can be removed and the younger crop can be allowed to grow on, until of larger dimensions: for if the trees forming the older crop are well grown and have not unduly large crowns, little harm will be done to the younger crop, especially if it consists of good stout poles.

Where Ash is underplanted, it must almost always be removed before the undercrop, as it comes to maturity so early, viz., from 60 to 75 years.

(c) **High Forest with Coppice.**¹—This system is somewhat similar to the system of two-storied high forest, but it involves the periodic cutting over, at ground level, of the undercrop.

The standards must consist of only thinly foliated trees, such as Oak, Larch, Ash, Black Walnut, and Black Poplars. The most suitable trees for the coppice are Spanish Chestnut, Hornbeam, Ash, and Alder, and to some extent Beech, but the stools of the latter are not usually long-lived, and its produce, unless large, has not much value.

The essential points in which this method differs from ordinary coppice with standards are, that the standards over a given area are all of one age, and thus height growth is

¹ This system has been named and recommended by the author as a substitute in many cases for the more common system of coppice with standards.

stimulated, as they help to draw each other up; there is a greater proportion of them per acre; and the well-being of the coppice, or otherwise, receives comparatively small consideration.

(d) **High Forest with Standards.**—This is a system which is characterised by a small crop of standards, say, 15 to 30 per acre, growing over an undercrop of shade-bearing trees. It is rather similar to two-storied high forest, but it implies not only a small crop of standards, but also, usually, a crop of standards growing on for a second rotation so as to produce extra large timber.

It is sometimes adopted in the growing of Oak timber. For instance, Oak may have been planted along with other trees, which have been harvested when mature, and then the Oak are underplanted and allowed to grow on for a second rotation.

THE CHOICE OF SYSTEMS.

It is very difficult to say which system is preferable to another; so much will depend upon the given circumstances of any particular case. But there are certain merits and demerits appertaining to each of the systems to which due consideration should always be given.

In cases where amenities for game preservation are of paramount importance some system of coppice will usually be decided upon; but when financial results alone are considered, the choice will often fall upon some system of high forest. In this latter connection, however, there is not that great difference in the nett financial returns as is usually supposed, if regard is had to the invested capital in each case.

On really poor land no form of coppice should be attempted, for the periodic laying bare of the soil has a deteriorating influence, and the coppice produce itself, which is young and sappy, removes a far greater quantity of plant food from the soil than is lost by the removal of an equal volume of mature timber.

For financial reasons, simple coppice can hardly ever be

recommended ; for its growth will usually result in a direct loss to the owner, owing to the low price that now obtains for coppice produce.

Coppice with standards can be recommended as affording covert for game. Only the timber of thinly foliated trees should, however, be grown as standards, viz.:—Oak, Ash, Larch, Black Poplars, and Black Walnut, and perhaps the Tulip tree (*Liriodendron tulipifera*), and the White Ash (*F. Americana*), and the Oregon Ash (*F. Oregonia*), and the Picardy Poplar.

The timber produced under coppice with standards will usually be of good girth, but it will not be so high, nor of such good technical quality as that produced under even-aged high forest ; especially is this the case with Oak. Furthermore, it will usually taper to a great degree. As usually practised, too much attention is paid to the welfare of the underwood, considering the low returns which it yields.

It is with a view of increasing the nett returns, and the height, quantity, and quality of timber produced, and at the same time of preserving the amenities, which are presented by an undergrowth of coppice, that the **system of high forest with coppice is recommended in most cases in preference to that of coppice with standards.** The same species of trees will be grown for timber as under coppice with standards, but they will be numerically somewhat greater.

The value of the coppice may be practically nil, except that cut when the standards are only saplings, or when nearly mature, so that, apart from its value as covert, it must be looked upon simply as a natural means of pruning the young standards, and afterwards, as keeping the soil clean, and preventing the growth of rank grass and weeds, and thus ultimately enabling a new crop of standards to be raised at a minimum expenditure.

The growth of the coppice can always be favoured as seems expedient ; it will suffer most when the standards are from 20 to 40 years old, but provided the stools are not killed, this does not matter. Near the edges of the rides it will

always be advisable to favour the growth of the coppice, and thus form an effectual screen and additional covert for game preservation.

Another point in favour of this method is, that when the standards are finally felled, the raising of the new crop is confined to a minimum area, the whole of which, where rabbits are numerous, can be fenced *en bloc* at a cheaper rate per tree than is usually the case when the young trees are each separately surrounded by a piece of netting or tarred felt; and also, the labour in looking after these young trees, and preventing suppression by the coppice, is very much less than where the trees are spread over a large area.

The quantity and quality of timber that will be produced by this method is, so far as the overwood is concerned, about similar to that grown as the overwood in two-storied high forest. Under this latter system, however, the total quantity of timber produced will be greater and more valuable than the total quantity produced where coppice growth forms part of the crop. These three systems should only be attempted, however, when there is a sufficiency of moisture in the soil, for the existence of an undercrop demands more moisture in the soil than is necessary if such crop were growing in the open. Also, the soil itself must at any rate be of fair quality. Under two-storied high forest there are two periods in one rotation, when there is a young crop affording covert for game; hence, for this reason, it will often be preferred to compartments of even-aged high forest.

When, however, it is desired to grow a maximum amount of timber which shall also be of the highest quality, the preference must be given to even-aged high forest at any rate for the shade-bearing trees, and also for such trees as Scots Pine and Corsican Pine, which, until they approach maturity, require a very close canopy, and are quite unsuited for being systematically underplanted, although the latter may be underplanted if the rotation is a long one.

Except in the early stages of their existence, these compartments will afford no suitable covert whatever for game, if they have been properly managed.

On poor, dry, exposed, sandy or gravelly soils, even-aged compartments of Scots or Corsican Pine grown on a short rotation are practically the only timber crops that can advisedly be grown.

However, for the growth of Oak, Ash, and Larch, this method is not so suitable as two-storied high forest; and if the land is too dry for underplanting, it is too dry for the growth of good Oak, Ash, or Larch, unless indeed the two latter are grown on a very short rotation. Even-aged mixtures of Oak, or Ash, or Larch, with the shade-enduring trees will give perhaps the greatest outturn in timber, but the shade-enduring trees must be such that they do not overtop or suppress the light-demanding trees.

The system of **high forest with standards cannot be recommended**. Financially, it will seldom prove remunerative to leave the trees for a double rotation. The only crop to which it is at all suitable is the Oak, but there is a great tendency for the trees to become stag-headed and to throw out numerous epicormic branches all along the stem.

Now, on poor soil, or in exposed places or wherever the conditions for the growth of timber are inimical, some system should be adopted, if possible, which avoids clear cutting the whole area.

With even-aged compartments of high forest, it is often possible to obtain natural regeneration under a shelter wood of mother-trees (or artificial regeneration may be adopted); but the greatest shelter and protection is obtained under the group system and the selection system. However, only shade-bearing trees can be grown under these two systems. Under the selection system, the maximum amount of shelter and protection is obtained, and there is at all times a certain amount of covert for game. But the timber produced will usually be somewhat tapering and not of very high technical quality.

Under the group system, the advantages of shelter and soil protection which exist under the selection system, are retained, but there will be a larger proportion of trees of good technical quality, especially if the groups are large.

On the other hand, as the groups are enlarged, so will the protection from wind be lessened.

The total quantity of timber produced under the group and the selection systems, does not vary materially from that produced under even-aged high forest.

As these two systems depend upon natural regeneration, though artificial aid may be given, it is imperative that rabbits be exterminated, or the whole areas will have to be wired in.

CHAPTER III.

THE NURSERY.

WHEREVER planting operations are annually carried out, it is almost imperative to raise the plants in a home nursery. And even if planting be only carried out occasionally, it will in many cases be advisable to make a temporary nursery for a year or two ; especially if the area which it is proposed to plant be of any considerable extent. In all cases, Hawthorns or "Quicks" should always be raised for estate fencing purposes.

The great advantages which are presented by the use of plants raised in a home nursery may be summarised as follows :—

- (1) There is no delay¹ between raising the plants and planting them out. Plants in trade nurseries are often raised months before they are ordered, and "sheued" into lines, so as to have the land cleared.
- (2) They can usually be raised for a very much smaller sum than they can be bought for.
- (3) The exact treatment that the plants have received is known.
- (4) The quality and origin of the seed is usually known.
- (5) The plants can be accustomed to the soil and situation in which they are going to be planted.
- (6) Plants can be sent out from the nursery as they are wanted day by day, and if a frost sets in, there need

¹ If plants when ordered from a trade nursery are not in stock, they are obtained elsewhere, and a double railway journey is the result, as, for the sake of appearance, they will be dispatched from the nursery where ordered.

be no plants that have been raised and await planting out, and thus the mortality among freshly planted trees is reduced to a minimum.

- (7) The risk of introducing insect and fungoid attacks is minimised.
- (8) No "culls" are ever used inadvertently.¹

FORMATION OF A NURSERY.

(1) Choice of Site.

Generally speaking, a **northern or north-western aspect is preferable** for a forest nursery.

On southern or eastern aspects the majority of trees will start into growth too early, and hence there is a great danger that they will suffer from late spring frosts; and on eastern aspects there is the additional risk of the plants suffering from the effects of cold, dry, east winds.

The actual altitude at which the nursery is situated is not a matter of very great importance in this country; though trees which are intended to be planted out at high altitudes should, advisedly be obtained from nurseries at similar altitudes. The relative altitude, however, is a matter of the very greatest importance. **A low relative altitude should never be chosen**; for late spring and early autumn frosts are far more frequent in valleys, dells and coombes, than on higher ground. For the same reason, a nursery site should never be chosen on a large expanse of level ground; gently sloping ground is to be much preferred.

Care should be taken that a very sheltered place is not selected; in fact, if the greater part of the planting is going to be done on exposed land, the nursery itself should be somewhat exposed, and the seedling trees can artificially be given such shelter as may seem expedient.

If possible and convenient, the nursery should be

¹ In trade nurseries it is a common practice to transplant the vigorous plants from a bed, and to leave the weaklings or "culls" for another year. Such culls, the produce of weakly seed, are worthless, but they are unfortunately often used.

near the head woodman's cottage, and a plentiful supply of water should be at hand or capable of being easily laid on.

On account of insect attacks, it should be far removed from the estate yard, where the unbarked timber forms a suitable breeding place for some injurious insects. And if possible, it should be away from old pasture-land, and areas of hardwood trees, for otherwise the ravages of the cockchafer grub will probably be a constant source of trouble.

And on account of beetles and pine weevils, it should not be near coniferous woods.

The best soil to select for a forest nursery is a sandy loam. A clay soil should always be avoided, for fibrous roots are not easily formed in it, and the soil has a tendency to "run together" and "set," thus rendering the rearing of seedlings an impossibility except at great expense. A depth of about 18 inches of soil is almost essential, as the supply of moisture will be more constant and plentiful.

(2) Size of the Nursery.

This must depend upon the area that has to be planted annually, and also upon the size and the age at which the plants are going to be planted out. Roughly speaking, if 4-year-old plants are going to be planted at 4 feet by 4 feet, the area of the nursery should be about 8 or 10 per cent. of the area that is to be planted annually.

Though, if only conifers are required, about 6 to 7 per cent. of the area to be planted annually would suffice.

And, in ordinary estate nurseries, an additional space should be allowed to admit of the raising of ornamental trees and garden shrubs, and "Quicks" for fences.

(3) Laying out a Nursery.

When the site has been determined, the whole area must be carefully prepared and fenced off against rabbits,¹ and stock if necessary. If the site is an old pasture, or if trouble is likely to result from wireworms or cockchafer grubs, a good dressing of gas-lime should be given, the soil then

¹ *Vide Chapter IV.*

trenched two spits deep, and another dressing of gas-lime given and left on the surface to wash in. When trenching, all stones should be carefully picked out for use on the paths or roads, and the earth well broken up.

No plants can be put in the nursery until some months after the gas-lime has been applied, as the plants would be poisoned if put in before oxidation had taken place.

Any large nursery should be divided up into sections, of about 1 acre each, by hard roads about 12 feet wide, so that a horse and cart can be drawn along without doing damage. These sections should again be divided up by paths about 4 feet wide, so as to admit of the use of wheelbarrows or hand-carts. Then these smaller sections may be again divided up, as may seem convenient, by narrow trodden tracks 15 or 18 inches wide.

About $\frac{1}{16}$ ¹ of the nursery will generally be devoted to the raising of seedlings; and it is advisable to have this portion laid out in long, narrow beds, 4 feet wide, running north and south. These beds may then be weeded and tended from either side without being trodden upon. The broad roads can be made of broken brick, rubble, etc., and finished with a coating of ordinary road metal, and, for neatness, the earth should be kept off the sides by an edging of brick on end or of 1 inch creosoted boards; but on economic lines, this latter expense is not warranted.

NURSERY MANAGEMENT.

A portion of the nursery should always be under a "cleaning" crop, as, for instance, potatoes or roots. And "green" manuring, especially with lupins, can always be recommended for any vacant part of the nursery.

It is preferable never to use ordinary farmyard manure, as it contains so many weed seeds, but good leaf mould and the application of artificial manures will easily compensate

¹ This presumes that some seed is sown broadcast and some in drills, and that the plants are planted out in the woods when 4 years old.

for this. These manures should only be used on the cleaning crop, as, if applied directly to the trees, it might prove too stimulating, and the wood of the young trees would not get properly ripened.

(1) Seed Beds.

These must always have a very fine tilth, and a small amount of sifted rubble or ashes should be raked over the top soil, so as to prevent the soil from "running" together and forming a "cake," through which the seedlings of small seed would have great difficulty in piercing.

Over such beds as require special protection, a screen of "**peignon**" or chestnut pale fencing may be stretched over a light frame-work about 2 feet 6 inches from the ground. This is by far the most convenient way of affording to tender species protection from late frosts in the spring or early frosts in the autumn, and also, provided the beds run north and south, of affording protection from hot sun.

These screens can be very quickly rolled up, when their protection is not required.

For instance, they might be rolled up every morning and unrolled every evening during the end of April and all through May as a protection against night frosts. A cheaper method of affording this protection, but one not nearly so convenient, is to place branches of birch, with the leaves on, across the bed from side to side.

Under no circumstances should branches of conifers be used for this purpose.

(2) Liability to Frosts.

Silver Fir and **Beech** are perhaps more in need of this protection than any other common species. They are very sensitive to frosts in the spring and autumn and also to hot sun, at any rate for the first few years of their existence.

Most young trees will succumb to or be seriously injured by late spring and early autumn frosts, but of **those especially tender**, besides Silver Fir and Beech, may be mentioned Black Walnut, Weymouth Pine, Acacia, Ash (all varieties),

Spanish Chestnut, Larch (the Japanese perhaps more so than the European), Douglas Fir, *Cupressus macrocarpa*, and Spruce (the Norway Spruce perhaps more so than the Sitka) and Oak.

Whereas, those trees which are **hardest in respect of** these **frosts**, and usually not injured thereby, are Scots Pine, Corsican Pine, Austrian Pine, Birch, White Poplar, Aspen Poplar, and *Cupressus sitchensis*.

But there are some trees which may be said to occupy an **intermediate position** in this respect, and they are:— Sycamore, Norway Maple, Alder, *Thuya gigantea*, Lime, Black Poplar and Black Italian Poplar, Hornbeam, *Abies concolor* and Elm.

With reference to this matter, the date at which tender species break out into leaf is a most important point. For instance, Oak (*pedunculata*) often escapes because it is late in breaking into leaf, and Sessile Oak, which is more tender, is usually somewhat later in breaking into leaf. And so with Nordmann's Silver Fir, a very tender species, but one which usually escapes because it is so very late in starting its new growth.

It will often happen that certain species of trees appear frost-hardy in one instance and not in another, and in order to account for these differences, it is necessary to ascribe them to the individuality of the particular trees, and the pre-disposition of certain seedlings to suffer, which have been raised from the seed of particular trees growing in particular localities; whereas the produce of seed of the same species of tree, but obtained from another locality or another climate, may be perfectly hardy.

(3) Choice of Seed.

There can be no doubt that, generally speaking, the liability to spring frosts is very greatly increased in the case of seedlings of tender species, raised from seed which has been grown abroad in a country where there is a very short spring, and where there is a rapid transition from winter to summer, and where active growth is long delayed

on account of the soil being frozen in spring and the roots consequently remaining inactive. Trees grown in this country from such seed will break into leaf early, as root activity will be stimulated by the mild winters and long springs. Also, a similar result would be expected if seed from trees growing at high elevations were sown at low elevations. It is for this reason that Scots Pine raised from seed grown on the Continent are less hardy than Scots Pine raised from home-grown seed.

But it does not follow from the foregoing that home-grown seed of all species of trees is preferable where it can be procured. Such is very far from being the case.

Home-grown seed of trees whose native habitat is in a country where there are cold winters and very hot summers, should never be used unless it is proved by generations of experience to be advisable or preferable. For, unripened seed or immature seed can never produce healthy, vigorous trees.

On the other hand, though great caution is necessary, there is every reason to believe that trees whose native habitat is a country with a climate characterised by mild, wet winters and only moderately hot summers—a climate similar to that in this country—will, even when recently introduced, bear strong, healthy, and vigorous seed, for which, though produced in this country, there is every justification for using.

Such trees would be those introduced from the coast region of British Columbia, namely, Sitka Spruce, Sitka Cypress, Douglas Fir, and *Thuya gigantea*. And, if seed of these trees be imported, it is very necessary, until experience may prove to the contrary, that the seed of such of these trees as also grow at high altitudes in the Rocky Mountains, should be obtained from the coast region, and not from the mountains.

A brief consideration of the foregoing points to the **advisability of using home-grown seed of Oak,¹ Ash**

¹ The author has observed an unusual vigour in some seedlings of Sessile Oak raised in this country from seed obtained in the Darmstadt district in Germany.

(common Ash only), Beech, Birch, Alder, Scots Pine, Wych Elm, Hazel, and Hornbeam, and perhaps of Douglas Fir, *Thuya gigantea*, Sitka Spruce, and Sitka Cypress. But to use only foreign seed of Larch, Norway Spruce, Silver Fir, *Cupressus macrocarpa*, Spanish Chestnut, White Ash, Oregon Ash, Austrian Pine, Corsican Pine, Weymouth Pine, Black Walnut, and Red Oak.

With regard to this latter class, experience may prove the contrary to be the case. But conclusions should not be too hastily arrived at. It often takes generations before trees become acclimatised to new surroundings, and though the seed may be plump and the seedlings appear strong and vigorous, time alone can prove that this vigour will be maintained to maturity. In all cases, only the best seed of healthy vigorous trees, should ever be used.

It may not be out of place here to state that, when considering the advisability and the suitability of the introduction of any exotic tree, the very greatest regard should be paid to the conditions as to climate, soil, altitude, and aspect under which it thrives in its native habitat.

The success of recently introduced conifers from the coast region of British Columbia may be anticipated with far greater confidence than can justly be placed upon the introduction of species from countries with a marked continental climate, and, though care is necessary, there is no need to anticipate any such calamity from fungoid disease, as that with which the growth of Larch in this country is now attended.

(4) The Storage of Seed.

All seed that is not going to be sowed directly it is ripe must be carefully stored. The seeds of Ash (the common Ash), Yew, Hawthorn, Holly, and Hornbeam, which do not germinate until the spring after they are collected, should be mixed with sand and stored in pits or "pies" in the open, where they should remain until about March a year hence, when, as soon as they show signs of sprouting, they should be sown in drills in carefully prepared beds. All other seed

should be stored in the dry, and out of the reach of vermin. They must not, however, be allowed to become too dry and shrivelled. An ideal storehouse is one with an earthen floor and a thatched roof, similar to an apple house. Large seed, like acorns and beech mast, should be kept in barrels, and smaller seed spread over paper laid on shelves, though large quantities must be stored in bins and shovelled over at intervals to prevent them heating ; so also the barrels of nuts must be carefully looked over at intervals. No seed, however, should be stored in bulk until it is properly dry, or it will quickly heat. Seed not artificially dried should be spread out thinly on a dry wooden floor of some building, and there allowed to dry naturally.

(5) The Sowing of Seeds.

The actual date at which it is preferable to sow seeds will vary according to circumstances, but, generally speaking, sowing in nursery beds should take place towards the end of April and in May. If the laws of Nature be followed, autumn sowing would generally be the case, but this latter method is open to several grave objections when practised in a nursery. When sown naturally in the forest, the mother trees afford shelter, the ground is kept cool until late in the spring, and thus growth is retarded and the danger from frosts minimised ; and even if these frosts do occur, the shelter of the trees will keep them off the young seedlings. But when sown in autumn in a nursery, there will usually be enormous losses incurred from late frosts, unless artificial protection is given. Then again, mice and vermin make inroads upon autumn sown seed-beds, and often cause serious loss.

On the other hand, spring sowing is not without its objections. A proportion of the seed sown will often not appear until the year afterwards ; for the germinative power becomes weakened, and, in some cases, the germinative power of a large proportion of the seed is entirely destroyed. Hence, a consideration of this must modify the general rule.

The seed of Silver Fir, Elm, Poplar, and Willow will lose

its germinative power very quickly ; so also is this the case, though to a less extent, with Oak, Spanish Chestnut, Birch, Alder, Hazel, and Beech ; these latter trees retaining a good germinative capacity for about 6 months. And though other seed may keep for another year, it should never be used if newer seed can be obtained. The seed of Wych Elm, Poplars, and Willow must always be sown directly it is ripe—this will be at the end of May and the beginning of June—for its germinative power is lost in a few weeks. It should be noted that English Elm never ripens its seed in this country.

The seed of Silver Fir, which is ripe in the autumn, should usually be sown at once, but it is absolutely imperative that the seed-beds should be protected from frosts, and also from hot sun in the summer. If sown in the spring the same germinative capacity cannot be expected.

The seed of nearly all other trees is ripe in October ; though Birch ripens its seed at the end of August, and it is naturally shed up to about March. Alder ripens its seed at the end of September, and it is usually shed in mid-winter and early spring ; and Weymouth Pine ripens its seed about the beginning of September, and sheds it immediately.

There is, however, no particular reason why seeds of any common tree, except Elm, Poplar, Willow, and Silver Fir, should not be stored for a few months and sown in the spring, so as to lessen the liability to damage from late frosts and from vermin. There is another advantage in spring sowing, and that is, that the surface of the seed-bed, prepared in spring, is in a far better mechanical condition for seedlings to break through, than can ever be the case with a seed-bed prepared in the autumn. Especially is this the case where small seed are concerned ; it would not much matter in the case of Oak, Spanish Chestnut, or Beech.

Now, although spring sowing must be the general rule in nurseries, except as already stated, large seed such as Walnut, Spanish Chestnut, Oak, and Hazel whose cotyledons remain below the surface of the ground, are often sown in Autumn, though, in the case of the two former, the risks are very great ;

and of these four, only the Oak and Hazel can ever advisedly be sown in autumn. Birch may often be sown in September, as it is so very hardy ; and, as its germinative capacity is not strong, this practice may with advantage usually be adopted, though naturally it is shed at a later date.

The following table will show the average germinative capacity of good seed (spring germination, except for Elm and Silver Fir) :—

	Per cent.		Per cent.
Sitka Spruce . .	70 to 75	Beech	50
Norway Spruce . .	70 to 75	Silver Fir	40
Scots Pine . .	65 to 70	Larch (Japanese)* . .	35
Austrian Pine . .	65 to 70	Larch (European) . .	35
Corsican Pine . .	65 to 70	Douglas Fir	30
Hornbeam . .	60 to 65	Alder	25
<i>Thuya gigantea</i> . .	60 to 65	Wych Elm	25
Oak	60 to 65	<i>Cupressus macrocarpa</i> . .	15 to 20
Ash	60 to 65	Birch	15 to 20
Spanish Chestnut . .	60	<i>Cupressus stichensis</i> (?) . .	15 to 20
Lime	55		
Acacia (False) . .	55		
Norway Maple . .	55		
Sycamore . .	55		
Weymouth Pine . .	55		

* This is extremely variable, some years only about 5 per cent. germinating, and other years 65 per cent.

When seeds are bought, their germinative capacity should always be tested. It is a very easy matter. Three or four hundred seeds or more (carefully counted) should be placed on a piece of flannel spread over a soup plate ; the flannel must be kept moist by water in the plate, and the plate should be kept in the dark. After a time those seeds which fail to germinate should be accurately counted and their proportion estimated.

Before sowing seeds in the spring, it is advisable to soak them in tepid water for some hours, so as to favour rapid and even germination. The seed-beds, having been prepared

with a very fine tilth as already described, must be nice and firm ; a fine tilth on a loosely made bed is of no use whatever for small seeds. When seeds are sown they must be covered over with soil, and the thickness of this covering should not be more than twice the length of the seed. It will thus be seen that seeds like Birch, Alder, and *Thuya gigantea* require practically hardly any covering. Such very small seed will get a sufficient covering if sown on the surface, and "firmed" in with a light roller, and a little fine ashes or rubble sifted over the top, just enough to hide the seed. This grit or ashes should be first sifted free from dust ; it will prevent the surface soil from "caking."

When sowing, seed may be either sown broadcast or in drills.

If sown broadcast, the operation is quicker and cheaper, and a greater number of seedlings can be raised on any given area. On the other hand, the weeding of the seed-bed is rendered almost impossible except by cutting through any large weeds at ground level with a knife, for to attempt to pull them up would result in also pulling up many seedlings ; and then again, the danger of the seedlings being injured by frost lifting is very much increased.

Any large seed, like Acorns, Beech nuts, or Chestnuts, or Walnuts, and so also any autumn sown seed, and any seed the seedlings from which are intended to be left for 2 years in the seed-beds, should invariably be sown in drills ; and so also should expensive seed. But in the case of other seeds, it is difficult to give preference to one method over another. Small seed, sown broadcast, should be lightly raked in, and if necessary, rolled, and have a little fine rubble or ashes sifted over the top.

When sowing in drills, the drills should be made across the seed beds (which should not be more than 4 feet wide), so as to facilitate weeding.

The drills for large seed like Oak and Spanish Chestnut should be about 8 inches to 12 inches apart, and the nuts placed 2 inches apart in the drills. The nuts of Spanish Chestnut should always be sown with the point of the nut

downwards; the reverse being the case with Horse Chestnut.

The drills for smaller seed should be about 6 inches apart, just sufficiently wide to enable a man to place his foot between two rows without damaging the young plants when weeding.

These drills may be marked with a stick and line, or a special **marking board** may be used with advantage. This marking board, which is placed across the bed, has three strips of wood fastened on the under side, one down the middle and one down each edge. These strips are about $\frac{3}{4}$ inch wide and $\frac{1}{8}$ or $\frac{1}{4}$ or $\frac{1}{2}$ or 1 inch in depth, according to the depth at which it is intended to sow the seed. These strips are 6, 7, 8, or 9 inches apart, according to the distance which is required between the drills;¹ the under surface of these strips may have a V-shaped notch all the way along, so as to leave a miniature ridge down the drill, and if the seed is dropped along that ridge, it will fall to either side and the drill will be more evenly seeded.

The seed may be sown by hand or poured gently out of a "seed can," which has various cone-shaped nozzles to suit the size of various seeds. After the seed is sown, the drills are smoothed and the bed lightly rolled.

Seed should never be sown when the land is wet, or the soil will get lumpy and perhaps form a paste and interfere with germination. In order to keep off birds, etc., it is a good plan to "pickle" the seed in red lead, mixed with water to the consistency of cream, or else to mix them with red lead after soaking them in water.

It is a great mistake, and a great waste of seed to sow too thickly; but the seeding must be relatively thicker if the germinative capacity of the seed is small, than when the reverse is the case.

Speaking generally, broadcasting requires about 3 times as much seed as when the seed is sown in drills.

The following table shows the number of seeds contained

¹ Two boards may be used instead of one. In such cases, each board need have only two strips, which are placed away from each edge one-half of such distance as the rows are apart.

in each pound, and the quantity required for sowing in drills per 50 feet run if the seed-bed be 4 feet wide :—

Kind of Tree.	Number of Seeds per lb. about	Quantity required per 50 feet run.	Distance apart of Drills.
		Lbs.	Inches.
Scots Pine	75,000	.4	6
Corsican Pine	31,000	.5	6
Austrian Pine	25,000	.6	6
Weymouth Pine	27,000	.9	6
Norway Spruce	64,000	.4	6
Sitka Spruce	197,000	.15	6
Silver Fir	10,000	3	6
Larch (European)	70,000	.8	6
Douglas Fir	40,000	1	6
<i>Thuya gigantea</i>	341,000	.15	Broadcast
Oak (Pedunculate)	130	6.5	8
Oak (Sessile)	155	5.2	8
Spanish Chestnut	112	7	8
Beech	2,000	5	6*
Ash	6,800	2	6
Wych Elm	60,000	.7	6
Alder	320,000	.8	Broadcast
Birch	800,000	.3 to .5	Broadcast
Sycamore	5,500	3	6
Norway Maple	5,500	3	6
Hornbeam	14,000	1	6
<i>Cupressus macrocarpa</i>	73,500	1	6
Larch (Japanese)	103,500	.5	6
Sitka Cypress	128,000	.8	6

* Sown about $\frac{1}{4}$ inch from each other in the rows.

The following table shows the price per lb. of seed, the

THE NURSERY

number of plants that may be expected from sowing 1 lb. of seed, and the price per 1000 of seedlings (for seed only) :—

Kind of Tree.	Price of Seed per lb.*	Number of Plants from 1 lb. of Seed, if Seed not sown too thick.†	Seed Cost (only) of 1000 Plants, about
Scots Pine . . .	{ £ 4 0 (Foreign) 6 0 (Scotch) }	12,000	{ S. D. 4 6 }
Corsican Pine . . .	2 6	8,000	4
Austrian Pine . . .	3 6	7,000	6
Weymouth Pine . . .	8 0	6,000	1 4
Norway Spruce . . .	0 10	13,000	0 0 3
Sitka Spruce . . .	16 0	35,000	0 5 2
Silver Fir . . .	0 6	2,000	0 3
Larch (European) . . .	1 3	7,000	0 2
Larch (Japanese) . . .	6 0	9,000	0 8
Douglas Fir . . .	14 0	6,000	2 4
<i>Thuya gigantea</i> . . .	12 0	64,000	0 6
Oak (Pedunculate) . . .	0 1	71	1 2
Oak (Sessile) . . .	0 1	88	1 0
Spanish Chestnut . . .	0 2	65	2 7
Beech . . .	0 4	800	0 5
Ash . . .	0 4	2,500	0 1 3
Wych Elm . . .	0 4	9,000	0 0 2
Alder . . .	0 8	35,000	0 0 1
Birch . . .	0 5	64,000	0 1 (for 12,000)
Sycamore . . .	0 4	2,250	0 2
Norway Maple . . .	0 4	2,250	0 2
Hornbeam . . .	0 5	6,000	0 1
<i>Cupressus sitchensis</i> . . .	2 0 0	7,000	5 9
<i>Cupressus macrocarpa</i> . . .	5 0	5,000	1 0

* The price will always vary a good deal, according to seed years, Beech being very often unprocurable.

† These results can only be expected with good seed, and if the weather is favourable.

(6) Treatment of Seedlings.

As a rule, most seedlings must be moved from the seed-beds when 1 year old; in certain cases they may remain for 2 years (or even 3 years occasionally) before they are moved.

Beech, Spruce, Silver Fir, Hawthorn, and Holly are usually left 2 years in the seed-bed; Silver Fir occasionally 3 years. All other forest trees are usually transplanted when 1 year old. Corsican Pine, *P. pinaster*, Spanish Chestnut, Black Walnut, Oak, Norway Maple, and Sycamore should always be transplanted when 1 year old. Other trees, except as stated, should be transplanted at 1 or 2 years of age, according to the growth their roots have made.

Any tree, unless it is going to remain permanently where sown, requires this transplanting, to induce the formation of fibrous roots. If left in the seed-bed, a long tap-root is generally formed and very few fibrous roots. If such a tree be dug up and planted, it will probably die.

The trees are transplanted into lines about¹ 8 inches apart, and the trees 3 to 4 inches apart in the lines. Thus there can be about 100,000 to 125,000 to the acre.

Before transplanting, any long tap-root must be cut off with a sharp knife to about 4½ inches in length. This will usually be necessary with Oak and Spanish Chestnut and Walnuts. The usual method in transplanting is to make a trench about 9 inches deep and with a vertical side; the seedlings are then held against this side, and the earth put back over the roots, which **must have a vertical position**. It is most essential that the roots never get doubled up, as they will never straighten again. The trench must be deep enough to take the full length of the roots, and the roots of any seedlings more than about 7 inches in length should be cut off with a sharp knife.

Instead of getting out a trench to plant the seedlings in, a wedge-shaped opening may be made with a broad (specially

¹ The lines should never be further apart than is absolutely necessary, as the cost per 1000 for weeding is enormously increased if the lines are far apart.

made) spade about 2 feet in width, the seedlings carefully lined in, and the soil then wedged back.

Seedlings thus transplanted are generally allowed to remain for 2 years, after which they are usually planted out in the woods. But if they are not going to be planted out at the end of this 2 years, they should always, except in the case of Norway Spruce, which may remain for 3 years, be again transplanted into rows, which should be about 14 inches apart, and the trees placed 6 inches apart in the rows. Thus there can be about 35,000 to the acre.

In cases where large trees are required for ornamental planting, they should be regularly transplanted in the nursery every other year, for otherwise they will suffer severely from the shock of removal.

In order to save the expense of transplanting, the roots of young transplants are often cut through with a sharp spade dug in on either side of the rows; such a method is admissible if it is desired to leave the plants for only one more year, but otherwise it is only a poor substitute for transplanting, and the growing trees will be found too close together in the rows.

Some trees, as for instance, Black Walnut, *Pinus pinaster*, and Corsican Pine, should be transplanted every year without fail, if their success in planting out is to be guaranteed.

A rotation, as it were, of cropping should be observed in the nursery. Hardwood trees should follow conifers, and *vice versa*, as this will minimise insect and fungoid attacks.

Throughout their life in the nursery the young plants require constant attention. If dry weather sets in, watering is generally necessary. Hoeing and weeding are always necessary, and must be done 3 or 4 times a year. It is very expensive, especially the weeding of seed-beds. The weeds, in beds sown broadcast, must be merely cut through with a sharp knife; to pull them up would disturb the seedlings.

As regards the cost of nursery operations.—Hoeing and transplanting are the chief items of expense.

There will not be much difference in the cost per 1000 plants, of hoeing seedlings, whether they were sown broad-

cast or in drills; for although the weeding under the former method is very much more expensive per square yard or perch, yet there will be many more seedlings on that area.

Weeding seedlings sown in drills 6 inches apart, in beds 4 feet wide, will cost 6d. per 50 feet run each time it is done, or 2s. per 50 feet run per annum (*i.e.* done 4 times). This is equal to 5d. per 1000 seedlings per annum for weeding, and may be taken as a fair price, whether broadcasted or in drills.

Hoeing and weeding transplants, in lines 8 by 3 inches, will cost for doing three times, 1s. 3d. per 200 square feet or 50 feet run of 4-foot bed. This is equal to 2s. 2d. per 1000 plants.

Hoeing and weeding plants twice transplanted into lines 14 by 6 inches, will cost for doing twice, 7d. per 200 square feet. This is equal to 3s. 8d. per 1000 plants.

The following table will show at a glance some of the expenses incurred in nursery work per 1000 plants, and per 50 feet run of a 4-foot bed, or per 200 square feet:—

	Per 50 feet run or per 200 sq. feet.	Per 1000.
Weeding seedlings { Broadcasted . . . (done four times) { Sown in drills . . . }	8. D. 5 0 2 0	s. D. 0 5 0 5
Weeding transplants in lines 8 x 3 inches } (done three times) }	1 3	2 2
Hoeing and weeding when twice transplanted } in lines 14 x 6 inches (done twice) . . . }	0 7	3 8
Lining out seedlings . . . . .	...	1 6
Lining out 3- or 4-year-old plants . . . .	...	3 6

The following table will show the net cost on the average of raising nursery stock of various ages after debiting all other charges, such as general maintenance charges, rates, taxes, digging, and manuring the ground, watering, lifting seedlings and transplants, and carting from the nursery to plantations, and an allowance for failures in the nursery (all "culls" discarded), etc.:—

THE NURSERY

Kind of Tree.	1 year Seedlings, per 1000.		2 year Seedlings, per 1000.		1 year 1 year, per 1000.		2 year 1 year, per 1000.		1 year 2 year, per 1000.		2 year 2 year, per 1000.		
	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	s.	d.	
Scots Pine (Foreign seed)	1	4	2	6	0	5	9	0	7	3	0	10	3
Scots Pine (Scots seed)	1	6	2	9	0	6	0	0	7	6	0	11	0
Corsican Pine	1	8	3	3	0	7	6	0	9	9	0	13	9
Austrian Pine	1	9	3	3	0	6	6	0	8	6	0	13	0
Weymouth Pine	3	10	6	3	0	10	3	0	13	9	0	17	9
Norway Spruce	0	11	2	0	0	5	3	0	6	6	0	10	0
Sitka Spruce	2	0	3	6	0	6	9	0	9	0	0	12	3
Silver Fir	1	7	3	0	0	6	9	0	8	9	0	12	9
Larch (European)	1	4	2	6	0	6	3	0	8	3	0	12	6
Larch (Japanese)	2	6	4	3	0	7	6	0	10	0	0	13	6
Douglas Fir	6	0	9	6	0	13	3	0	18	6	1	2	3
<i>Thuya gigantea</i>	2	0	3	6	0	6	9	0	9	0	0	12	3
<i>Cupressus macrocarpa</i>	2	9	4	6	0	7	9	0	10	6	0	14	0
<i>Cupressus stachensis</i>	11	0	17	0	1	1	0	1	7	9	1	12	6
Oak (Pedunculate)	4	0	8	0	0	9	6	0	14	6	0	18	0

PRICES OF HOME-GROWN PLANTS

Note.—The above presumes that the seed is of good germinative capacity for its kind. In many cases the germinative capacity of seeds is very much below the average; especially is this the case with Japanese Larch, Sitka Spruce, and Douglas Fir; so that in many years the cost of raising the plants will be considerably more; and on the other hand, it may be considerably less in some years.

(7) Other Methods of Raising Trees.

Many trees are usually propagated by other means than from seed.

These other methods are :—

- (1) by Suckers ;
- (2) by Layers ;
- (3) by Slips or Cuttings.

By Suckers.—By this means it is usual to raise White Poplars, Aspen Poplars, and Picardy Poplars. Small plants are dug up in the woods, the roots being severed from the parent trees with a spade. These roots are carefully trimmed with a sharp knife, and then the trees are planted in nursery lines and left there for one or two years.

By Layers.—This is the usual method for propagating Lime and Elm. Certain trees are periodically coppiced, and long shoots of about 8 years' growth are layered.¹

By Slips or Cuttings.—This is the usual method of propagating Black Poplar, Black Italian Poplar, Willow Privet, Laurel, and Box. The cuttings of the three former should be taken in the spring, just as the sap is rising ; when if not planted into lines at once, they should be left with their ends in water ; cuttings of Privet, Laurel, and Box are best taken in September.

The cuttings of Poplars and Willow are usually obtained from coppiced stool shoots of about 4 years' growth, older wood should not be used. Sometimes, however, they are cut from uncoppiced trees, but it is not to be recommended, and it takes much longer to cut the "slips." A sharp knife must always be used.

The usual practice is to cut truncated "slips" about 7 to 9 inches long ; these are then lined out in the nursery, by pushing them into the soil, and leaving only about $\frac{3}{4}$ of an inch showing above the ground.

Great care must be taken not to skin the bark in pushing them in, and if the soil seems a little too stiff, it is absolutely

¹ Layering or Plashing is described in Chapter X.

necessary to make a hole for each "slip" with an iron prong. These cuttings are left for one or two years, when they are ready to put out in the woods.

These cuttings will throw out perhaps 3 or 4 shoots, but only the best one of each should be allowed to grow.

Often, in the case of Poplars, which have a terminal bud, long cuttings, 6 to 10 feet long, are cut, and these placed out in the wood direct. The object in this case is to obtain a big tree in the shortest space of time possible, but such cuttings are very expensive to buy, and can only be used if procured at home.

So also large cuttings of Willow (10 feet long) are often taken, so as to make a tree in the shortest possible time; such long cuttings often pay, especially where there is any danger from frosts.

Many other trees and shrubs can be raised from cuttings. Various species of *Thuya* and *Cupressus* are often raised by this means, but if it is desired to grow timber, the practice cannot be too strongly condemned; for such trees will always assume a more or less branchy, shrubby habit of growth. The method, however, is the surest means of perpetuating any particular characteristic which it may be desirable to retain from an ornamental point of view.

(8) Stocking a Nursery with Purchased Plants.

Now, although the raising of seedling plants in any large home nursery is much to be preferred, it will often be deemed advisable to stock a small nursery with purchased seedlings, as sufficiently skilled labour will probably not be available.

Very great care must be taken in the selection and purchase of the seedlings,¹ and if obtained at a reasonable price, the method is likely to give very good results.

¹ It is advisable never to use seedlings imported from foreign countries. Only recently the author observed a bed of seedlings which was badly attacked by a fungus common in Germany but not as yet very common in this country. An unnecessary risk is run if seedlings are imported.

Even if planting is only done occasionally, it is far preferable, in most cases, to make a temporary nursery and school purchased seedlings for 1 or 2 years, rather than to buy older trees from a trade nursery; for success in finally planting out will be much more certain, and if by chance a bad stock has been purchased, the loss is small and confined to a small area as compared to a failure when purchased stock is directly planted out.

(9) The Pruning of Nursery Stock.

This, in the case of conifers, should never be resorted to except that a double leader may be cut away, though often it will be preferable not to plant the tree at all; for the risk of disease and insect attack is so very much increased.

But some pruning of hardwoods will often be advisable. Whenever pruning is practised, a sharp knife should always be used. Any trees with long tap-roots should have these roots cut off, and a sloping cut should be made. This will often be the case with Oak, Walnut, and Spanish Chestnut, both when lining out seedlings and when the plants are raised for being planted out. So also, if any roots are injured, they must be cut off. If the roots are pruned, it is advisable to prune off some of the side branches up to half the length of the stem, so as to restore a correct balance and prevent the new leaves from wilting owing to lack of soil moisture.

The small branches must be cut off quite flush with the main stem, not shortened back and leaving a snag.

Such pruning of the side branches, up to one-half the total height of the tree, can always be recommended for hardwood trees, before they leave the nursery, though it adds to their expense. And, of course, any double leaders must be cut off.

Any excessive pruning is very bad, for there will not be sufficient leaf surface to elaborate good material for the production of new roots. Excessively pruned trees become "mop" beaded and throw up suckers or stem shoots near the ground, owing to a state of hypertrophy which is induced.

(10) Lifting the Plants for Planting Out.

This must be done very carefully indeed. It is very essential that they be raised right up with a spade, before they are pulled away from the earth. If they are to a great extent pulled up, the greater part of the fibrous roots will be severed, and the trees will suffer accordingly. When "lifted," the plants are pruned as necessary, and should then be counted and tied in bundles, and the roots wrapped round with damp moss or straw and covered up with sacking, and immediately carted to the site where planting is to be done. They should then be unloaded, and their roots placed in a trench, and then some earth thrown over the roots.

Only such plants as are wanted for one day's planting should be brought at a time, unless the nursery is a long way off. The roots must never be allowed to become dry, either from the effects of wind or sun.

INSECT AND FUNGOID AND OTHER ENEMIES IN THE NURSERY.

The chief trouble from insect enemies in the nursery is from **cockchafer grubs** and **wireworms** and the **Pine weevil**. The latter, though often doing enormous damage, chiefly to Spruce and Scots Pine when from 3 to 6 years old, is more prevalent in the forest, where it is attracted by freshly cut tree stumps.

As regards the former pests, gas-lime on the fallow portion of the nursery is the best remedy, as already stated. Sometimes a system of trapping is practised for getting rid of the cockchafer grubs. Sods of turf are laid face downwards here and there, or potatoes, cut in half, are hidden a few inches in the ground at intervals. The position of the latter should be marked by sticks, and the potatoes and the sods of turf should be examined constantly, and the grubs destroyed.

A preventative remedy is to dust flowers of sulphur over the beds in May and June, which stops the beetle laying her eggs. Land badly affected must be summer fallowed and

the surface raked over constantly when the grubs are near the surface ; they can then be collected and destroyed.

The grubs bite right through small roots and gnaw the bark from larger roots.

As regards damage by fungi, the most frequent cause of trouble is from *Phytophthora omnivera*, *Hysterium pinastri*, and *Rosellinia quercina*.

The *Phytophthora omnivera* is the cause of the "damping off" of the cotyledons of seedling Beech. It also attacks Ash and Maples, and occasionally other seedlings. It is somewhat similar to the "Potato Disease."

The cotyledons become black and rotten ; and wet, damp weather favours the disease.

The *Hysterium pinastri* is the Leaf-shedding Disease. It is most common on Scots Pine when from 2 to 6 years of age, but it also attacks other evergreen conifers. Early in the autumn, black spots appear on the leaves ; these contain the mycelium of the fungus ; next spring, about April, the leaves become brown all over and are shed. It is most common in damp localities, and in crowded nurseries.

The *Rosellinia quercina* is the Oak Root seedling fungus. It attacks the roots of Oak seedlings of 1 or 2 years of age, though occasionally when a few years older. The first signification of the disease is generally the sickly appearance of the leaves of the young plants. But an examination of the roots will probably decide the point. The diseased tap-roots will show small black pustules, about the size of a pin's head. This disease spreads very quickly from plant to plant. When discovered, a trench should be dug round the infected area, and the plants in that area pulled up and burnt, and quick-lime spread over the area and dug in ; and Oak should not be placed on such ground again for some years. Other diseases may be mentioned, such as *Septoria parasitica* on Spruce, *Botrytis cinerea* on most conifers, and *Pestalozzia Hartigii* chiefly on Spruce and Silver Fir.

Wherever any of these three fungous diseases appear, the plants in the infected area should always be at once burnt, and the soil dressed with quick-lime.

No delay in dealing with any diseases should ever be permitted.

Apart from insects and fungi, much **damage** is often done in nurseries **by mice**. The best means to adopt is to poison¹ them. Branches of gorse put round a bed will often keep them off.

¹ In order not to poison game, the poison should be laid in drain tiles hidden just below the ground.

CHAPTER IV.

PLANTING.

FENCING AND PRELIMINARY PREPARATIONS.

WHEN any planting operations have been decided upon, it will practically always be necessary to fence off the area against rabbits, and sometimes against stock, before planting can be started. And in the case of land being planted up for the first time, it will often be necessary to carry out a certain amount of land drainage, though, if more than a few shillings have to be spent per acre on such drainage, it will usually preclude any possibility of ultimately obtaining any reasonable return on the outlay, except under very exceptional circumstances.

FENCING OF LAND.

Rabbit Fences.—Seldom, if ever, is it safe to make a new plantation without surrounding it with a rabbit-proof fence for the first 10 or 15 years; by which time the bark of the trees should be too thick for the rabbits to attack. The amount of damage done annually by rabbits in young plantations is enormous.

A suitable rabbit fence, consisting of wire netting, wooden posts, and one row of wire at the top, will cost from 6d. to 8d. per yard run.

The wire netting should be 4 feet wide; 1 inch mesh, and the No. 18 gauge, galvanised wire.

But, in order to save expense, it is sufficient if only the lower 2 feet of the netting be 1 inch mesh, and the upper

2 feet 1½ inch mesh. Such netting is often made; but, if there be any difficulty in procuring it, the manufacturers will thread together two 2 feet widths (of 1 and 1½ inch mesh); and this will be very much cheaper than having a single 4-foot width of 1 inch mesh. When two widths are thus threaded together, the 1½ inch mesh netting should be No. 17 gauge, otherwise it would be liable to tear. Before the netting is unrolled, it should be dipped in black varnish, taken out, and allowed to dry; such a precaution will double the life of the netting, for otherwise its coating of zinc soon becomes defective in places.

Such netting will cost about 19s. per roll of 50 yards.

The wooden posts or stakes should be 5 feet 3 inches long, and, by preference, may be split out of Oak, Spanish Chestnut, or Larch, with an average cross-section of about 5 by 3 (like an arris rail). Some smaller, intermediate stakes, should also be used, in order to cheapen the cost. These stakes and posts should be sharpened or pointed, and all bark stripped off, and, by preference, they should be creosoted; but, failing that, they should be charred at ground level, and the charred portion should be painted over, whilst still hot, with boiling tar. However, it would be a great mistake to tar unseasoned stakes; for that would only hasten their destruction. Whether creosoted or not, all posts should be barked.

The bigger stakes would be worth about 7d. each, and the smaller stakes 3d. each, sharpened and creosoted.

The top wire should be No. 5 (or 6) 7-ply galvanised wire. No 5 costs about 15s. a cwt., and there are about 392 yards of it in 1 cwt.

Small straining posts, each with a strut, must be fixed about every 230 yards. In erecting the fence, it is very advisable to have the netting sloping from the ground outwards, away from the ground to be planted, as this will prevent rabbits from climbing over. The netting must also be let into the ground and turned outwards away from the land to be planted; for this will prevent the rabbits from burrowing under.

The posts should be driven into the ground, holes being made with a crowbar if necessary. They should be 10 feet apart (to 12 feet), and a small one should alternate with a big one. The row of wire should pass freely through staples at the top of the posts, and should only be rigidly fastened to the straining posts. Sometimes the staples are driven "home" and the wire thus pinched on to each post; in that case, the straining posts may be dispensed with; but the former is the better method; and when no longer required, the fence is easily moved without injury.

The netting should be fastened only to the top wire, to which it should be tied with wire. The top of the netting should be 3 feet 2 inches to 3 feet 3 inches from the ground, the remaining portion being turned under the ground. If it be desired to fasten the netting by staples to the posts, it will be necessary to drive the posts in a slanting direction; but, in no case must the staples be driven "home," or the netting will be much torn when it is finally removed.

For the sake of economy, the top wire is often dispensed with; in that case, of course, the netting must be fastened direct to the posts; but such a fence is easily torn down.

The cost of such a fence may be estimated as follows:—

For 250 yards. Posts 11 feet apart—

34 posts, 5 inches by 3 inches (arris section), creosoted, at 7d. each	£0 19 10
34 stout stakes, creosoted, at 3d. each	0 8 6
1 small straining post and strut, creosoted	0 4 6
1 straining bolt, nut, and washer	0 0 10
68 staples at 1s. 3d. per 100	0 0 10
5 rolls of netting, 1 inch and 1½ inch mesh, and Nos. 18 and 17 gauge, at 19s.	4 15 0
250 yards No. 5, 7-ply gal. wire, at 15s. per cwt.	0 9 6
Labour of erecting, haulage, dipping netting in black varnish, nails for strut, tying wire, supervision, etc.	1 5 0
Total for 250 yards	£8 4 0

Equals nearly 8d. per yard run.

A stepping-stile should always be made at various places

over the fence, otherwise it will get damaged. A couple of big stones, one on each side of the fence, and a stake to catch hold of, is all that is necessary.

Fences against stock are very much more expensive.

Briefly, a 6-rowed wire fence with T iron standards, and a straining post every 250 yards, can be erected for about 1s. 1d. a yard run. If wire netting be required in addition, one row of wire may be omitted, and the additional cost will be about 4½d. a yard run.

A morticed oak post and 4-rail fence will cost about 2s. 7d. a yard run. And a dwarf fence, with small split oak posts and 2 rails, erected on a small bank, will cost about 1s. 2d. a yard run.

Cost per acre of a rabbit fence.—This will vary according as to whether the area to be fenced is large or small; and also with the shape of the area.

Any given area requires the smallest amount of fencing, if such area is confined within a circle; also the fencing required for a square is less than that required for a rectangle.

Now, supposing that the area to be fenced is square, and that a rabbit fence costs 8d. a yard run (= 14s. 8d. a chain), then the following will be the cost of fencing:—

For 1 acre:—

$$\begin{aligned} \text{Number of chains*} &= \sqrt{10} \times 4 \\ \therefore \text{Cost of fencing} &= \sqrt{10} \times 4 \times 14s. 8d. \\ &= \underline{\underline{\mathcal{L}9, 4s. 6d.}} \end{aligned}$$

For 10 acres:—

$$\begin{aligned} \text{Number of chains} &= \sqrt{100} \times 4 \\ \therefore \text{Cost of fencing} &= \sqrt{100} \times 4 \times 14s. 8d. \\ &= \underline{\underline{\mathcal{L}29, 6s. 8d.}} \end{aligned}$$

For 40 acres:—

$$\begin{aligned} \text{Number of chains} &= \sqrt{400} \times 4 \\ \therefore \text{Cost of fencing} &= \sqrt{400} \times 4 \times 14s. 8d. \\ &= \underline{\underline{\mathcal{L}58, 13s. 4d.}} \end{aligned}$$

* 10 square chains = 1 acre.

PLANTING

For 100 acres:—

$$\begin{aligned}\text{Number of chains} &= \sqrt{1000} \times 4 \\ \therefore \text{Cost of fencing} &= \sqrt{1000} \times 4 \times 14s. 8d. \\ &= \underline{\underline{\text{£92, 9s. 9d.}}}\end{aligned}$$

For 1000 acres:—

$$\begin{aligned}\text{Number of chains} &= \sqrt{10,000} \times 4 \\ \therefore \text{Cost of fencing} &= \sqrt{10,000} \times 4 \times 14s. 8d. \\ &= \underline{\underline{\text{£293, 6s. 8d.}}}\end{aligned}$$

The following table shows the cost per acre according to the size of the plantation:—

Area.	Total Cost.			Cost per acre.
	Acres.	£	s. d.	
1	9	4	6	9 4 6
10	29	6	8	2 18 8
40	58	13	4	1 9 4
100	92	9	9	0 18 6
1000	293	6	8	0 5 10½

Now, when making calculations as to the financial returns to be obtained from timber growing, it will make an enormous difference to the results if the average outlay on fencing be taken at a large sum or a small sum per acre.

For instance, the difference in the cost of fencing per acre of a 10 acre plantation and a 40 acre plantation, is about £1, 10s. per acre.

Now, on an 80 years rotation, the outlay per acre of £2, 18s. 8d. on fencing a 10 acre plantation will have accumulated in 80 years at $3\frac{1}{2}$ per cent. interest to £46 (nearly), or at 4 per cent. interest to £67½, and the crop per acre is a debtor to this amount at the end of the rotation for fencing only.¹

¹ This presupposes that the materials of the fence when removed in 10 or 15 years' time are worthless; any value they may then have will, however, greatly reduce the debt.

But the outlay per acre of £1, 9s. 4d. on fencing a 40 acre plantation will only amount at $3\frac{1}{2}$ per cent. interest to £23 (nearly), or at 4 per cent. interest to £33 $\frac{1}{4}$, and thus, according to the rate of interest taken, the crop per acre at the end of the rotation is debtor for fencing to a much smaller amount, although even this is a considerable sum.

And the **difference** of the accumulated debt per acre of the 10 acre and 40 acre plantation is £23 if $3\frac{1}{2}$ per cent. interest be reckoned, and £33, 15s. if 4 per cent. interest be reckoned.

And if the rotation had been 100 years, the **difference** would have been £45, 15s. (nearly) at $3\frac{1}{2}$ per cent. interest, or £74 at 4 per cent. interest.

Thus it will be seen how very important it is to keep down all expenses at the beginning of a rotation, whether such expenses be incurred in fencing, draining, planting, or otherwise.

However, when making general calculations as to the returns from timber growing, some outlay for fencing must be provided.

It would obviously be ridiculous to charge as for fencing 1 acre; and it would be equally absurd, at any rate in the case of private estates, to estimate as for 1000 acres. For even if such an area were going to be planted, it will often be dissected by roads and bridle-paths and rights of way, across which the continuous fence could not be extended.

Perhaps the fairest method, on the average, is to reckon as for 40 acres; that is, about 30s. per acre; though on most private estates that area is too large, and £2 per acre, or £2, 10s., would be a more accurate estimate.

A very important point to remember when planting up large compact areas, in the course perhaps of the next 5 years, is the fact that, if there be no reason to the contrary, it will be far more economical to fence the whole area at once, than to make a separate fence each year for $\frac{1}{5}$ of the area, or even to fence a **larger** area than will be actually planted in the next few years. For instance, if 10 acres, situated in 3 blocks on an area of 40 acres, are to be planted each year for

the next 3 years, the following table will show the relative cost of fencing the whole area of 40 acres at once, or of making 3 separate fences for the three 10 acre plantations. The comparison must be made between the total capital invested in fencing at the end of the 2nd year when the last 10 acres is just completed.

	10 acres at a time (30 acres in all).	40 acres at the beginning.
	£ s. d.	£ s. d.
Cost of fencing 10 acres in the present year .	29 6 8	...
Cost of fencing 10 acres 1 year ago, £29, 6s. 8d., amounts in 1 year* to . . .	30 7 0	...
Cost of fencing 10 acres 2 years ago, £29, 6s. 8d., amounts in 2 years* to . . .	31 8 3	...
Cost of fencing 40 acres 2 years ago, £5 ² 13s. 4d., amounts in 2 years* to . . .	...	62 16 6
Total . . .	£91 1 11	£62 16 6

* Interest reckoned at $3\frac{1}{2}$ per cent. per annum.

Thus, although 10 acres be fenced, which is not going to be planted, there is a saving of £28, 5s. 5d., or nearly of £1 an acre.

DRAINAGE OF LAND.

It may sometimes happen that a large area of land is at present valueless, because it is water-logged, but that a small outlay in providing means whereby the water may be carried off, will result in the whole area becoming sufficiently drained and capable of growing timber. In such a case, the cost per acre over the whole area will be small, and the work can advisedly be undertaken.

It should be remembered that there are many soils, practically barren for agricultural purposes, which will grow good timber if only they be not too dry, or not too wet.

Any drainage of forest land must always be by open

"cuts ;" any system of pipe drainage is of course out of the question.

Any systematic "herring bone" drainage, as is adopted on agricultural land, can seldom, if ever, be adopted in forestry, if a profit be desired.

Fortunately it is, generally speaking, only on stiff clay soils where such a course would ever be wanted. Now, supposing that open "cuts" be made 21 feet apart on flat stiff clay land, the cost per acre, including a contribution towards "mains" and culverts, would amount to about £4, 10s. But this sum is prohibitive; for forest growth is very slow on stiff clay lands, and a profit would seldom be earned on this additional outlay.

However, much benefit will often accrue on such land by making a certain number of channels, so as to lead superfluous water off as quickly as possible.

Open ditches should be cut on one or both sides of the rides in such plantations, and branch channels at intervals should discharge at an acute angle into them.

The branch channels dissecting the compartments should have an average depth of 3 feet, and should be about 15 inches wide, and cut with practically a vertical face; and the main channels should have an average depth of 3 feet 6 inches.

Culverts must be provided where these channels cross the rides; they may be made "box-shaped" with 2-inch creosoted planks, or else concrete pipes, 12 to 24 inches diameter, may be used. These home-made concrete culverts are very much cheaper than purchased pipes of similar bore.

The open ditches by the sides of the rides serve not only for carrying off water, but also as convenient points for combating forest "ground" fires.

Cost of Draining.—The cost of making the "cuts" 3 feet deep, will on stiff clay soil be 8d. a rod; and if the "cuts" be 3 feet 6 inches deep, 10d. a rod.

Now, if an area of 40 acres were divided up by channels into blocks 44 yards by 44 yards (*i.e.* just under half an acre each), there would be 40 rods of "cuts" or "ditches" to be

made per acre ; which, at 8d. a rod, would be £1, 6s. 8d. per acre ; or, adding for culverts and mains (say) £1, 10s. per acre.

In cases where land will grow a crop of some hardy, non-exacting species, but is too wet for some more exacting and more valuable species, it will usually be the better plan to grow the non-exacting species, without going to the expense of draining, rather than to drain the land and grow the more valuable species. This latter species will probably be able to follow on as a second crop at the end of the rotation ; for, it must be remembered that a crop of trees will drain the soil to a very great extent of superfluous moisture ; the water table will be lowered ; and the decaying roots of the previous crop afford little water channels to carry away water to the subsoil.

The effect of drainage by trees is sometimes very marked ; the surface soil on peaty land often being lowered some 6 inches to 1 foot.

When draining peat lands of any depth, it is preferable to effect the drainage by 2 or 3 operations, rather than by 1 operation ; for in the latter case it will often happen that the sides of the cutting will fall in. After draining, the peat will shrink to an extraordinary degree, and planting should not usually take place until the peat has fairly settled.

There is another matter with respect to drainage, which is of great importance to have regard to, and that is, the extreme danger of draining land on which, or near to which, a crop of timber is growing. And especially is this the case if the crop be approaching maturity. Drainage effected for agricultural purposes has often been known to adversely affect a plantation near by.

OTHER PRELIMINARY OPERATIONS.

Cleaning and Preparing the Land.—It will almost always be advisable to burn off all rubbish and rank growth that may exist on the surface of the land. This will lessen

the danger of the young plants being choked ; it will provide a small quantity of easily soluble plant food, and it may lessen the danger of insect and fungoid attacks.

When planting up, for the first time, land which is now covered with a thick matting of grass, it will generally be advisable, after burning it, to plough it over and bury the sod, though there are exceptions to this rule.

There are, however, many foresters who are directly opposed to such a course, and who maintain that it is not only a needless expense, but that its adoption is likely to be followed by evil effects.

It is asserted that, although the trees usually grow far better for the first few years, their roots penetrate deeper into the soil than would be the case if the surface were not ploughed, and that, as the surface soil becomes consolidated, these trees will suffer in consequence, owing to their roots having an insufficient supply of air. And, to support this contention, it is usual to instance the failure in early life of some particular crop which has been grown on arable land.

Now, that certain crops, Scots Pine in particular, grown on old arable land, especially if of a stiff nature, do often succumb or show signs of failing before maturity is reached, is a fact beyond doubt. But there is not the slightest evidence to prove that it is due only to the effects of ploughing the land.

When land is ploughed, it very soon gets consolidated again, and, in 12 months' time, before the roots of the young trees can have grown very much, the pressure of the surface soil will be just as great as though it had never been ploughed ; and this pressure will be far greater than the pressure exerted by the humous surface soil of land previously under a good crop of timber. Thus it is evident that the mere fact of ploughing cannot be followed by such detrimental results.

It is quite possible that old arable land that has been richly manured may cause constitutional weakness in trees, and render them more susceptible to fungoid diseases ; but it must always be remembered that whenever the roots of

trees descend into a subsoil unfavourable to them, whether it be a stiff, wet clay, or an impenetrable rock, or a barren sand, they will of necessity show signs of failing. But, that the ploughing of land will cause the roots, beyond the first season's growth, to descend into the subsoil, is highly improbable.

The great advantages of ploughing ordinary pasture land are, that the young trees are more likely to become immediately established, as their fibrous roots have a plentiful supply of fine soil through which to push their way directly growth begins, and they have not to compete with a thick matting of turf for their food requirements and moisture. A soil covering of turf transpires far more moisture than is evaporated from the surface of bare land ; and it also prevents rain and moisture from reaching the roots of the trees, as may easily be realised by anyone who cuts a turf from a lawn after a heavy storm of rain in a dry summer. The dry state of the soil under the turf will often make it difficult to imagine that there has been any rain at all. Then again, the young crop will not require such attention in being kept clean and free from being choked, as would be the case if planting had been done direct on the turf, and smaller plants can be used ; thus very greatly lessening the expense of planting. On poor land the surface will remain fairly clean for 2 years or more, but on rich land a strong growth of weeds and grass will soon appear ; but even in such cases, it will generally be possible to use plants one year younger than would otherwise have been advisable. Furthermore, wherever grass can be prevented from growing, the danger from late and early frosts will be very much lessened ;¹ especially is this the case on southern aspects.

Now, ploughing the land will, generally speaking, only be necessary when the soil is covered with grass ; on heather soils, all that is necessary is usually to burn the surface. But there are, however, certain cases when a surface covering of grass is not detrimental, and may even be beneficial. For instance, on exposed high altitudes, its shelter will

¹ This is explained later on in Chapter V., pp. 72, 73.

benefit the plants ; but in such places the grass itself is not usually tall and rank ; and the turf has not a close, matted sod, like turf on good land ; nor is there the same competition for plant food and water. So also, there is not the same danger of late and early frosts during the growing season.

And, furthermore, on poor shifting sands a loose covering of grass will be beneficial by binding the soil together.

The Laying out of Rides and Compartments.—This matter has already been alluded to.¹ The general rule was stated that the broad main rides or roads should be made parallel to, or in the direction of, the prevailing winds ; whilst only narrow rides should run at right angles to the prevailing winds, so as to minimise the danger of windfall, which is greatest in even-aged high forest and under the group system.

But this general rule must sometimes be departed from on account of the natural features of the ground. The main ride or road should, on undulating land, be marked out with an easy, even gradient, where possible ; avoiding unnecessary bridges and steep inclines.

When large areas are planted, it will often be advisable to convert some of the main rides into good hard metal roads. If stone can be quarried near by, the cost of metalling the roads will vary from 3s. 6d. to 6s. a yard run. But such an outlay should never be undertaken at the beginning of a rotation ; as money would be needlessly spent without any benefit being obtained for a long term of years.

When steep hillsides are planted, the main ride should be along the valley at the bottom, down to which the timber may easily be dragged ; or slides may be made to effect the same purpose.

The proportion of any woodland area occupied by roads and rides is often very considerable ; and, when the land is valuable, it involves a direct loss of income ; a matter which should be taken into account when making financial calculations.

¹ *Vide Chapter II.*

CHAPTER V.

PLANTING—*continued.*

AS TO THE CHOICE OF TREES TO PLANT.

CONCERNING ALSO THE SPECIAL DEMANDS OF TIMBER TREES, AND THEIR HABITS, AND THE CONDITIONS SUITED TO THEIR GROWTH, AND THEIR FINANCIAL RETURNS.

BEFORE describing the actual methods by which trees may be planted, it is necessary to discuss at some length :—

- (1) The individual demands of trees as to locality and soil.
- (2) Their peculiarities of growth, and the conditions suited to their growth.
- (3) The financial returns that may be anticipated from planting any particular species.

For, without such knowledge, and without paying the very greatest attention to such considerations, it is impossible ever to carry out planting operations with success.

An enormous sum of money is annually wasted by planting trees in localities and soils unsuited to them; and also by making injudicious mixtures of trees which are otherwise suited to the locality.

THE INDIVIDUAL DEMANDS OF TREES AS TO LOCALITY AND SOIL.

The chief factors determining the possibility of trees growing successfully, as far as locality and soil are concerned, are :—

- (1) The supply of moisture in the soil and atmosphere.

- (2) The shelter and protection that exists from gales and from late spring and early autumn frosts.
- (3) The depth of the soil.
- (4) The mechanical condition of the soil ; its adhesiveness or otherwise, etc.

To some extent, however, these factors are interdependent.

Before, however, attempting to make a choice, a careful study of all trees in the neighbourhood should be made ; for, provided conditions be similar, the evidence of growing timber is far more reliable than any individual opinion. But, of course, the absence of certain trees in a locality does not necessarily prove that they will not succeed if planted.

Then again, before the above considerations can be fully taken into account, it will be necessary to dig trial holes at intervals over the area to be planted, so as to satisfy oneself as to the nature of the soil and the moisture it contains, etc.

Besides the four factors just mentioned, there are other considerations to which regard must be paid, such, for instance, as the requirements as to plant food and as to heat. And so, again, the possibility of floods, the likelihood of fire, and so on.

Now, before considering how the various species of trees are affected by these factors, it is necessary to consider the manner in which the **aspect and altitude** will influence the locality and the soil.

The **Aspect** exerts a far greater influence on the locality and over the welfare of tree growth than is usually supposed ; especially is this the case where young crops are concerned. In almost all cases the growth of trees is far better on northern, north-eastern, and north-western aspects, than on southern, south-eastern, or south-western aspects. In a general way, it may be said that southern aspects are hot and dry, and that northern aspects are cool and moist.

The intensity of the sun's rays is greater on sloping land with a southern aspect than is the case on flat land ; and it is least on slopes with a northern aspect. This is a direct cause for both the soil and the atmosphere being drier on

southern than on northern aspects. Now, inasmuch as the decay of leaves and humus, which hold moisture, as it were like a sponge, is very much more rapid on southern aspects, it follows that this loss of humus is accompanied by a corresponding diminution in the available amount of moisture for the crop. It is this lack of sufficient moisture which is usually responsible for the less vigorous growth of trees on southern aspects than is evidenced on northern aspects.

The prevalence of, and the damage caused by, late spring and early autumn frosts, especially to young crops, is, to a very great extent, governed by the aspect of the locality; or more correctly, by the aspect when considered along with the altitude. These frosts are a more frequent cause of the failure of young plantations than is commonly imagined.

The Influence of Aspect and Altitude on Frosts.—In discussing this question, it is necessary to remember that these **late spring and early autumn frosts** are very local indeed. They occur usually on still, cloudless nights, when the air is very dry, and especially after a hot, sunny day. The area affected is usually very circumscribed; and it is the lowest land in the locality, especially if wet, that is affected, to which the cold air sinks, and from whence it cannot find an outlet; whereas the land a few feet higher will, as the cold air descends, and is therefore in motion, often escape. Hence it is that these frosts are far **more common on southern aspects**, where the air is dry, and at **relatively low altitudes**, where the cold air remains stationary. Then again, they are more common on stiff, wet land, which a hot sun has chilled by evaporation, than on well-drained land. They often extend over a large area of flat land, as, relatively, it is low-lying land; whereas on undulating and on sloping land, the frost is confined to the valleys, dells, or coombes. Another very important point to remember is, that there is a **greater liability** to these frosts **on maiden land** covered with grass and weeds, than on land that is perfectly clean, or which has a good layer of humus covering it. For in this latter case, the rapid evaporation of water and radiation of heat is retarded; whereas if there be a surface covering

of grass, any moisture thereon is quickly evaporated, and the radiation of heat from the grass itself is very rapid, and thus a frost is often induced. Also, the free circulation of air, near the ground, is interfered with.

The liability to damage by spring frosts is almost always more severe on southern aspects, because on such aspects the trees break into leaf much earlier than on northern aspects.¹ So also the actual damage is usually more severe, as, so often, the bright morning sun rapidly thaws the twigs still covered with frozen rime. The slower that the twigs thaw, the less will be the damage that will be done.

Aspect and Altitude in Reference to Gales.—It is necessary to consider these two factors together, for it does not necessarily follow that the higher the altitude the greater the damage that will be done by storms; though such may be apprehended when the aspect faces the direction of the prevailing winds. Local knowledge is of great importance in this respect, but it will usually be found that the south and west of the country are more exposed to south-westerly gales, whereas the north and east are more exposed to north-easterly gales; though any range of mountains or hills in the neighbourhood will greatly determine this question.

Altitude in Reference to Tree Growth.—In this country any reference to the actual altitude above sea level at which trees will grow is liable to be very misleading; especially if comparisons be made with data as to altitudes at which similar trees will grow on some big continent. The highest altitudes in this country are barren, wind swept, rocky peaks; whereas the same altitudes on a big continent are often at a relatively low altitude.

In Great Britain there is very little land above 1000 feet which is suitable for timber growing; and there is a great deal at a lower altitude even than this which is far too exposed and barren for timber growing. The relative altitude is the determining factor.

¹ And on high altitudes the growing season is very much shorter, and spring activity much later than at low altitudes.

1. The Demands of Trees as to Moisture.

The amount of moisture, both in the soil and in the atmosphere, is perhaps the most important consideration affecting tree growth. The majority of trees prefer a moist atmosphere; especially is this the case with Sitka Spruce, Sitka Cypress, Norway Spruce, Silver Fir, Douglas Fir, *Thuya gigantea*, Ash (European), most Poplars, Alder, *Cupressus macrocarpa*, and Spanish Chestnut.¹ However, Scots Pine, Austrian Pine, and Corsican Pine prefer a dry atmosphere.

Then again, the majority of trees require a plentiful supply of moisture in the soil for their healthy development and to make good the losses caused by transpiration. This is especially the case with the above class requiring a moist atmosphere, and so also with Tree Willows, White Poplar, Black Poplar, Black Italian Poplar (*P. Canadensis*), Pedunculate Oak, Hornbeam, and Weymouth Pine.

Trees such as Sycamore, Norway Maple, Beech,² Sessile Oak, Larch, and Elm will succeed with rather less moisture.

The White Ash (*F. Americana*) will thrive on soils far too dry for the Common Ash. So too, White Alder and *Abies concolor*, Aspen Poplars, and Walnut trees will grow on quite dry soils, and (perhaps) Sitka Cypress.

The best trees for very dry soils are Scots Pine, Austrian and Corsican Pines, Acacia, Birch, and Mountain Ash.

Those trees thriving on dry soils, will, generally speaking, thrive also on soils containing more moisture.

Birch is the most accommodating tree of all, and will grow practically anywhere, even on sour, ill-drained soils. But, with the exception of Birch, no trees can grow on ill-drained land which is sour, or wet with stagnant water.

A moderate excess of water, provided it be well aerated and is not stagnant, is not detrimental to Alder Willows,

¹ Spanish Chestnut will grow in a dry atmosphere and on fairly dry soil, but the timber is then usually very shaky; whereas, with sufficient moisture, and other conditions suitable, it is usually of very fine quality.

² Beech will thrive with considerably less moisture, on chalk and other limestone soils, than otherwise appears necessary for its well-being.

Poplars, Sitka Spruce, or Norway Spruce ; though, as already stated, it is usually very difficult to get trees established on wet localities on account of the increased danger from frosts.

To a great extent, a damp soil will afford conditions suitable for growing trees which on drier soils will only thrive if the air be moist. And *vice versa*, a moist air will make good the deficiencies of a dry soil;¹ for the relative humidity of the atmosphere will determine, to a great extent, the degree of transpiration effected by any tree.

Thus imported trees which are naturally found in high mountainous regions in their native country, where perhaps the soil is thin and not capable of holding much water, but where they are constantly shrouded in mist, will succeed, here in Britain, only on moist soils at low altitudes, or where the air is moist, such as in the neighbourhood of large sheets of water—the sea, or inland lakes.

Such trees as Norway Spruce, and, to a less extent, Silver Fir, will usually succeed far better in high mountainous regions in their own country than they will in Great Britain. For though in this country they may be planted on moist soil, and though the summer rainfall may be far greater than is the case in their native home, yet the growing season is longer in this country and transpiration continuously more active. Whereas, in their native home the growing season is very short, and excessive transpiration is so often checked by mists and fogs, and on account of the short growing season, the total amount of moisture required is less than in this country. Norway Spruce is more suited for growth in Scotland than in England ; whereas, for Silver Fir, England is more suitable, on account of the warmer summers.

From the foregoing, it will be evident that on southern aspects, where the air is dry and, in most cases, the soil also, care should be taken to plant only such trees as make slight demands for moisture. Though at high elevations, owing to the growing season being shorter and owing to active

¹ Thus on dry soils a far greater choice of trees is possible on northern aspects than on southern aspects.

transpiration being often retarded, a lesser degree of moisture will usually be admissible. Or perhaps a southern aspect will be advisable where otherwise a northern aspect would be indicated.

2. The Demands of Trees as to Shelter and Protection from Gales and Frosts.

The necessity for considering the liability of trees being damaged or thrown by storms is far greater when planting maiden land than when planting well-managed forest land. In the former case, there is probably no shelter from other crops of trees ; whereas in the latter case, if fellings have been made in a direction opposite to that of the prevailing winds, the older compartments will protect the younger crops. Though on exposed steep hills this protection will be reduced to a minimum.

The trees which are most likely to be thrown by the wind are Norway Spruce and English Elm. Sitka Spruce, however, is a storm-proof tree, and has a much deeper root system than Norway Spruce.

Douglas Firs are rather liable to have their tops blown off, but if planted over large areas this danger greatly disappears.

Scots Pine is very liable to be broken by any weight of snow on its branches, as they are brittle. But it must none the less be considered as a very storm-proof tree.

Although most trees, except Norway Spruce and English Elm, are firmly anchored to the soil by their roots, yet many of these must, for other reasons, be avoided in exposed places.

The trees best suited to withstand ordinary gales are :
—Austrian Pine, Corsican Pine, Scots Pine, Sycamore, and Norway Maple.

Now, when planting up maiden land, it will often be necessary to plant shelter belts of these storm-proof trees. For such a purpose the Austrian Pine and Sycamore are perhaps the most suitable. These belts should be about 30

feet wide, and are, of course, more efficient if planted some years before the rest of the land. And they should always be heavily thinned so as to encourage the formation of bushy trees. Their efficiency is increased if evergreen shade-bearing bushes are also planted.

Very few trees will thrive if subjected to gales and the **salt spray of sea-water**. The best trees to plant in such localities are the Austrian Pine, Maritime Pine (*P. pinaster*), Bank's Pine (*P. Banksiana*), Corsican Pine, *Cupressus macrocarpa*, and (probably) the White Spruce (*Picea alba*).

Whereas, if conditions are a little more favourable, and also of course depending on the soil, the following trees may succeed: Sycamore, Norway Maple, White Poplar, Evergreen Oak, Turkey Oak, and *Pinus insignis*.

And again, there are several shrubs which will stand sea-spray and exposure, the best being Sea Buckthorn (*Hippophae rhamnoides*), *Escallonia*, Tamarisk, *Euonymus*, Gorse, and Privet.

The susceptibility of various trees to late spring and early autumn frosts has already been referred to.¹ But it should be noted that there is often a distinct "frost-line," in many cases only a few feet from the ground, and that, when once tender trees are above this line, they will usually continue to grow without further injury. Now, as late frosts do not always occur every year, a quick-growing species, though tender, may sometimes succeed in a frost locality; and sometimes big trees are planted in such a locality in order that they may quickly grow above the frost-line. But, in any known frost locality, or where experience would lead one to anticipate these frosts, only frost-hardy trees should ever be planted. Such trees are Birch, Corsican Pine, Austrian Pine, Scots Pine, White Poplar, Aspen Poplar, and Sitka Cypress.

Furthermore, it should be remembered that trees which have not recovered from the shock of planting are far more susceptible to damage than trees which are well-established and vigorous.

¹ *Vide Chapter III.*

3. The Demands of Trees as to Depth of Soil.

With reference to the depth of soil required by trees, the condition of the subsoil or the rock underneath the surface-soil is often one of the most important factors to be taken into consideration. If the subsoil consist of a disintegrated rock, a shallower surface-soil will suffice than would be the case if the rock were unbroken. So also, if the stratification of the rock be vertical, a shallower surface-soil will suffice than if it were horizontal.

Deep soils are always more beneficial than shallow soils, even if the trees be shallow rooted species. For the roots of trees will have a greater space in which to find the food they require, and there will usually be a more constant supply of moisture.

The **trees requiring the greatest depth of soil** in a finely divided state, are :—Oak, Spanish Chestnut, Ash, Black Walnut, Acacia, Silver Fir, Douglas Fir, *Cupressus macrocarpa*, *Thuya gigantea*, Weymouth Pine, and Sitka Spruce.

Whereas, on **very shallow soils** of about 15 inches in depth, only Birch and Aspen Poplar will grow if the subsoil be impenetrable. Spruce would grow on such a shallow soil if there were sufficient moisture in the soil and air, but in this country such would rarely be the case.

There are, however, some trees which naturally require rather a deep soil, but which will grow on shallow soils, if the subsoil rock be disintegrated. Thus Larch, Beech, Scots Pine, English Elm, Sycamore, and Norway Maple will grow on shallow clay soils overlying oolitic limestone.

Beech will thrive well on thin soils overlying the chalk.

Scots Pine, which naturally requires a deep dry soil, is very accommodating, and will succeed well on many quite shallow soils.

Trees naturally requiring a deep soil, will usually, if grown on soil without sufficient depth, fall off greatly in height, and never reach maturity ; and any timber which may be grown will be of poor quality.

On shallow soils, it is often possible to grow poles 30

and 40 years of age, of such trees as require a deep soil; whereas it would be quite impossible to grow mature timber of such trees.

4. The Demands of Trees as to the Mechanical Condition of the Soil.

The soil best suited to the growth of most trees is a slightly stiffish loam with a deep soil covering of decaying humus. Very porous soils are usually dry, especially if shallow, and hence only suited to a comparatively small number of trees, whereas on very stiff soils the choice of trees is still more limited. In this latter case the roots have a difficulty in penetrating, and they do not obtain enough air, and the soil gets sour. The natural drainage on such soils is bad, and they are more liable to late and early frosts. Often, especially on sandy gravels on which only heather is growing, there will be a pan or a hard, thin, impenetrable layer a few inches below the surface of the soil. The roots of trees will never penetrate such a pan; and if it be necessary to plant such land, the pan must be artificially broken up.

So also in cases where the seedling growth of trees is required, it is most essential to have a few inches of the humous soil, for, apart from the extra amount of moisture assured on dry soil, it will enable the growth of seedling roots to proceed with little hindrance.

Now, on the stiffest soils the best trees to plant are Norway Spruce, White Poplar and Pedunculate Oak, though the growth of all, and especially of the latter, will be very slow.

But it must be remembered that very stiff soils are not at all suited to tree growth. Often, however, good Spanish Chestnut coppice is grown on stiff clays, and it would seem that many trees will succeed better on stiff soils when coppiced, than when grown for timber. On soils not quite so stiff, but, however, still classed as heavy land, the three trees just mentioned will thrive, and also Sessile Oak, Black Poplar, Black Italian Poplar, Sitka Spruce, *Cupressus macrocarpa*, Silver Fir, *Thuya gigantea*, Hornbeam, Spanish Chestnut, Sycamore, Norway Maple, and Beech, so also

Scots Pine, Corsican Pine, and Douglas Fir; but it will often be found that a short rotation, especially for the last 3 species, will have to be adopted.

Ash is the most particular of all trees, and will succeed best on really deep stiffish loams, though lighter land, especially moist humous soil, with a clay bottom about 4 feet below the surface, will also suit it. In a general way, it may be said that soil really suited for growing Ash is usually worth 30s. to £2 an acre for farming purposes.

Larch is also very particular if it is to be grown to perfection. Deep, stiff, adhesive clays are quite unsuited to it; so also are light, dry, porous soils, and thin soils overlying chalk. It delights, however, in a stony, rocky soil, if it can obtain sufficient moisture.

Thin clays with a disintegrated rocky or stony subsoil are very suited to it; so also are good deep loams. When planted on stiff clays, chalk, or dry gravels, it usually becomes hollow or "**pumped**."

On light, porous soils, the best trees to plant are Scots, Austrian, and Corsican Pines, Acacia, Birch, and White Alder.

As to Food Requirements.—The food requirements of trees are very slight when compared to the requirements of agricultural crops. Even the poorest soils can usually provide all the food material necessary, provided always that the fallen leaves be not removed from the soil.

According to Ebermayer, the loss per acre of Lime, Potash, and Phosphoric Acid, occasioned by the removal of crops of timber, will amount on the average in lbs. per acre per annum to—

	Lime, CaO.	Potash, K ₂ O.	Phosphoric Acid, P ₂ O ₅ .
By removal of timber only . . .	9	4	1·4
By removal of timber and leaves . .	62	11	8
Whereas cereal crops remove on the average about . . .	14	28	21

It will thus be evident that most of the valuable mineral ash is determined to the leaves, and that the timber itself contains only a little. Hence the rapid soil deterioration, as far as mineral plant food is concerned, that takes place when leaves are removed from woodlands. The removal of leaves is, moreover, also accompanied by a loss of moisture and also a loss of nitrogen, for decaying leaves and humus afford the chief source of nitrogen in the form of nitric acid for the growing trees.

Now, experiments have shown that the leaves of many trees, especially Beech, Hornbeam, and Poplars, will, as they decay, become associated with conditions under which the free nitrogen of the air is rendered available for plant food. The free nitrogen of the air is also utilised by leguminous trees such as Acacia (*Robinia*) by means of micro-organisms contained in nodules on their roots. There are also trees which are not leguminous, such as Alder, which have nodules on their roots containing a fungus, and which, by a process of symbiosis, manufacture and absorb nitrogenous substances, which are, in their turn, utilised by the tree.

A somewhat similar condition prevails in the case of Oak, Spanish Chestnut, Beech, and some other trees, on whose roots are small mico-rhizas, the mycelial filaments of which absorb nitrogenous substances for the tree, and perhaps also manufacture them, thus utilising the free nitrogen of the air.

So also, a symbiotic growth is witnessed when mixtures of *Pinus montana* and Spruce are made. In this case, it would seem that a fungus on the roots of the former aids in the provision of nitrogenous food material for the latter; especially is this the case on poor sandy soils.

The amount of nitrogen required by timber crops is very small when compared to the requirements of agricultural crops. The perpetual removal of mature timber from well-managed woodlands should never result in a loss of nitrogen to the soil. There will, on the other hand, often be an actual gain of soil nitrogen.

The average amount of lime, potash, and phosphoric

PLANTING

acid lost by the removal of mature timber has already been noticed. But it is necessary to note that under coppice systems, the loss to the soil of mineral plant food and of nitrogen is more than double the loss sustained by removing mature timber. This is evident from analyses, which show that the percentage of Ash constituents in various parts of trees varies considerably, as is shown by the following table :—

	Per cent. of Ash varies from		
	In Conifers.		In Deciduous Trees.
Large timber*3 to .5	.3 to 1.0
Twigs and small branches	. .	1.0 „ 2.0	.8 „ 2.0
Bark	2.0 to 6.0	
Leaves	1.5 „ 3.0	3.7 „ 7.6

* The heartwood of a tree contains less ash than the sapwood ; also, most of the nitrogen in timber is found in the sapwood, there being hardly any in heartwood.

In a general way, it may be said that broad-leaved trees remove more valuable mineral food from the soil than conifers, that Beech removes more than other deciduous trees, and that Silver Fir removes more than the Pines or Spruces. But the amount is so small that the artificial manuring with "cinereals" is not necessary.

Though, were leaves habitually removed for litter, etc., the loss of plant food would soon be evident.

It will be noticed that the annual requirements of trees for timber and leaves, amount, in the case of potash and phosphoric acid, to less than half of that removed per acre per annum by cereal crops, and that the amount of lime required for trees is nearly 5 times that removed by cereal crops, but that, as the leaves contain most of the lime, potash, and phosphoric acid, these minerals are annually returned to the soil in an available form.

It should be remembered that any analysis of tree leaves

is liable to be rather misleading if it be taken as a guide to the food requirements of any particular crop, or the amount of plant food returned per acre per annum by the fall of the leaves. For, before any correct conclusions can be arrived at, the total weight of leaves produced per acre per annum must be ascertained. Analyses show that the percentage of Ash per unit of weight is far greater in deciduous broad-leaved trees than in conifers. This is shown by the following table :—

	Per cent. of Ash per unit of weight, about		Per cent. of Ash per unit of weight, about
Ash	7.6	Hornbeam	:
Black Poplar	7.0	Beech	:
Elm	7.0	Birch	:
Lime	6.5	White Alder	:
Acacia	6.0	Common Alder	3.7
Sycamore	5.0	Silver Fir	3.0
Aspen Poplar	5.0	Larch	2.5
Willow	5.0	Spruce	:
Oak	5.0	Weymouth Pine	:
White Poplar	4.6	Scots Pine	:
		Austrian & Corsican Pine	1.8

As far as the chemical constituents are concerned, the best trees to plant on really poor soils are :—

Birch, Scots, Corsican, and Austrian Pines, Aspen Poplar, Acacia, Mountain Ash, and White Alder.

The trees requiring most plant food are :—

Beech, Hornbeam, Spanish Chestnut, Silver Fir, Ash, Elm, Oak, Sycamore, and Black Poplars.

Some trees show a preference or a dislike to certain minerals in the soil.

Thus, any excess of lime is usually detrimental to Douglas Fir, Weymouth Pine, Spanish Chestnut, *Pinus*

pinaster, Plane trees, and Tulip trees. It seems to act as a poison to them.

Whereas, Beech, Ash, Corsican Pine, Austrian Pine, Yew, Walnut, and Box distinctly prefer a calcareous soil.

Larch usually prefers soils with plenty of lime in them, though it never thrives where chalk is near the surface; this, however, cannot be attributed to the chemical composition of the soil or subsoil.

So again, any acidity in the soil usually acts as a poison to trees.

Land covered with heather is usually too acid for the broad-leaved trees, except Alder and Birch, to grow well in, and only conifers should be planted, for the first rotation, on such land. Though, if the heather has not been long established, it would often suffice for broad-leaved trees. Such a case might occur where arable land had gone out of cultivation and the heather had only occupied the ground for a few years. It is the acid contained on heather land that is so often instrumental in forming a "pan."

On these slightly sour soils, Birch, Alder, and the conifers will succeed, if there be a sufficiency of moisture, and not an excess of it. On the driest of such soils, only Birch, Scots, Corsican, and Austrian Pines should be planted.

Usually speaking, trees are very intolerant of poisons in either the soil or the air.

Near large towns and factories the atmosphere is often laden with poisonous compounds. In such a case, deciduous broad-leaved trees may often succeed when evergreen trees fail.

The Plane tree (which sheds its bark), Elm, Lime, Acacia, Black Poplars, Horse Chestnut, and Sycamore are the best trees to plant when such conditions prevail.

On the other hand, Beech, of the broad-leaved trees, is the most susceptible; and of the conifers, Silver Fir.

As to Heat and Warmth.—The effects of heat on tree growth are very varying; for the determining point is so often the amount of available moisture. No locality in this country is too hot for tree growth, provided that there be a

sufficiency of moisture in the soil. This, however, is seldom the case; for the hotter the soil and situation, the less moisture will there usually be.

With reference to this matter, it should be noted that southern aspects are the hottest, and that sandy soils are the quickest to heat, and, after them, chalky soils; whereas northern aspects are the coolest, and clay soils are the slowest to become heated; and that, as already stated, southern aspects and sandy soils are generally too deficient in moisture to be as favourable for timber growing as northern aspects, or soils with more moisture in them.

There are, however, certain instances when the warmer southern aspects are preferable. For instance, on the stiffer soils with plenty of moisture, tree growth will sometimes be better than on the cooler aspects; especially is this the case when the land is situated at a relatively high altitude, where the danger from late frosts is minimised. And again, where oak bark is of importance, that grown on the hottest aspects will contain the most tannin.

Then again, it is very probable that only the hottest aspects and localities are suitable for those exotic trees which are accustomed to very hot summers, and which have a difficulty in ripening their wood in this country—such, for instance, as Black Walnut; but care must also be taken that the locality has sufficient moisture, and that it is not specially subject to late spring and early autumn frosts.

Spanish Chestnut does far better in hot localities, provided there be sufficient moisture, which indeed is essential. It is a tree far more suited to the south-west of England than to any other part of Great Britain; and the same may be said of *Cupressus macrocarpa*, though this latter requires a moist atmosphere as well as a moist soil.

Another advantage that can be claimed for southern aspects and hot localities is that the extra warmth will generally be instrumental in the production of better seed; especially is this the case with reference to such trees as Silver Fir and all other imported trees, in whose native countries hot summers are experienced.

However, by way of a summary, it may be stated that these **hot aspects** are, especially if the soil be light, **very much more difficult to plant** and manage than cool, moist localities; for growth in the spring starts early; late spring and early autumn frosts are common; the effects of dry weather in the summer are always more severe; and the retention of a soil covering of humus is a more difficult matter. On such aspects, planting will often have to be confined to Scots and Corsican Pines, or merely to Austrian Pine for shelter.

Another matter that should be mentioned is the injurious effect that a hot sun often has on young plants, especially when they have been recently planted out. Transpiration takes place at a greater rate than that at which the roots, which have not become established, can supply the necessary amount of water, and hence the young trees wilt, and often die.

So also, a hot sun in early spring often induces transpiration before the root system has become active; and nearly all the evergreen conifers can be seriously injured, and sometimes killed, in this way; the leaves turn brown and fall off.

Silver Fir and Beech are always, when young, very intolerant of a hot sun, and protection from it is almost imperative; and, for this reason, these two trees, which will bear intense shade, are far more suited for underplanting than for being planted on open ground, and this quite apart from their susceptibility to late frosts.

Many other trees, such as *Thuya gigantea* and Douglas Fir, benefit from a little shade when young.

As to Floods.—Any prolonged flooding of land is detrimental to trees. The trees least injured are Alder, Willows, and Poplars, but even these would probably be killed if flooded during the time in which the buds were breaking out into leaf.

In all cases where coppice areas are liable to become flooded, the stools should be cut some distance from the ground, as, otherwise, the latent buds, from which the new shoots would grow, will become rotten.

As to Fire.—The danger from fire is one of the greatest risks with which afforestation is attended. And when planting and tending crops, every means must be taken to minimise this risk as far as possible.

The greatest damage is to be apprehended in the case of coniferous crops, and especially Scots and Corsican Pine. When planting such crops, all heather and rank growth on the surface of the land should always be burnt. And Fire belts or Fire lines ought generally to be planted.

About every 40 acres should be surrounded by a fire belt; and they should also be planted by the side of any much frequented public road, and on either side of railway lines.

These fire belts should be about 40 feet wide, and should be composed of broad-leaved trees. The best plan is to keep them periodically coppiced, and thus have a very dense canopy, under which it is impossible for heather or grass to grow. Only one half of the width should be coppiced at a time, and the other half should be cut some 8 or 10 years later when that portion which was first cut is well grown up.

Poplars are the least inflammable of any trees, but, as these fire belts are usually required on very dry Pine soils, probably the best trees to plant will be the False Acacia (*Robinia*), White Alder, and Birch.

On the better soils, fire lines may be made very much wider, and mature broad-leaved trees grown; but care must be taken to keep the canopy always dense, and avoid clear cutting.

Fire lines of barren sand are very effective, but their cost is usually prohibitive.

Ordinary ditches, cut round the compartments, are, however, convenient points at which to attempt to stop an existing fire.

It is always very advisable to keep all grass on the rides cut, and have it removed, so that, when a fire occurs, it will not easily spread across a ride.

SUMMARY.

Having regard to all the foregoing, it will be very evident how difficult it is to make a correct choice of the trees to plant on any particular soil and in any particular locality. And, it is still more difficult to lay down any stereotyped rules for planting any particular class of land.

But, by way of a summary, the following lists are given for trees suited to particular classes of land, without reference, however, to the financial advantage of planting one species in preference to another.

On very Stiff Clays (if deep).—Norway Spruce,¹ White Poplar and Pedunculate Oak, and also for coppice (only), Spanish Chestnut, Hornbeam, and Hazel.

On Clay Land, not quite so Stiff (if deep).—Norway Spruce,¹ White Poplar, Pedunculate and Sessile Oak, Black and Black Italian Poplars, Sitka Spruce, *Cupressus macrocarpa*, Silver Fir, *Thuya gigantea*, Common Alder, Hornbeam, Spanish Chestnut, Sycamore, Norway Maple, and Beech; and also Scots Pine, Corsican Pine, and Douglas Fir, but these latter must be grown on a short rotation.

Shallow Clay Soils, resting on Disintegrated Limestone Rock.—Larch, Beech, English and Wych Elm, Sycamore; Norway Maple, Scots and Corsican Pines, and Sitka Cypress.

On Dry Sands and Gravels.—Scots Pine, Corsican and Austrian Pines, Birch, Acacia,² and White Alder.

On Soils not quite so Dry.—The same trees, and also White Ash and *Abies concolor*; and, if a little more moisture, Beech, Silver Fir, Sessile Oak, Aspen Poplar, Sycamore, and Norway Maple.

On Thin Soils overlying the Chalk.—Beech, Corsican and Austrian Pines, Yew, and Box.

On Deep pure Peats.—Birch, Scots Pine, and Weymouth Pine; and Norway Spruce, if the peat be not too dry; and

¹ Norway Spruce will also succeed on shallow clay soils.

² Acacia will not succeed if the soil be sour.

also, probably, Nordmann's Silver Fir, Corsican Pine, *Cupressus macrocarpa*, and *Thuya gigantea*.

On fairly Shallow Peat Soil¹ with Deep Mineral Subsoil.—The same trees, also Silver Fir, Douglas Fir, and *Thuya gigantea*; and Alder, if moist enough.

Sand Dunes on the Sea-Coast.—Austrian Pine, *Pinus pinaster*, Scots Pine, Corsican Pine, *Pinus Banksiana*, and (probably) White Spruce (*P. alba*).

For Sea-Coast planting if the Soil be good enough.—The same trees, and also *Cupressus macrocarpa*; and, if somewhat sheltered, Sycamore, Norway Maple, White Poplar, Evergreen Oak, Turkey Oak, and *Pinus insignis*.

And, as shrubs—Sea Buckthorn, Tamarisk, *Escallonia*, *Euonymus*, Gorse, and Privet.

For Localities subject to late Spring and early Autumn Frosts (if the soil be suitable).—Scots, Corsican, and Austrian Pines, Birch, White Poplar, Sitka Cypress, and Aspen Poplar.

And lastly, good deep loams with sufficient moisture are suitable to all trees.

Ash is very particular, and prefers a deep, calcareous, marly loam.

And in the case of Douglas Fir, Weymouth Pine, *Pinus pinaster*, Spanish Chestnut, and Tulip trees, any excess of lime seems to act as a poison.

THE PECULIARITIES OF GROWTH AND THE CONDITIONS SUITED TO THE GROWTH OF TREES.

(A.) Concerning the growth peculiar to individual trees, the chief points to consider, exclusive of volume increment and financial returns, are :—

- (1) The Shape of the Crowns.
- (2) The Relative Height Growth.
- (3) The Persistency of Side Branches.
- (4) The Shade-bearing or Light-demanding qualities of different species of trees.

¹ These soils will probably be too acid for broad-leaved trees.

(B.) And as regards the conditions under which they may best be grown, it is necessary to consider :—

- (1) The Age and Distance apart at which trees should be planted.
- (2) The Merits and Demerits of Pure and of Mixed Woods, and the Methods of mixing.
- (3) The Choice of System under which the crops may preferably be grown.
- (4) The advisability, or otherwise, of a rotation in cropping.
- (5) The Season for Planting.

(A) CONCERNING THE GROWTH PECULIAR TO
INDIVIDUAL TREES.

(1) **The Shape of the Crowns.**

This is a matter to which due consideration must be given when planting mixtures of trees, or when contemplating underplanting, etc. For the final development of the crowns will, to a great extent, determine the ultimate number of trees that may be left per acre for the final crop, and the individual growing space they require. All the broad-leaved trees and Scots, Corsican, and Austrian Pines naturally develop a wide branching crown as they grow old. Whereas Douglas Fir, Larch, Silver Fir, Spruce, and Weymouth Pine, never normally develop a large crown, but preserve their conspicuous central axis even in old age; though, if grown in the open, they will generally be clothed to the ground with a luxuriant growth of side branches. The Sessile Oak grows naturally with a much straighter stem than the Pedunculate Oak; and it is less inclined to form a spreading crown.

As regards those trees which naturally form large crowns, it may be mentioned that crown development should be suppressed until the principal height growth is attained, but that, after that period, it must be encouraged to a very considerable extent, or the trees will unduly suffer.

(2) The Relative Height Growth.

This is a very important matter indeed when contemplating planting a mixture. It is necessary to know not only the ultimate height growth of the different species of trees, but also the relative height growth of the trees when young.

The fastest growing trees when young, and up to about 15 years of age, are, more or less, in the following order, provided that the soil and locality suit each tree :—

CLASS I. Douglas Fir. $Cupressus macrocarpa$. Poplars. Tree Willows. Sitka Spruce. Birch. Norway Maple. Sycamore.	CLASS III. Lime. Elm. $Thuya gigantea$. Spanish Chestnut. Norway Spruce.
CLASS II. $\left\{ \begin{array}{l} \text{Japanese Larch.} \\ \text{Corsican Pine.} \\ \text{Austrian Pine.} \\ \text{Alder.} \\ \text{Ash (F. Oregonia).} \\ \text{Ash (F. Americana).} \\ \text{Ash (European).} \\ \text{Weymouth Pine.} \\ \text{European Larch.} \\ \text{Scots Pine.} \end{array} \right.$	CLASS IV. $\left\{ \begin{array}{l} \text{Hornbeam.} \\ \text{Beech.} \\ \text{Oak (Sessile).} \\ \text{Oak (Pedunculate).} \end{array} \right.$
	CLASS V. $\left\{ \begin{array}{l} \text{Silver Fir.} \\ \text{Yew.} \end{array} \right.$

Now, with reference to the above :—

Poplars, Willows, and Birch very soon attain their principal height growth, in from 20 to 30 years.

Norway Spruce when about 8 years old, and Silver Fir when about 16 years old, begin to grow very quickly, and continue this rapid height growth until their principal height growth is attained.

Japanese Larch when about 20 years of age will usually be caught up by the European Larch.

Beech begins to grow fairly rapidly when about 20 years of age, if the canopy be close.

Oak, especially the Sessile Oak, grows fairly fast when about 35 years of age.

Corsican and Austrian Pines do not retain their very active growth for more than about 30 to 35 years.

The **ultimate height growth** of trees, in soils best suited to them, is somewhat as follows :—

CLASS I., <small>Attaining 120 feet and over, under the best conditions.</small>	{ Douglas Fir. Sitka Spruce. Silver Fir. Norway Spruce. European Larch. (Weymouth Pine.)	CLASS III., <small>Averaging 85 to 105 feet, when well grown, and on good soil.</small>	{ White Poplar. Black Poplar. Black Italian Pop- lar. Spanish Chestnut. <i>Cupressus macro- carpa.</i> Ash. Sycamore. Norway Maple. Corsican Pine. Austrian Pine.
CLASS II., <small>Averaging 105 to 120 feet when well grown, and on good soil.</small>	{ <i>Thuya gigantea.</i> Sessile Oak. Beech. Pedunculate Oak. Scots Pine. Elm.	CLASS IV., <small>Averaging under 85 feet, even under the best conditions.</small>	{ Tree Willows. Birch. Hornbeam. Alder. Yew.

(3) The Persistency and Vigour of Side Branches.

This is a matter which seldom if ever receives the attention it merits, and it varies very greatly in different species of trees. The side branches of shade-enduring trees are usually the most difficult to prune off naturally, as they remain alive even in very subdued light; whereas, under similar circumstances, the branches of light-demanding trees would quickly die, and in most cases fall off.

But even when the side branches are dead, some trees will retain their dead branches for a much longer period than other trees, and unless the dead branches of trees quickly fall off, the quality of the timber produced will be very much lowered.

For when the tree is cut up, it will often contain loose dead "knots."

As regards the persistency of the branches, it may be stated that small dead branches drop off quicker than large branches.

The side branches of Larch readily fall off, and give very little trouble; and next in order come, perhaps, those of Ash, Birch, Poplars, and Willows.

The side branches of Oak do not very readily fall off; and for the first 30 years of their life the trees should be grown very close together, so as to prevent any large branches ever being formed.

The side branches of Spruce, and Scots, Corsican, Austrian, and Weymouth Pines, are, even when dead, very persistent, especially if they be more than an inch in diameter.

On account of their shade-enduring qualities the side branches of Silver Fir, Beech, Hornbeam, Spruce, and Douglas Fir are not readily killed, and will not, if they become of any size, readily fall off.

It is very necessary to pay the greatest attention to this matter, when deciding on the distance apart at which planting should be done, or when deciding upon any particular mixture of trees, and the arrangement of that mixture.

For the **success of any even-aged mixture**, or at any rate a mixture where every tree differs from its neighbour, or where the mixture is by alternate lines of trees, is, apart from soil and locality, **almost entirely dependent upon their relative height growth and their mutual pruning effects**.

In many cases, these two considerations are entirely ignored; and the effect produced is often exactly similar to the evil effects of planting trees too wide apart.

For instance, suppose a mixture of Larch and Silver Fir were made by alternate trees, planted 4 feet apart. The Larch would grow much faster than the Silver Fir, and, for the first 25 years of the life of the crop, conditions would exist similar to planting pure crops of Larch or Silver Fir 8 feet apart each way; for, practically speaking, neither of the trees would exert any pruning effects on each other until the space of 8 feet were bridged over.

In the case of pure crops, the conditions for natural pruning

are ideal, if the trees are planted at the correct distance apart ; and, when mixtures are made, the same ideal should be aimed at ; that is to say, the height growth and the persistency of the side branches should, as nearly as possible, be identical ; thus admitting of the growth of perfectly clean timber, pruned only by natural agencies.

Larch and Ash will generally prune each other nicely, but they will not affect the pruning of side branches on any other trees to any appreciable extent ; and any other trees growing next to them in an even-aged mixture, will be of an inferior quality, unless artificially pruned.

As regards other deciduous trees :—They will prune each other fairly well, provided their relative height growth be similar.

The Pines will prune each other nicely, and so will the shade-bearing conifers, provided, in both cases, the relative height growth be similar ; but, as regards the latter, there is usually a great difference in the height growth.

And again, it may be stated as a general rule, that no deciduous trees will properly prune the evergreen conifers, even though the height growth be similar.

It must be remembered, that the real efficiency of natural pruning is due to the fact that **side branches are not allowed to develop**. It is quite a fallacy to suppose that well-pruned trees can be grown, if large side branches have once developed, unless, indeed, artificial pruning be resorted to. It is impossible to prune their branches off naturally by means of some vigorous growing tree. For instance, any idea that badly grown Oak can be “pruned up with Beech” is quite fallacious.

This question of the pruning of side branches is of far greater importance in woods artificially planted, at a distance of 3 or 4 feet apart, than it is in the case of woods raised naturally from seed.

In the latter case, the trees are crowded from infancy, and the development of side branches is always suppressed.

But, in artificial woods, the development of side branches is encouraged to start with ; for they grow for years, until

a canopy is formed, without interruption; and, by the time natural pruning begins, these branches are already big and formidable.

(4) The Shade-bearing or Light-demanding Qualities of Trees.

It is very necessary to pay great regard to this matter. If a mixture be planted, it is imperative that, if the species chosen have not the same height growth, the species that grow the slowest are capable of withstanding the shade of the quicker growing species. So also, when underplanting is adopted, only the shade-bearing trees can be used. Any disregard for this question must result in absolute failure. Care must also be taken when underplanting, that the under-crop does not catch up the over-crop before it is desired to fell the latter.

The most light-demanding trees are:—Larch, Birch, Scots Pine, Oak, Acacia (*Robinia*), Corsican Pine, Poplars, Willows, and Elm; also, Ash and Spanish Chestnut when mature, though these latter too, and especially Spanish Chestnut, will bear considerable shade when young, or when grown as coppice.¹

The trees that will bear the greatest amount of shade² are:—Silver Fir, *Cupressus macrocarpa*, Beech, Nordmann's Silver Fir, Hornbeam, *Thuya gigantea*; and, next in order, come Sitka Spruce, Sitka Cypress, Douglas Fir, Weymouth Pine, Spanish Chestnut (when young), Hazel, and Lime.

The Norway Spruce will only bear shade when the conditions for its growth are quite favourable; otherwise it is quite intolerant of shade.

The shade-enduring trees are all thickly foliated, and their canopy is complete, and no soil deterioration should take place under them; but the light-demanding trees are thinly foliated, and, as maturity approaches, their canopy becomes broken, and the humus disappears and the soil becomes covered with a rank growth. The fall of leaves

¹ As to the suitability of trees for coppice, *vide* Chapter X.

² *Vide* also Chapter VIII.

from Beech and Hornbeam is especially dense and valuable, and the condition of the soil is much improved by these species. Spanish Chestnut trees also produce very beneficial effects ; their canopy is, however, somewhat deficient towards the end of a rotation.

(B) AS REGARDS THE CONDITIONS UNDER WHICH TREES
MAY BEST BE GROWN.

(1) **The Age and Distance apart at which Trees
should be Planted.**

These two considerations are largely interdependent. For, *cæteris paribus*, the larger the trees, the greater the distance apart at which they may be planted, and *vice versa*. As a rule, trees should never be more than 4 years old when planted out, though occasionally older trees are planted out as standards over coppice. However, the older the trees, the greater is their expense, and the longer they take, in nearly all cases, to become established.

It is no uncommon occurrence for a plantation made with 2-year-old trees, planted close together, to be as far advanced in 10 years' time as a plantation made with 4-year-old plants planted at 4 feet or 4 feet 6 inches apart. For the young trees become more quickly established, and there is not the same energy of growth dissipated in the production of side branches.

Owing to the great saving in expense, young 1 or 2 year seedling trees should always be planted where possible.

This should always be possible on properly managed forest land from which a crop of timber has just been cleared ; for it should be perfectly clean. It will also be possible, almost invariably, on poor heather land ; but on maiden land where there is a covering of grass or other rank growth, it will not usually be advisable or possible, unless, by ploughing the land, it will remain fairly clean at any rate throughout the first summer. Wherever possible, a cleaning crop, such as potatoes, should be taken from such maiden land as is

good enough to prevent a loss of more than 15s. an acre being incurred. For the loss will be refunded by the saving effected by planting younger plants.

As a general rule, 1 and 2 year seedling plants should not be planted farther apart than 2 feet 6 inches to 2 feet 9 inches —that is, 7000 to 5800 plants per acre.

For the extra expense of planting the large number of seedling trees is not very great; and it is always most essential to obtain a close canopy as soon as possible; and the necessity for filling up blanks is largely avoided. The actual distance apart at which trees should be planted, depends chiefly upon the persistency of the side branches and the vigour of each year's growth. The side branches must be naturally killed before they are too big to readily drop off; in other words, the trees must be planted so close that large side branches can never develop.

The maximum distance apart at which trees three to four years old should be planted in even-aged high forest is as follows :—

5 feet apart .	<div style="display: inline-block; vertical-align: top; margin-right: 10px;"> Poplars. Tree Willows. </div> <div style="display: inline-block; vertical-align: top;"> Larch. Douglas Fir. <i>Cupressus macrocarpa</i>. Ash. </div>	<div style="display: inline-block; vertical-align: top; margin-right: 10px;"> Austrian Pine. Corsican Pine. Scots Pine. Weymouth Pine. Spruce (Sitka), and up to 3 feet 6 inches apart. Spruce (Norway). </div>
4 feet apart .	<div style="display: inline-block; vertical-align: top; margin-right: 10px;"> Norway Maple. Sycamore. Hornbeam. Spanish Chestnut. Beech. <i>Thuya gigantea</i>. </div>	<div style="display: inline-block; vertical-align: top; margin-right: 10px;"> 3 feet apart . 2 feet 9 inches . 2 feet 6 inches . </div> <div style="display: inline-block; vertical-align: top;"> Oak.¹ Silver Fir. </div>

2. The Merits and Demerits of Pure and Mixed Woods, and the Methods of Mixing.

As regards pure and mixed woods, there are many ad-

¹ This close planting of Oak is very advisable, so as to induce height growth. Only a very small proportion of Oak trees originally planted, are ever worth leaving when 40 years of age.

vantages and disadvantages connected with each method. But, briefly, the **advantages of pure woods** are:—

- (1) They are very easy to manage, and thinning operations require least skill.
- (2) The whole crop is ready to be cut at the same period.
- (3) Trees of the same species reciprocally prune the branches of each other, better than is the case with any mixture.
- (4) Natural regeneration of one species is more easily effected than that of a mixture.

But on the other hand, pure woods are often open to grave **disadvantages**, namely:—

- (1) All thinly foliated trees open out their canopy when the principal height growth has ceased, and they are no longer able to preserve the fertility of the soil; rank grass and other growth will appear; and the amount of moisture available for the trees will be much diminished.
- (2) The danger from particular insect and fungoid attacks is increased; and, in the case of pure coniferous woods, the danger from fire is greater than when coniferous trees are mixed with broad-leaved trees.¹
- (3) Thinnings of some pure crops are often almost valueless.

On the other hand, when **mixed woods** are grown, the disadvantages of pure woods are largely avoided; and other **advantages** comprise:—

- (1) If some species not suited to the soil and locality have been planted, they may be removed as thinnings, and other trees which are more suitable may be left for the final crop.
- (2) In the case of shallow rooted trees, the danger from storms and gales is largely avoided if they be mixed with deep-rooted trees.

¹ Pure Larch, especially if grown on flat cold land or on southern aspects, is far more liable to Larch Disease than when grown on northern aspects.

- (3) Where the soil varies in particular spots, the trees best suited to such places can be planted, thus utilising the ground to the fullest advantage.
- (4) Where thinly foliaged trees, which alone cannot preserve the fertility of the soil, are mixed with shade-bearing trees, whose rate of growth must be slower, the latter, by their soil-improving qualities, cause a more vigorous and more prolonged growth of the thinly foliaged trees. For instance, Oak¹ or Larch, when mixed with Beech or Hornbeam or Spanish Chestnut, will grow far finer timber than were the Oak or Larch grown alone.
- (5) Mixtures of thinly foliaged trees with shade-bearing trees will, provided the latter never outgrow the former, yield a greater out-turn of timber per acre than pure crops of thinly foliaged trees, as a greater number of stems per acre is admissible and the thinly foliaged trees will have relatively a greater growing space.
- (6) A given soil can often supply sufficient plant food and water for a mixture of trees, whereas it might not be able to do so for an exacting pure crop. For different trees make different demands on the soil for plant food and water; and as their root systems differ, some being deep-rooted and some shallow, the supplies can be drawn from a larger area.
- (7) More valuable thinnings will be realised by introducing species such as Larch, Ash, and Spanish Chestnut, than were a pure crop of Oak, Beech, or Silver Fir grown.
- (8) The original cost of forming a plantation can often be reduced by planting a proportion of cheap plants, which can be removed as thinnings.

Whereas, the chief **disadvantages** of mixed woods include the following:—

- (1) They are difficult to manage, and require great skill.

¹ Oak must be given a start when grown with Beech, or it will be outgrown and suppressed in most cases.

- (2) The natural pruning of side branches is often very defective, and with many mixtures it is impossible to produce clean straight boles.
- (3) Maturity is reached with different species at different dates.

Now, as regards the formation of mixed woods, the mixtures may be either :—

- (A) EVEN-AGED ;
- (B) UNEVEN-AGED.

(A) **Even-Aged Mixtures** :—There are very many ways of mixing trees in an even-aged mixture, the three chief ways being :—

- (i) By single trees : that is, in a sporadic manner.
- (ii) By alternate rows.
- (iii) By patches or groups.

(i) and (ii) **Mixtures by Single Trees and by Alternate Rows** require the very greatest skill. Neither method will give good results for all the trees unless the height growth and the reciprocal pruning effect be similar. It is a common practice to plant alternate rows of some hardy, quick-growing trees along with some tender, slow-growing species ; the hardy species are regarded as "nurses," and are cut out when not required. But in such a case, the slow-growing, tender species will seldom be well pruned. A better plan is to plant at least 3 rows at a time (and often more) of the tender species, and then a row of nurses ; for by this means some of the tender species will be properly pruned, and the pruning will continue after the removal of the nurses. But, where possible, another excellent plan is to introduce any tender species which will bear shade—and many of them will—under the canopy of an existing crop of thinly foliated trees, and so make an uneven-aged mixture and bring about the system of two-storied high forest. And if desired the over-crop can be gradually removed and an even-aged forest left. In such a case, however, it is imperative to plant a large number of seedlings, so as to discount any damage

occasioned by the removal of the over-crop, at any rate if the latter be of any considerable size. In this connection, it may not be out of place to state that **Birch are the best of all nurses.**

So again, mixtures by single trees, when every tree differs from its neighbour, will seldom be successful; for even if the trees have relatively the same height growth, one class—that is, one-half the crop—will be of very bad quality if there be a great difference in the mutual pruning of each other.

For instance, suppose a mixture of Larch and Corsican Pine be planted, and that one keeps pace with the other. The Larch will all be excellently pruned, but the Corsican Pine will, every one of them, be branchy and knotty, as the Larch will exert no effect upon them whatever. Often it is thought prudent to introduce into a mixture a valuable species whose success as a pure crop is doubtful. In such a case, it should be introduced sporadically, perhaps one tree every 16 feet apart, and the majority of the crop, known as the “ruling” species, should consist of trees which will prune the valuable species correctly, but will not overtop them. In such a case, the welfare of the valuable species is the chief consideration. Its success will more than counter-balance any loss in technical value of their neighbouring trees, which, even if the valuable species fail, will only form a small proportion of the whole crop, and can be removed as thinnings.

For instance, it might be desired to grow some Larch on cold flat land, but the chances of disease are far too great to risk a pure crop. But, it would be a perfectly legitimate gamble to plant Larch at intervals of 20 feet, and to have all the rest of the area pure Scots Pine.

The great difficulty of planting mixtures by single trees or by alternate rows, and at the same time obtaining good results for a fair proportion of the crop, cannot be too strongly insisted upon.

The old-fashioned promiscuous “nurseryman’s” mixtures must for ever be abandoned. The greater the number of

trees introduced into a mixture, the more difficult does the task of correctly mixing them become.

(iii) **Mixtures by Patches or Groups.**—However, a mixture by patches is as a rule the best method of forming an even-aged mixture. It is the easiest and safest method of forming a mixture, and any change in the character of the soil can be utilised to the fullest advantage.

The patches may be of any size— $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, or 1 acre, or even more. By such a method, any ill-effects produced by lack of pruning, or by difference in height growth, is confined only to the trees forming the outside rings of the patches. Therefore, the larger the patch, the less harm results from any indiscretion in this respect. Though if the patches be too large, they are, to all intents and purposes, small pure woods, and the disadvantages of pure wood have to be considered.

It should be remembered that mixtures are found in natural virgin forest more often than pure crops. But Nature's method of mixing trees is to a great extent by patches, though the patches are often small.

In the case of a mature forest, it will sometimes appear that the mixing has been by single trees. But this is not so in a general way. For an old tree dies and leaves a vacant space, which usually becomes very thickly seeded, and, although there may be many species seeded on this area, it will usually happen that in a year or so one species will have suppressed all others, and a pure patch grows up. And again, at other times, another patch may be seeded with another species, owing to differences in seed years and other causes. And so it happens that the fine, tall, clean trees so often to be found in virgin forest, have usually been drawn up and pruned by trees of their own species.

And apart from this fact, it is very much easier for mixtures to be grown successfully when thick natural seeding has taken place, producing perhaps 100,000 plants to the acre, than when artificial planting at 3 or 4 feet apart has taken place; for in the former case side branches hardly have a chance of developing.

Again, it is an important matter that, when planting

mixtures, provision should always be made, if possible, to insure that the trees removed as thinnings are easily saleable. The most saleable trees, when small, are usually Larch, Ash, and Spanish Chestnut. But, of course, very often they cannot be sacrificed.

(B) **Uneven-Aged Mixtures.**¹—As regards uneven-aged mixtures, it is necessary to bear in mind that the younger trees must always be able to bear the shade of the older trees.

The following are some notes on particular mixtures by single trees or alternate rows² in even-aged high forest, unless otherwise stated, supposing that soil and situation be favourable; and they have reference chiefly to the questions of relative height growth, and the mutual pruning of side branches; leaving out of account financial considerations.

Good or Fair Mixtures.

Oak and Beech quite good. The Beech will often, however, catch the Oak up; therefore it is always best to grow the Oak pure, and to underplant, at about 45 years of age with Beech, and thus make a two-storied high forest. This should give most excellent results.

Oak and Spanish Chestnut.—A very good mixture, if the Chestnut be coppiced before the Oak is surpassed; then the Oak should be grown as high forest with coppice. The best plan with Oak, however, is to grow them pure, and underplant when from 40 to 55 years of age; afterwards the undercrop may be coppiced if suitable. It must be remembered that only a very small proportion of any Oak trees originally planted will be growing vigorously and be worth leaving at 40 years of age. Hence it is advisable to grow the crop pure, so as to have a large choice. For if the ultimate result is to be successful, only quick-growing, vigorous trees must be left. Hornbeam may take the place of either Spanish Chestnut or Beech, though it is not so profitable.

¹ *Vide Chapter VIII.*

² As already stated, the disadvantages can often be lessened or avoided by planting 1 row in 4 or 5, etc.

Oak with Alder makes an excellent mixture, but the Alder must be coppiced.

Larch and Ash is quite good. However, one or other must be ultimately sacrificed; and underplanting must take place with Beech or Spanish Chestnut before grass appears. Often, however, Douglas Fir or Sitka Spruce will be preferable for underplanting the Larch.

Larch and Spanish Chestnut is a very good mixture. The Chestnut will not be well pruned; and, by preference, they should be coppiced.

Larch and Beech is a very good mixture, as far as the growth of Larch is concerned; but the Beech will not be well pruned, and must be looked upon as an aid to growing good Larch. It is more preferable to grow pure Larch, if the risk can be taken, as, for instance, on a northern aspect; or a mixture of European and Japanese Larch may be grown, and then either of these crops should be underplanted with Beech when about 30 years of age.

Larch and Scots, Corsican, or Weymouth Pines.—This is admissible where pure Larch is deemed too risky, as on southern aspects, etc. But the Larch should only be planted sporadically, about every 12 to 20 feet apart. If planted closer, there would be too large a proportion of the Pines of poor quality.

Larch and Alder.¹—An excellent mixture, but the Alder must be coppiced.

Ash and Spanish Chestnut make a very good mixture; underplanting might ultimately be necessary, unless the Chestnuts were coppiced. The Ash will always be the better grown and cleaner trees.

Ash and Alder is very good, but the Alder must be coppiced.

Sycamore, Norway Maple, and Spanish Chestnut will make a very good mixture, but the former should only form a small proportion of the crop, as they are not usually very saleable when small.

Weymouth, Corsican, and Scots Pines make quite a good

¹ Larch, of course, is out of the question on ordinary Alder soils.

mixture ; especially the two former. Ultimately the Corsican will be outgrown, and pure Weymouth Pine can be left, or Weymouth Pine and Scots Pine.

Douglas Fir and Sitka Spruce make a good mixture, but at present a very expensive one.

Douglas Fir and Thuya gigantea will often be a good mixture ; the latter will ultimately be outgrown in most cases.

Poplars and Japanese Larch, or Tree Willows and Japanese Larch, may be grown together, provided the Larch, which are grown merely to afford valuable thinnings, do not form more than half the crop. The Larch will soon be outgrown, and must be removed as thinnings ; and artificial pruning will probably be necessary. Underplanting with Douglas Fir or Sitka Spruce or other trees should then often be adopted ; and these will ultimately form a coniferous crop after the Poplars or Tree Willows are mature.

Poplars or Tree Willows with Alder make an excellent mixture ; but the Alder must be treated as coppice on (about) a 25-year rotation.

Bad and Inferior Mixtures.

As already indicated, the broad-leaved trees should seldom, if ever, be alternately mixed with the **evergreen** conifers. For the latter will, all of them, be coarse and inferior, and in many cases the broad-leaved trees also will be coarse and branchy, as when mixed with very slow-growing conifers, as, for instance, Ash and Silver Fir. But even if the broad-leaved trees be well pruned, the large number of inferior conifers will render the mixture inadvisable.

Hence all such mixtures as Oak with the Pines or Spruce, or Silver Fir, or Douglas Fir, are very objectionable ; so also are mixtures of Ash with these trees, etc. In most cases, also, the Oak will be outgrown.

Oak and Larch is objectionable, because the Oak will soon be outgrown, and will also be unpruned.

Oak and Ash is not good ; for the Ash will soon outgrow the Oak, and neither will be well pruned.

Ash and Beech is bad, as the Beech will surpass and suppress the Ash. It is, however, an excellent plan to underplant Ash with Beech. As regards the former case, it would be perfectly correct if the Ash were cut out before the Beech caught them up. This might be possible; but usually the Beech will begin to interfere with the Ash about 10 years before the latter are mature.

Douglas Fir mixed with any common trees, except Sitka Spruce or *Thuya gigantea*, cannot be recommended. The result will always be similar to growing the Douglas Fir at great distances apart, for no other trees will prune them to any extent.

Spruce and Corsican or Scots Pine had better be avoided, as the Spruce will usually be left behind for the first 20 years. But if it keep pace with these trees, it may be planted; only, there is not much advantage in having the mixture. Ultimately the Spruce will outgrow the Pines.

Silver Fir and Spruce or the Pines should be avoided, as the Silver Fir grow so slowly to start with; and when they ultimately compete with the Spruce or Pines, both the Pines and the Silver Fir will be very coarse and branchy.

Silver Fir and Douglas Fir is an even worse mixture. In fact, it is impossible to obtain good results by mixing Silver Fir alternately with any other trees, whether conifers or broad-leaved trees.

Silver Fir should be almost invariably used for underplanting,¹ and thus for forming uneven-aged mixtures.

Larch and Douglas Fir cannot be recommended. The Larch are often planted to lessen the expense, but they will be outgrown and suppressed by about the twelfth to fifteenth year, and will then all have to be cut out. Furthermore, the Douglas Fir which have been next to them will not be well pruned.

Larch and Spruce must be avoided. Though excellent Larch may be grown, the Spruce will all be inferior. Another great reason against the mixture is the fact that the Larch aphis and the Spruce aphis are an alternating generation

¹ For further details as to underplanting, *vide* Chapter VIII.

of the same insect. And there is no doubt that the Larch aphis is an aid to the infection of the Larch Disease.

Larch and Scots Pine is also a bad mixture, except as previously mentioned ; for the Scots Pine will all be of bad quality. Also the fungus of Larch Disease¹ lives as a saprophyte on the bark of Scots Pine.

The foregoing are, of course, only a few of the many possible mixtures. But they serve to illustrate the difficulty of achieving success when planting species alternately or by alternate rows.

However, as already stated, the plan of having a row of nurses here and there is quite correct when necessary ; but these rows must not be too close together if an even-aged mixture is being planted. The nurses usually employed are Larch, Corsican Pine, and Scots Pine, which are quick-growing, cheap, and hardy.

Birch, however, **should usually be planted for nurses**, as they grow quickly, are immune to late and early frosts, and their shade is very slight, and they will not have to be removed so early as the Pines. In most cases, the Birch should be given 6 to 8 years' start before the tender species are planted. The function of nurses is merely that of protection from inimical influences. Hence they should always if possible be grown as an overwood and the tender species introduced as a separate crop under the shelter of the nurses ; the latter should be removed when no longer required. No attempt should be made to effect any natural pruning by means of the "nurses" ; for such pruning can only be effected to the detriment of their efficiency as nurses.

Then again, the Poplars should also, in many cases, be largely used for nurses, especially to trees that will bear shade ; however, artificial pruning will always be necessary. On clay land, Poplars planted every 16 feet apart, the rest of the area being pure Spruce, should give very good results ; or if the land be not too stiff and it be desired to grow Silver Fir, the Poplars may be given a few years' start, say 6 or

¹ According to some authorities.

8 years, and the Silver Fir planted when a slight canopy is formed.

In these cases the Poplars should be artificially pruned, like standards over coppice, and, when about 45 to 50 years of age, they should yield very fine timber.

By way of a Summary, the following general rules should be observed :—

As to Mixtures.

In Even-Aged Woods :—

- (1) When mixtures are made, they should preferably be made by patches or groups.
- (2) Mixtures by alternate species of trees, or by alternate rows, will give good results in only a few cases, *i.e.* if the mutual pruning and height growth be similar.
- (3) Where quick-growing nurses are required, or where a mixture by rows is desired, there should be 3 to 8 rows of one species together, and then 1 or more rows of the other species, unless the mutual pruning effects be similar.
- (4) A greater degree of mixing is admissible with trees sown thickly than with trees artificially planted at comparatively great distances apart.
- (5) Evergreen conifers should never be alternately mixed with broad-leaved trees or with Larch.
- (6) Evergreen conifers may usually be alternately mixed with each other if their height growth be similar.
- (7) A valuable species may often with advantage be introduced sporadically at about every 12 to 20 feet apart, amongst other species, but artificial pruning will often be necessary, and, unless it be capable of bearing some shade, it must be quicker growing than the other species.

In Uneven-Aged Woods :—

- (1) The younger trees must always be capable of bearing the shade of the older trees.

As to Pure Woods.

(1) All the shade-bearing conifers may be grown pure, and are usually preferably so grown, except when making a mixture by underplanting thinly foliaged trees.

(2) The shade-bearing, broad-leaved trees, *e.g.* Beech, may be grown pure, but at present prices it will not usually be profitable except in a few districts.

(3) Thinly foliaged, light-demanding trees should not be grown pure unless—

- (a) The rotation be very short (when the land will still be clean).
- (b) Underplanting take place before the canopy has become too broken.
- (c) Soil and situation be only capable of growing some thinly foliaged trees, *e.g.* Scots or Corsican Pines, on poor, exposed places; however, in such cases the rotation should always be short.

Finally, the oracular advice may be given to "always plant pure woods unless there be a reason to the contrary."

3. The Choice of System.

This matter has already been dealt with.¹ It is, however, necessary, for the most part, to determine at the time of planting, the particular system under which the trees are to be grown, for certain trees are quite unsuited to some of the systems.

But, briefly, it may be repeated that for thinly foliaged trees the best plan is to grow them pure² where possible, and then to underplant them later on, thus forming a two-storied high forest. Or they may be grown as standards over coppice, or preferably as high forest over coppice.

Whereas for shade-bearing trees alone, even-aged high forest will usually give the best results.

In the case of land now under timber, which it is intended

¹ *Vide* Chapter II.

² The extreme risks incurred in growing pure Larch have, however, already been referred to.

to cut and afterwards to replant, the new crop should, if the conditions be not suited to the growth of timber, be introduced under a light shelter-wood, and clear cutting should be avoided. This, however, is only possible with shade-bearing species, unless the shelter-wood be very quickly removed.

When planting large areas, it will seldom be advisable to plant with a view to the whole area being managed under the same system. For as the soil, situation, aspect, and altitude vary, so must the species of trees that should be planted, and so too, in many cases, must the system under which they should be grown.

Thus on exposed places it may be advisable to grow shade-bearing trees under the selection system, unless the soil be too dry. If the soil be very dry and exposed, even-aged high forest of Scots Pine or Corsican Pine may be indicated. Then again, in some places, if not too exposed, the shade-bearing conifers may be grown under the group system. And on the best land, high forest with coppice, or coppice with standards, or two-storied high forest, will probably be indicated, and so on.

4. The Advisability or otherwise of a Rotation of Cropping.

In a general way, there is no necessity to observe in forestry a rotation of cropping, as is necessary in the case of agricultural crops. For soil exhaustion will not follow in properly managed woodlands.

However, it will often be possible and advisable to plant a more valuable species on land from which a less valuable species has just been removed.

For instance, mistakes may have been made when the previous crop was originally planted, or originally the land may have been too poor, or the situation too unfavourable, for any valuable, exacting species; but after the first rotation the soil is improved, so that a more valuable species will now grow; or again, a tender species which it was not possible to

plant originally, may now be introduced under a slight shelter-wood of the old crop.

Occasionally, also, the danger from insect or fungoid attacks will render a change of cropping necessary.

For instance, it would be very indiscreet to replant with Larch, an area which is already very badly affected with Larch disease.

Then again, on Scots Pine or Spruce areas, there is a great risk, in replanting with either of this species, of the whole area being destroyed by the Pine Weevil; and as these two crops cannot usually be said to be remunerative (at present prices), it will be advisable, where possible, to follow on with some other species.

If this be impossible, the area should be burnt over, and planting should be delayed for 2 or 3 years if the locality be subject to the pest.

The continental method of pulling the roots out of the ground would not pay in this country.

Furthermore, on stiff clay soils a change of cropping may often be advisable. For instance, pure Scots Pine or Spruce may have been originally planted, but at the end of the rotation, the soil will be in a far better condition, and a more valuable species can now be grown. For, to a large extent, the soil will have become drained, and the decaying roots of the old stumps will act as little water channels to assist in the natural drainage, and many trees will now thrive whose growth on maiden clay land is often inferior.

5. The Season for Planting.

Much difference of opinion exists as to the best season for planting; whether it should take place in the autumn or in the spring.

Under certain circumstances one or other of the seasons has much to recommend it.

The planting season extends from about the beginning of October to the end of April.

In all probability, the most favourable time for planting

trees is in the **late spring**, when the root system has become active, but before the buds have opened. The tree, then, as it were, appears to make use of suppressed energy ; and, on being planted, the root growth often continues its activity instead of being greatly checked, and gets quickly established.

But the amount of this late planting must always be very limited, for it is only during an interval of about one week that these conditions prevail.

Therefore, if a large area has to be planted, the merits and demerits of autumn or ordinary spring planting must be carefully considered. Though probably both autumn and spring planting will be adopted, so as to equalise the pressure of work.

Now, when trees are planted in the autumn, their roots get established to some extent by the time that spring growth commences ; and this is a distinct advantage over ordinary spring planting. Another advantage in the case of evergreen trees is, that the ill-effects, which sometimes result in death, caused by a hot sun in the early spring inducing transpiration before the roots of spring planted trees can make good the loss of moisture, will often be avoided.

Of course, this wilting may be sufficient to kill the autumn planted trees, but these will have a better chance of surviving than any spring planted trees, as their roots will have become somewhat established.

This wilting in early spring is fairly common in the case of Silver Fir, Scots Pine, *Thuya gigantea* and Douglas Fir.

However, autumn planting is open to many objections, amongst which the following may be mentioned :—

- (1) The plants are very liable to get lifted by the frost.
- (2) They get swayed to and fro by the wind.
- (3) On stiff land, the holes in which the trees are planted tend to become water-logged, and the roots of the trees may become rotten.

On the other hand, these dangers are largely avoided when spring planting is adopted.

In the majority of cases, it is nearly always preferable to dig the pits some weeks before the trees are planted, as the soil becomes more mellow and sweetened. However, on well-drained, moist, light soil, this does not much matter. But on any land inclined to be acid, it should be adopted.

On stiff clay soils great care is necessary. It is generally a mistake to dig the pits in the autumn and plant them in the spring, as they will become filled with water, and will eventually dry with a "puddled," caked surface. They should be dug at about the end of March, and planted up a fortnight afterwards.

As a general rule, it may be said that porous land in sheltered localities should be planted in the autumn, but that stiff land or exposed places should be planted in the spring.

And any localities subject to late frosts should be planted as late in the spring as possible.

So also, late spring planting should be adopted for trees which are difficult to transplant, such as Corsican Pine, Black Walnut, or tender species like Weymouth Pine.

On the whole, perhaps, broad-leaved trees and Larch are more suitable for autumn planting than evergreen conifers.

In mid-winter planting must generally be suspended on account of frosts. No planting should ever take place if there be the least frost in the air or on the ground.

Damp, still, muggy days are the best for planting.

It must be remembered that planting must always be finished earlier in the case of trees which flush their buds and leaves early, than where the reverse is the case. And it must be finished sooner in the South of England, than in the North of England or Scotland.

AS TO THE FINANCIAL RETURNS THAT MAY BE
ANTICIPATED BY PLANTING ONE SPECIES IN
PREFERENCE TO ANOTHER.

This question of the financial returns is one of the greatest considerations affecting planting. The aim and desire must, in nearly every case, be to grow those trees which will yield the greatest pecuniary returns.

But before the most valuable species can be determined upon its probable success must be assured; and it is therefore necessary to carefully weigh all the considerations that have been previously discussed in this chapter.

The financial returns of crops of particular species are discussed hereafter.¹

For the most part, the conclusions arrived at are referable to pure crops, but they should enable a valuable opinion to be formed as to the financial advisability of any mixture.

It is, however, necessary to allow for differences due to the trees being grown under different systems; also, the enhanced value that certain species have over others as thinnings should not be lost sight of. And another important point to note is, that the soil may be of one quality for one species, and yet of another quality for some other species.

For instance, the soil may be first quality for Scots Pine, and yet only third quality for Ash.

However, the following table will show the order in which the different species stand, with reference to their pecuniary returns, if the soil and situation were equally suited to all, beginning with those that make the greatest return. It is presumed that the cost of planting, fencing, and cleaning the crop for the first few years is £8 per acre.

It must be noted that many of the trees will often only be grown in mixtures. But it is imagined that a proportionate

¹ *Vide Chapter XII.*

area is stocked with a pure crop; and that each species is grown on its most suitable rotation.

Remarks.	Order of Merit.	If average price per foot equals
		s. d.
If all money spent on planting, or received for thinnings, etc., be calculated at 4 per cent. compound interest, then, on average land, Douglas Fir should return a rental for the land (after paying interest on planting, etc.), equivalent to about £1, 10s. per acre; Larch, 8s. to 10s.; Ash, 7s. to 9s. per acre per annum.	Douglas Fir . . . Black Poplar . . . Black Italian Poplar . . . <i>Cupressus macrocarpa(?)</i> . . . White Poplar . . . Larch. Ash Spanish Chestnut . . . Sitka Spruce (?) . . . <i>Thuya gigantea</i> . . .	o 9 } o 8 o 6 o 6 i 0 i 6 i 0 o 6½ o 7½
There is very little difference in the financial position of these trees; and, if monies spent and received be calculated at 4 per cent. compound interest, then there will usually be a direct loss , even though the land were reckoned rent free, unless, as will often be the case with the conifers, the cost of planting, fencing, and cleaning the young crop be less than £8 per acre.*	Weymouth Pine . . . Corsican Pine . . . Oak Scots Pine Silver Fir Norway Spruce . . . Beech	o 7½ o 6½ i 9 o 7 o 6½ o 6½ i 0

* *Vide Chapter XII.*

Note.—Tree Willows will give a better return than Poplars if a large proportion of the timber can be sold at a big price, say, 3s. to 6s. a cubic foot for cricket bats.

CHAPTER VI.

PLANTING—*continued.*

PLANTING OPERATIONS.

CONCERNING ALSO THE ARTIFICIAL SOWING OF
CROPS OF TREES.

THE DIFFERENT METHODS OF PLANTING TREES.

AMONGST the more common methods adopted for planting, may be mentioned the following :—

- (1) Planting in Pits.
- (2) Planting in Holes made with a Planting Spike.
- (3) Planting with a Curved Planting Spade.
- (4) Notching :
 - (a) With an Ordinary Spade ;
 - (b) With Schlich's Spade ;
 - (c) With a Wedge-shaped Planting Iron.
- (5) Dibbling with an Iron Dibble.

1. Planting in Pits.

This is the most expensive method, but it is the only method admissible with large plants. The actual size of the pits must vary according to the size of the plants; but they must be large enough so as to admit of the roots having a natural position, and sufficiently deep so as to prevent any roots from being doubled up. It is a very common error to make the pits too wide and not deep enough. Pits for 4-year-old plants should generally be dug 8 to 10

inches wide, and 10 to 12 inches deep. If there be a soil covering of turf, it should be removed in two thin slices, and placed on one side. This is most easily done with a specially made spade, or iron, the exact width of the holes, with the blade set on at an angle to the shaft. After the turf is taken off, the holes are got out with a spade, using also a pick-axe if necessary; the earth should be placed on the other side of the hole to that where the turf was put.

When the time arrives for planting, each tree requires a man and a boy to plant it, if it is to be properly done; one man, single-handed, cannot possibly plant any considerable quantity of trees in pits. A boy should hold the tree in the centre of the hole, whilst the man fills in the hole. When a little of the finest earth has been filled in, the boy should give the tree a gentle shake, so as to cause the earth to fall in between the rootlets, and at the same time he should gently draw it up, so that the "neck" of the tree is slightly above the level of the ground. Then the rest of the earth should be filled in and firmly trodden in by the man, but in doing so, he must take very great care not to injure the bark of the young tree with his boots. Also, the very greatest care must be taken to insure that, when finally planted, the tree stands **exactly the same distance out of the ground as when in the nursery.** If planted too deep, the tree will never thrive; especially is this the case with Spruce and other conifers. When the planting is finished, the two pieces of turf should be placed, face downwards, on each side of the tree. The practice of putting the turf at the bottom of the hole must be condemned, as raw turf is apt to heat; and on the other hand, its effects, when placed on the surface, are most beneficial as evaporation of moisture is retarded.

The cost of making the pits will be about 18s. to 20s. per 1000; but of course a great deal depends on the soil. The cost of planting the trees will be about 9s. to 10s. a 1000. However, the pits will not cost more than 15s. or 17s. per 1000, if the land has been previously ploughed.

2. Planting in Holes made with a Planting Spike.

This is a method which should be very much used; it is suitable for all 3-year-old plants, and for many 4-year-old plants, and even older plants in some cases.

The planting spike consists of a straight wooden handle or shaft inserted into a heavy iron head. The head should be about 14 inches long, and in section 5 inches square at the top. From this section it should taper down to a fine sharp point. This head may be hollow, and of cast iron, but the actual point should be of hardened steel. It is really like a crowbar with a very big head and a wooden shaft. Occasionally a cross T-handle is provided, but it is better to have a plain shaft, for the cross handle causes the workmen's arms to get unduly jarred, and causes unnecessary discomfort.

When the holes are made, another man follows on and does the planting. He holds the trees in position with one hand, and, with a trowel in the other hand, scrapes together some soil, and fills in the hole, and then treads it firmly.

The cost of planting in this way will be from 6s. to 9s. per 1000.

Where there is a soil covering of turf, it must first be removed, and then replaced face downwards. Also, in such a case, it will generally be necessary for a separate man to hoe up a little fine earth before the holes are made, with which the man who is doing the planting may fill in the holes, since he would have a difficulty in scraping together the earth with a trowel. This will considerably add to the expense.

The cost of removing turf, hoeing up soil, and planting, will be from 13s. to 16s. per 1000. This, however, compares very favourably with 27s. to 30s. a 1000 for making and planting in pits.

Instead, however, of separately removing the turf, and hoeing up soil for each tree, it will be much cheaper to plough the land, when planting can then easily be done for

6s. or 7s. per 1000; and there will be the additional advantage that the land will remain more free from any rank growth for the first year or so.

3. Planting with a Curved Planting Spade.

This is another cheap method of planting. It is suited to about the same sized trees as can be planted by means of the planting spike.

The spade has an ordinary wooden handle, but a long, curious shaped blade. This blade is about 16 inches long, and the last portion, of about 8 or 10 inches of it, is curved slightly upwards. The head of the blade is about 7 inches wide; it then rapidly becomes narrow, so that, at 8 inches away from the head, it is about $3\frac{1}{2}$ inches wide; from thence it tapers gradually to the end, where it is about $2\frac{1}{2}$ inches wide. Two men are required to plant a single tree, when this implement is used.

One man carries the spade and another man the plants and also a small ordinary spade. The first man inserts the curved spade at an angle into the ground, at about 8 inches from the spot where it is desired to plant the tree. He then levers the soil up so that the curved blade comes near the surface. Then the other man cuts down with the ordinary spade on to the long, curved blade, at the spot where the tree is going to be planted. Here he parts away the soil, so as to make room for the tree. He is then handed a tree by the other man, which he inserts. The long, curved spade is then worked up and down, so as to shake earth about the roots; and then it is withdrawn, and the earth over the roots is firmly trodden in.

Now, the removal of the long-bladed spade leaves a channel leading down to the roots of the tree. And it is most important to heel in the mouth of this channel, so as to prevent the air from drying up the roots of the plants. Much harm will be done if this precaution be omitted.

The cost of planting by this method will vary from 11s. to 16s. per 1000.

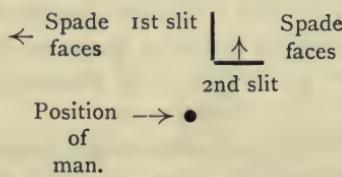
This method could not be practiced if there be a thick soil covering of turf, unless the turf be first removed. It is chiefly suitable for light friable soil; and it should not be tried on stiff land with clay near the surface.

4. Notching, or "Slitting."

This is only suitable for 1 or 2 year seedling plants, or such seedlings as have no stout side roots.

(a) When an **ordinary spade** is used, it is best to get an old, short spade, which is well sharpened. And it is very desirable that the blade be vertical, and in a line with the shaft. There are various ways of notching with the spade, but the L system is perhaps the best. The spade is inserted **vertically** into the ground; it is then withdrawn, and then again inserted **vertically** at right angles to the end of the original cut, thus cutting an L.

Then the operator levers the ground up, and the tree is slipped in by a boy at the corner of the L. The spade is then withdrawn, and the ground firmly trodden. In many cases the services of a boy, to assist the planter, are dispensed with. It is very essential that the tree should be in a vertical position after it is planted. And in order to effect this the planter should stand rather in front of, and to the side of the place where he is going to plant the tree. The spade should be inserted so that the first slit shows a somewhat convex, perpendicular face. This may be illustrated thus:—



Other systems consist in making the cuts in the shape of a T, or by cutting a maltese cross, and then inserting the spade a third time, a little distance away, and thus opening up the centre of the cross. This slitting is only suitable if the soil covering does not fall to pieces during the operation.

The cost of thus notching or slitting will be from 4s. 6d. to 5s. 6d. per 1000.

(b) **Notching with Schlich's Spade** is an improvement on ordinary notching, and 3-year-old plants can often be notched by this means. The spade has rather a long blade, which, at the end, narrows in a great deal, and has a more or less pointed end. The centre of the blade is rather thick, and the end and sides taper to a feather edge.

The spade is inserted quite vertically, and then swayed to and fro. By this means a wide opening is made at ground level, which, lower down, tapers in to a "neck," and then again broadens out.

The spade is then withdrawn and the plant inserted carefully by a boy and held in position. The man then inserts the spade vertically about 4 inches behind the original cut, but parallel to it; he then works it to and fro, so as to close up the opening. Again he inserts it in front of the original cut, and again works it to and fro. By this means not only is the top of the opening closed, but also the wide opening at the bottom of the cleft. If the spade be only worked one way towards the tree, the bottom of the cleft will not be closed in. It is therefore most important to work it both ways. This working of the spade to and fro, to close the opening, effects an appreciable amount of cultivation of the soil.

Finally, the ground must be firmly trodden round the tree.

The cost of notching with a Schlich's spade will vary from 7s. to 9s. per 1000.

(c) **Notching with a Wedge-shaped Planting Iron.**—This is suitable for the same sized trees as can be notched with Schlich's spade. The operation is performed in much the same way, but the earth is only pressed back from one side. The iron is a clumsy implement, and has nothing to recommend it.

In all forms of slitting, great care must be taken that the roots never get doubled up. The roots of the trees should always be put right down to the bottom of the notch or slit,

and then raised to the correct level. The boy inserting the plants should be provided with a long wooden spatula, similar to that used by navvies for cleaning their spades, only much longer. With this, the roots can be nicely pushed down without doing them any injury.

It is most important never to adopt any kind of notching on stiff clay soils. For the sides of the notch or slit will dry with a hard-glazed surface, through which the young roots cannot easily penetrate.

5. Dibbling.

This is a convenient and cheap method of planting seedlings on light soil. A one-handed iron dibble, or planting "peg," is used. A man inserts it into the ground, withdraws it, and then, with the other hand, places the tree in position. Then he inserts the dibble a little distance off, and closes the opening by pressing the soil back. In as much as the dibble is inserted with only one hand, it could not be used on any but very light porous soils.

The cost will be about 4s. per 1000.

As to the Choice of Methods.

This has been to some extent already indicated.

A great deal will depend upon the nature of the land.

Where possible, dibbling should be adopted, as it is the cheapest method. But where it is required to plant larger plants, such as 3-year-old plants, or, in many cases, 4-year-old plants, **the planting spike can usually be recommended over any other method.** It is cheap, and the young plants have fine soil, in which to start their growth, put into the holes. Thus they meet with far better conditions than if they be notched. In cases where there is no surface soil that can be scraped into the holes, notching may be a little cheaper; but soil can easily be provided by turning over a furrow every 2 feet 6 inches or 3 feet, according to the distance apart at which the planting is to be done; and, then, making the holes with the spike along the furrow.

It may be argued that notching is less objectionable on

clay soils than is the use of the spike, as the spike compresses the clay on all sides; but it must be remembered that the roots start to grow in fine soil put in the hole, and by a later period the compressed clay will have regained its normal pressure owing to the action of earth worms, etc.

However, on really stiff clays, planting in pits is usually preferable; and, of course, large trees must also be planted in pits.

The Number of Trees per Acre.

This will vary according to the distance apart at which the lines are made, and also according to the disposition of the trees in the lines.

There are various methods of arranging the disposition of the trees over the area, but more commonly the trees are arranged by "squares" or by "equilateral triangles." In the latter case, each tree is the same distance apart from all its neighbours, but the lines are nearer together than the distance from tree to tree. In the former case, the lines are the same distance apart each way, but the trees are not the same distance apart from all their neighbours.

The triangle system is a little more difficult to carry out, and it requires relatively a greater number of trees per acre, but close canopy is sooner formed, and natural pruning is much better effected.

To calculate the number of trees for "square" planting :—
Divide the number of square feet per acre by the square of the distance apart from tree to tree.

Thus, for 4 feet planting,

$$\frac{43,560}{4 \times 4} = 2722 \text{ trees per acre.}$$

To calculate the number of trees per acre for "triangle" planting :—Divide the number of square feet per acre by the square of the distance apart from tree to tree, and multiply the result by 1.155.

Thus, for 4 feet planting,

$$\frac{43,560}{4 \times 4} \times 1.155 = 3143.$$

PLANTING

The following table shows the number of trees required per acre for "square" planting :—

Distance apart in feet.	Trees required per acre.	Distance apart in feet.	Trees required per acre.
1 $\frac{1}{2}$	19,360	12 $\frac{1}{2}$	278
2	10,890	13	257
2 $\frac{1}{2}$	6,970	13 $\frac{1}{2}$	239
3	4,840	14	222
3 $\frac{1}{2}$	3,556	14 $\frac{1}{2}$	207
4	2,722	15	193
4 $\frac{1}{2}$	2,151	15 $\frac{1}{2}$	181
5	1,742	16	170
5 $\frac{1}{2}$	1,440	16 $\frac{1}{2}$	164
6	1,210	17	150
6 $\frac{1}{2}$	1,031	17 $\frac{1}{2}$	142
7	889	18	134
7 $\frac{1}{2}$	774	18 $\frac{1}{2}$	127
8	680	19	120
8 $\frac{1}{2}$	603	19 $\frac{1}{2}$	114
9	537	20	108
9 $\frac{1}{2}$	482	22	90
10	435	24	75
10 $\frac{1}{2}$	395	26	64
11	360	28	55
11 $\frac{1}{2}$	329	30	48
12	302	33	40

Sundry matters relative to the Control of Planting Operations.

When holes are being dug, or when notching is being carried out, it is not of course possible in practice to dig them with mathematical accuracy as to their distance apart.

But where several men are working together, the most competent man should be responsible for keeping the line. Thus, if there be six men digging, this competent man will take every sixth row, and the line of this row should be marked or indicated by sticks. The position of these sticks is ascertained by carefully measuring the distance from the last row which this man dug. Then the other men take their line from this man as best they can.

Each man should have a stick of his own, cut to the correct length of the distance from hole to hole, with which he should measure the distance from hole to hole along his line.

When actually planting in pits, if a mixture is being planted, the head woodman should place the correct species in the holes, just in advance of the planters, so as to avoid confusion.

When notching is being carried out, and a mixture is being planted, it is very difficult to keep the lines and avoid confusion with the mixture. But there should be sufficient men, so that one man plants all his rows, for the day, in a similar manner.

When planting operations are taking place, great care is necessary that the roots of the trees are not left exposed to sun, frost, or dry winds, before they are planted. If there be a home nursery near, the plants required for each day may be brought daily to the centre of the day's operations. They should be laid with their roots in a trench, and a little soil and damp straw or moss thrown over them.

If the nursery be some way off, two or three days' supply may be brought, but they should be properly "sheued" into trenches, and their roots covered up with soil.

They should not lie too thickly in the trenches, otherwise air will get down in between them and dry the roots.

In such cases, the plants required for each day's planting are carried every day to the centre of the day's operations, and protected with soil and wet moss, etc. Only sufficient plants should be given out at a time for about an hour's

planting. These should be laid in baskets, and their roots covered with moss.

When plants arrive from a trade nursery from a distance, they must usually be similarly treated. But sometimes they will arrive in a frost. In such a case, if the frost look like lasting, they should be unpacked and placed in a barn or cellar, and their roots covered with wet moss and straw. The frost must be kept from them at all costs. If they were not unpacked they would probably become heated, and thereby be injured.

If they have been unduly long in arriving after they were dispatched, or if they appear to have been tampered with, they should be signed for, at the railway office, as "damaged."

It may not be out of place to state that, when plants are brought from a trade nursery, they should be carefully chosen, and they should be inspected in the nursery, if possible, at the end of the summer, when the leaf is still on. A few should be dug up, and their roots carefully examined, and their age and treatment noted.

In some cases it would pay to send the head woodman to superintend the raising and dispatch of the plants.

SOME NOTES ON THE METHODS OF PLANTING IN PARTICULAR CASES.

It has already been noticed, that the planting up of maiden land is attended with far greater risks and more expense than the planting of land from which a good crop of timber has just been removed.

Whenever planting is done on land with a surface covering of rank grass, it will be imperative to use larger plants than should usually be used where the surface covering is of short growth, and such planting, with large plants, will necessitate planting them in pits. But, often, it will be preferable to plough the land, and plant smaller trees in holes made with a planting spike.

On heather land, all that is usually required is to burn

the surface covering and cut away any gorse after burning,¹ and then either notch in seedlings, or plant 3-year-old trees with the planting spike.

When thus planting a hillside, the best plan is to turn a furrow horizontally across the slope, and then to plant in the line of the furrow. This will help to catch any surfaced water as it comes down the slope. And when planting with the spike, it affords a supply of earth to fill in the holes with.

Wherever a "pan" exists near the surface, it must be broken through. An ordinary crowbar will usually be the best means of doing this. Though subsoiling with steam tackle will do more efficient but more costly work.

On wet peat land, an excellent plan, after having cut open drains as previously described, is to dig out large squares of peat, and plant by means of the spike, or by notching, or dibbling, etc., on the top of these squares. This is known as "tumping;" and it renders the surroundings of young seedlings drier than would otherwise be the case. It is always desirable to have mineral soil next to the roots of the young trees, for, as already stated, very few trees will grow in practically pure peat soils.

If mineral soil exist near the surface, it can easily be obtained, and the holes made with the planting spike may be filled in with this soil. But otherwise, it will be advantageous to cart some soil on to the area, and place 2 or 3 handfuls into each small hole. It will also be very beneficial, on such land, if a little basic slag or ground lime be previously mixed up with such soil.

On clay soils, if wet and very stiff, it is often advisable to adopt "tumping."² Big, square, deep sods are cut out and placed face downwards. This should be done in the autumn;

¹ If slow-growing trees be planted, it will probably be necessary to grub the gorse; this, however, will be very expensive, and will add £1 an acre or more to the cost, according to the quantity of gorse.

² This tumping on stiff land was largely practised a century ago, or more, when planting apple trees on such land; only, very large "tumps" were made.

and then in the spring the small trees can be planted with a planting spike, etc. Birch should be used as nurses.

On exposed land, when planting in pits, it will be advisable to place the trees in one corner of the pit: namely, in that corner farthest away from the direction of the prevailing wind. By this means, the stem of the tree will not make such a big hole when it is swayed by the wind.

Planting Frost Localities.—This has already been largely dealt with. It will often be advisable, where only a moderately hardy species is decided upon, to plant large trees so that they quickly get above the frost line. In the case of broad-leaved trees which have been planted some years, and which have become frost-bitten, excellent results will often follow if such trees be cut over in the spring close to the ground.

Then, if in that spring late frosts be absent, the trees will often grow 4 to 8 feet, and so rise above the frost line.

In such localities, wherever there is an existing crop of timber, it should never be clear cut. But a shelter-wood should be left, and then at any rate half-hardy species may be planted, if they will withstand the shade.

It is necessary to be very suspicious of frosts occurring on low lying moist land, or on clay soils.

A most excellent way of establishing a crop in frost localities is to plant pure Birch, and then to underplant them, some 8 to 12 years later, with the species that it is desired to grow; but the latter must be able to withstand a little shade.

Planting Shifting Sand, and Sand Dunes.—The first step to take, is to endeavour to bind the sand together, and to prevent it from being constantly shifted from place to place.

Screens of wattled hurdles should be erected on the windward side of the area to be planted. Against this a bank of sand will quickly be formed; then the hurdles must be raised and the bank made higher. Thus, ultimately the land on the leeward side will be sheltered from the wind and storms. It is preferable to have two parallel rows of hurdles, near each other, so that the sand is caught between them; and thus a wider bank is formed.

In the case of **sand dunes near the sea-shore**, where the sand is salt, the surface of the sand must be bound together by planting or sowing various sand grasses, such as the Marram Grass¹ (*Psamma (=Ammophila) arenaria*), Baltic Marram (*P. Baltica*), the Sea Lyme Grass (*Elymus arenarius*), and Sea Carex (*Carex arenaria*).

Until a soil covering of grass or the like be obtained—and it will often grow naturally—and until the sand has been washed free from all salt, the planting of trees should be deferred. When planting takes place, the marram grass, etc., should be forked up where each tree is to be planted. Then, as each tree is planted, it should be firmly trodden in, and the marram grass placed round it, so as to act as a mulch and keep off the sun. If the expense can be incurred, a handful of good stiffish loam, inserted with each tree as it is planted, will materially assist in assuring a good start.

Any trees intended for planting on barren sands should have very fibrous roots; and if 2- or 3-year-old plants (which are the most suitable) be planted out, they should have been **transplanted every year** in the nursery. They should be finally planted out in the months of March and April.

It is advisable, if possible, to have a nursery near the sea and in a fairly exposed position, so as to acclimatise the trees.

In the case of **Inland Sand Dunes**, similar protective methods must be adopted. The binding together of the sand can be effected by various grasses and plants, such as Couch Grass or Twitch, the Creeping Willow (*Salix repens*), *Salix arenaria*, and the Everlasting Pea (*Lathyrus sylvestris*). Sometimes Jerusalem artichokes are planted as "nurses" for the young trees, and to prevent the sand from blowing about. Another plan sometimes adopted is to partially cover the surface of the sand with faggots or other vegetable rubbish, such as cut reeds, etc., and then to sow tree seeds, or else to plant young trees.

¹ The marram grass will soon die as the surface of the sand becomes stale.

So, again, the ground is often partially covered with sods of heather, in which pine or other seeds have been sown previously to the sods having been cut.

This plan is expensive, but still it has given very good results.

Planting Ornamental Trees.—Special care is usually called for when planting a few ornamental trees. They are often rather large, and will require to be firmly staked. The trees should be fastened to the stakes with bands of hay, in the figure-of-8 fashion, and the ends of the bands tied with string. This will allow the tree to expand and prevent chafing.

Small valuable trees planted in exposed places should be protected by screens of wattle hurdles. Often it will be advisable to plant shelter belts of quick-growing trees a few years before the more valuable trees are planted. The shelter belt should consist, partly at any rate, of broad-leaved trees, some of which should be coppiced after they have been planted 3 or 4 years, and thus a thick screen will soon be effected.

When in the nursery, any trees intended for planting out when comparatively old, should be regularly transplanted every other year. When removed for planting out, the more earth that can be taken up with the roots the better.

Sometimes it is desired to transplant a fairly large tree from one part of a garden to another.

In such a case a deep trench should be dug all round the tree, at a distance of about 2 feet from the centre—or more according to the size of the tree—during the previous spring to that in which it is to be removed. This trench should be dug with a sharp spade so as to cut through any roots which are met with. The trench should then be tightly filled with straw, and the top just covered with earth. The tree must be kept well watered all the summer through, so as thus to induce the growth of new fibrous roots within the 2-feet radius. Then, when the tree is planted, it will not be so likely to die.

ESTIMATES FOR PLANTING AND ESTABLISHING.

The following estimates will serve as useful guides. It is in all cases supposed that the trees are raised in a home nursery; otherwise the expenses will usually be far greater.

It is also presumed that an area of about 40 acres is fenced at a time, at a cost of 30s. an acre.

Supervision is not specially charged, as it is reckoned along with the annual outgoings of the whole area under forest management. The cost of weeding and cleaning, cutting out rank grass and replacing dead trees, is, however, included, thus giving the total cost of establishing a plantation.

(1) **Pure Douglas Fir.**—On good deep loam now covered with grass; 2 year 2 year plants used. Pit planting 4 by 4 feet apart:—

Digging pits, 2700, at 18s. per 1000	£2 9 0
Planting, at 9s. per 1000	1 4 6
2750 ¹ 2 year 2 year, at 30s. per 1000	4 2 6
Planting only	£7 16 0
Rabbit fencing	£1 10 0
Cutting-out, etc.	1 14 0
	3 4 0
Total cost per acre	£11 0 0

(2) **Douglas Fir.**—Same as (1) (*i.e.* 2 year 2 year plants; 4 by 4 feet apart), but trees put in with a planting spike. The land first ploughed deeply once in the autumn:—

1 ploughing	£0 13 0
Planting with spike and trowel, at 7s. per 1000	0 19 0
2750 plants, at 30s. per 1000	4 2 6
Planting only	£5 14 6
Rabbit fencing	£1 10 0
Cutting-out, etc.	1 10 6
	3 0 6
Total cost per acre	£8 15 0

¹ To allow for waste.

(3) **Douglas Fir.**—Same as (2), but ploughing omitted, and the turf removed at each place where a tree is to be planted, and also some earth hoed up to fill in the holes with:—

Removing turf, hoeing, and planting, at 16s. per									
1000								£2	1 0
2750 plants, at 30s. per 1000								4	2 6
Planting only							£6	3 6	
Rabbit fencing						£1	10	0	
Cutting-out, etc.						1	14	0	
Total cost per acre						£9	7 6		

(4) **Mixed Ash, Larch, and Spanish Chestnut.**—On grass land ; planted 4 by 4 feet in small pits ; trees 1 year 2 year :—

Digging pits, 2700, at 17s. per 1000	£2 6 0
Planting, at 9s. per 1000	1 4 6
1000 Larch, 1 year 2 year, at 12s. 6d.	0 12 6
850 Spanish Chestnut, at 25s. 6d.	1 1 9
900 Ash, at 11s. 6d.	0 10 4
Planting only	£5 15 1
Fencing	£1 10 0
Cutting-out, etc.	1 15 0
Total cost per acre	£9 0 1

(5) **Mixed Ash, Larch, and Spanish Chestnut.**—Same as (4), only the land ploughed and the trees planted with the planting spike :—

1 ploughing	£0 13 0
Planting, at 7s. per 1000	0 19 0
Plants (as before)	2 4 6
Planting only	£3 16 6
Fencing	£1 10 0
Cutting-out, etc.	1 11 6
Total cost per acre	£6 18 0

(6) **Pure Oak.**—Planted in pits 3 by 3 feet apart; 1 year 2 year plants used; on stiff grass land:—

Digging 4840 pits, at 18s. per 1000	£4 7 1
Planting, at 9s. per 1000	2 3 6
4900 Oak, at 18s. per 1000	4 8 3
Planting only	<u>£10 18 10</u>
Fencing	£1 10 0
Cutting-out, etc.	<u>1 5 0</u>
	2 15 0
Total cost per acre (say)	<u>£13 14 0</u>

(7) **Pure Oak.**—Same as (6), only 4 feet apart:—

Digging 2700 pits, at 18s. per 1000	£2 8 6
Planting, at 9s. per 1000	1 4 3
2750 trees, at 18s. per 1000	2 9 6
Planting only	<u>£6 2 3</u>
Fencing	£1 10 0
Cutting-out, etc.	<u>1 15 0</u>
	3 5 0
Total cost per acre	<u>£9 7 3</u>

(8) **Pure Oak.**—Same as (6) (*i.e.* 3 by 3 feet apart, with 1 year 2 year plants), only on perfectly clean land from which a crop of timber has just been removed, and the trees planted with a planting spike:—

Planting 4840 trees, at 8s. per 1000	£1 18 9
4900 plants, at 18s. per 1000	4 8 3
Planting only	<u>£6 7 0</u>
Fencing	£1 10 0
Cutting-out, etc.	<u>0 15 0</u>
	2 5 0
Total cost per acre	<u>£8 12 0</u>

PLANTING

(9) Pure Oak.—Same as (8), only 4 feet apart :—

Planting, 2700, at 8s. per 1000	<u>£1 1 6</u>
2750 plants, at 18s. per 1000	<u>2 9 6</u>
Planting only	<u>£3 11 0</u>
Fencing	<u>£1 10 0</u>
Cutting-out, etc.	<u>1 2 6</u>
	<u>2 12 6</u>
Total cost per acre	<u>£6 3 6</u>

(10) Pure Scots Pine.—Planted on grass land ; in pits 3 by 3 feet apart ; 2 year 2 year plants used :—

Digging 4840 pits, at 18s. per 1000	<u>£4 7 1</u>
Planting, at 9s. per 1000	<u>2 3 6</u>
4900 plants, at 13s. per 1000	<u>3 3 9</u>
Planting only	<u>£9 14 4</u>
Fencing	<u>£1 10 0</u>
Cutting-out, etc.	<u>1 0 0</u>
	<u>2 10 0</u>
Total cost per acre (say)	<u>£12 4 0</u>

(11) Pure Scots Pine, on grass land ; 1 year 2 year plants used ; 3 by 3 feet apart ; planted with a planting spike ; the land first ploughed :—

1 ploughing	<u>£0 13 0</u>
Planting 4840 plants, at 7s. per 1000	<u>1 13 10</u>
4900 plants, at 11s. per 1000	<u>2 14 0</u>
Planting only	<u>£5 0 10</u>
Fencing	<u>£1 10 0</u>
Cutting-out, etc.	<u>1 5 0</u>
	<u>2 15 0</u>
Total cost per acre (say)	<u>£7 16 0</u>

(12) Pure Scots Pine.—Same as (11), only trees 4 by 4 feet apart:—

1 ploughing . . . . .	. £0 13 0
Planting 2700 trees, at 7s. per 1000 . . . . .	. 0 19 0
2750 trees, at 11s. per 1000 . . . . .	. 1 10 3
Planting only . . . . .	. £3 2 3
Fencing . . . . .	. £1 10 0
Cutting-out, etc. . . . .	. 1 12 6
	<hr/>
Total cost per acre (say) . . .	. £6 5 0
	<hr/>

(13) Pure Scots Pine.—Planted 3 by 3 feet apart; 1 year 2 year plants on heather land; a furrow being turned for each line of trees, and a planting spike being used:—

Burning the surface, and turning a furrow every 3 feet . . . . .	. £0 5 6
Planting 4840 plants, at 7s. per 1000 . . . . .	. 1 13 10
4900 plants, at 11s. per 1000 . . . . .	. 2 14 0
Planting only . . . . .	. £4 13 4
Fencing . . . . .	. £1 10 0
Cutting-out, etc. ¹ . . . . .	. 0 4 6
	<hr/>
Total cost per acre (say) . . .	. £6 8 0
	<hr/>

(14) Pure Scots Pine.—Same as (13), only 2 year seedlings being used:—

Burning the surface, and turning a furrow . . . . .	. £0 5 6
Planting 4840 plants, at 6s. per 1000 . . . . .	. 1 9 0
4900 trees, at 2s. 6d. per 1000 . . . . .	. 0 12 3
Planting only . . . . .	. £2 6 9
Fencing . . . . .	. £1 10 0
Cutting-out, etc. ¹ . . . . .	. 0 10 0
	<hr/>
Total cost per acre (say) . . .	. £4 6 0
	<hr/>

¹ This will often be unnecessary.

(15) Pure Douglas Fir.—2 year seedlings; on waste land; planted with a planting spike; 3 by 3 feet apart:—

Burning and turning a furrow	£0 5 6
Planting 4840 plants, at 6s. per 1000	1 9 0
4900 plants, at 10s. per 1000	2 9 0
Planting only	<u>£4 3 6</u>
Fencing	£1 10 0
Cutting-out, etc. ¹	0 10 0
	<u>2 0 0</u>
Total cost per acre (say)	<u>£6 3 0</u>

With reference to the above, the cost of planting Spruce will be a trifle under that of planting Scots Pine; whilst that of Larch will be very slightly in excess of the cost of planting the Scots Pine.

The great increase in the cost when trees are planted close together should be noted; so also, should the saving in cost, which can be effected when planting land that is perfectly clean.

And, as a general rule, it may be stated that even on foul land, it is cheaper and better to clean the land and to plant a large number of seedlings, and to keep them clean, than to plant a small number of larger trees, which may be big enough to escape injury from any rank grass.

THE ARTIFICIAL SOWING OF CROPS OF TREES.

Woods may sometimes be formed by direct sowing. But it will seldom be satisfactory to try and thus establish a wood on maiden land, as, owing to the rank growth of grass and weeds, the young crop will get choked. However, there are exceptions, which will be noted. Furthermore, sowing is uncertain, and in many cases, if the seed be expensive, it is considerably more expensive than planting seedlings, and should not be attempted.

¹ This item may be much more, or perhaps even less, according to the soil covering.

The sowing of acorns, even on rather rank land, is often successful, and so also is the sowing of the seed of Spanish Chestnut and Walnut, for these species have very large seed, with a large store of food material, and the seedlings possess great energy, and it is very probable that the best grown trees of these species will prove to be those that have been sown *in situ*. However, any direct sowing on foul grass land is almost sure to end in failure. If the land be clean, acorns may be either dibbled in, or sown broadcast and ploughed in with a light furrow. If the land be at all foul, it must be ploughed and cleaned, and then the acorns should be dibbled in lines 2 feet apart each way, and the acorns should be 6 inches apart in the lines.

Heather land may easily be sown with the seeds of Scots Pine or Corsican Pine, provided that the heather be not too rank and be not mixed with much bracken, brambles, etc. Sometimes it will be preferable to burn the surface and sow the seed a year afterwards; a small amount of heather gives very beneficial protection.

On **hillsides** it will often be advisable to turn a furrow horizontally along the hill, about every 15 inches apart, and sow the seed along the furrow, lightly raking it in and firming the ground.

The seed may be sown at the end of April, if a seed-bed be thus prepared. But, if it be sown broadcast, it should be sown much earlier, so as to let heavy rains wash the seed into the soil through the heather. A good fall of snow will effect the same purpose.

Wherever seed are sown in lines on land that is at all foul or likely to become foul, it will often be advisable, in order to save expenses in connection with the cleaning of the young crop, to have the lines far apart, say 5 or 6 feet, and to sow the seed very close together in the lines. By this means the cost of hoeing and cleaning will be very much reduced.

The seed in the lines may advisedly be sown in 3 parallel rows about $3\frac{1}{2}$ to 4 inches apart from each other. Then

when the trees grow, those in the centre row should be very well pruned trees, having been pruned by the two outside rows, which are retained until the trees in the centre rows are large enough to prune each other.

This method, however, is open to the objection that the small trees planted so closely in the lines which are far apart, sway about a great deal, and chafe the stems of each other, and thereby increase the risk of diseases.¹ The same plan may be adopted when dibbling in seedlings, but it is open to the same objection.

Sowings may, however, often be made with advantage on clean land which is now growing timber. The new crop, if shade-bearing, may be sown and left as an under crop in two-storied high forest; or else, if light-demanding, it may be sown under a very light canopy after most of the old crop has been removed. In the latter case, the shelter wood must not be retained for more than a year or so, but, owing to the covering of leaves, any rank growth of grass will be kept in check, and the young crop should easily hold its own.

The season and manner for sowing has already been discussed.² It should be remembered that stale seed should always be avoided.

Direct sowings, however, should never be attempted unless the soil and situation be favourable, though Birch seed may be sown almost anywhere, except on rank grass, where the seedlings would be smothered.

Generally speaking, seed is either sown broadcast, or in lines, or in patches.

On ordinary clean forest land, all that is necessary is to rake it in, so that it reaches the mineral soil. If the land be not clean enough, patches or lines must be hoed up.

These lines should be about 2 feet apart. On the average, only about half of the quantity of small seed necessary for sowing broadcast will be required for sowing in lines.

¹ The author has observed a great prevalence of *Nectria ditissima* in Beech and Oak so grown.

² *Vide* Chapter III.

The cost of labour in sowing must vary greatly. On perfectly clean forest land, seed can be broadcasted, or sown in lines or patches, and raked in for about 4s. 6d. an acre.

But if it be necessary to hoe up lines and clear them of weeds, etc., the cost will be about £1 an acre; though, if a plough can be worked, the labour should not be more than 10s. an acre.

Dibbling acorns, in rows 2 feet apart and acorns 6 inches apart in the rows, costs about 12s. an acre.

For sowing small seed in rows, a seed-can is most useful, and will save a great deal of time. When the seed is sown in little patches, about 6 or 7 seeds, if small, should be sown on each patch. This, though, will depend upon the germinative capacity and other considerations.

The following table will show the relative cost of sowing broadcast and sowing in lines about 2 feet apart, and also of dibbling 1 or 2 year seedlings at the rate of 10,000, 6000, and 4000 per acre (*i.e.* just over 2 feet, 2 feet 6 inches, and 3 feet 3 inches apart).

It is assumed that the land is perfectly clean; that unless otherwise stated, the cost of sowing and raking in is 4s. 6d. an acre; that, for sowing in strips, about half the amount of seed usually sown broadcast is necessary; and that the cost of dibbling is 4s. per 1000.

Fencing against rabbits is not included.

When comparing the cost of direct sowing with the cost of dibbling in seedlings, as shown in the following table, it must be noted that nothing has been charged for keeping the sown crop clean. Thus, if any cleaning be necessary, it will materially add to the expense. If the land were foul with weeds, the cost of cleaning, for the first year, would vary from 8s. to £1, 5s. per acre, or even more.

PLANTING

Kind of Tree.	Broadcasting.			Sowing in lines, about 2 feet apart.			Seedlings dibbled in.			
	Labour at 4s. 0d. per acre; if no hoeing necessary.			Age of Seedlings.			4000 Seedlings, just over 2 feet 6 in. apart.			
	Cost of Seed per lb.	Lbs. per acre.	Total Cost.	Lbs. per acre.	Average.	Total Cost.	Years.	£ s. d.	£ s. d.	
Norway Spruce	£ s. d. 0 0 10	8	0 11 2	4	0 7 10	{ 1	2 10 0	1 10 0	1 0 0	
Scots Pine	0 6 0 (clean) or 12 (unclean)	6 1 8 6	2 0 6 3	1 2 6	1	2 13 4	1 12 0	1 1 4	0	
Foreign seed	0 4 0	12 (clean)	0 16 6	1	2 11 8	1 11 0	1 1 0			
Corsican Pine	0 2 6	1 14 6	0 19 6	19 6	Iyr. : Iyr.:	5 15 0	3 9 0	2 6 0		
Weymouth Pine	0 8 0	25	Far too expensive.	...	2	5 2 0	3 1 0	2 0 0		
Larch (European)	0 1 3	18	1 0 7	9	0 15 9	1	2 14 0	1 12 0	1 1 4	
Larch (Japanese)	0 6 0	Too expensive.	...	...	1	3 5 0	1 19 0	1 6 0	
Silver Fir	0 0 6	60	1 14 6	30	0 19 6	2	3 10 0	2 2 0	1 8 0	
Douglas Fir	0 14 0	24	Far too expensive.	...	1	5 0 0	3 0 0	2 0 0		
Sitka Spruce	0 16 0	4	3 8 6	2	1 16 6	1	3 0 0	1 16 0	1 4 0	
<i>Thuya gigantea</i>	1 12 0	2	3 8 6	1	1 16 6	1	3 0 0	1 16 0	1 4 0	

EXPENSE OF CROPS SOWN DIRECT 141

Kind of Tree.	Cost of Seed per lb.	Broadcasting.			Sowing in lines about 2 feet apart.			Seedlings dibbled in.					
		Lbs. per acre.	Total Cost.	Lbs. per acre.	Total Cost.	Age of Seedlings.	Years.	£	s.	d.	£	s.	d.
<i>Cupressus macrocarpa</i>	. . .	£ s. d. 0 5 0	Average. 25	£ s. d. Far too expensive.	Average. Far too expensive.	£ s. d.	1	3	7	6	2	0	6
Sitka cypress	. . .	2 0 0	22	Far too expensive.	...	...	I	7	10	0	4	10	0
Oak	0 0 1	{ 900 (often less)	4 5 0	500 (often less)	{ 2 17 0 dibbled in at 15s.	I	4	0	0	2	8	0
Spanish Chestnut	. . .	0 0 2	{ Too expensive, except for a light seeding. 250 lbs. dibbled in costing about £3; and should produce 10,000 to 14,000 plants	150	2 14 6	75	I	6	0	0	3	12	0
Beech	0 0 4	...	...	...	...	I	3	2	6	1	17	6
Ash	0 0 4	35	0 16 2	...	...	I	4	0	0	2	8	0
Sycamore and Norway Maple	0 0 4	45	0 19 6	...	...	I	2	12	6	1	11	6
Birch	0 0 5	10	0 9 0	...	...	I	2	11	8	1	11	0
Alder	0 0 8	12	0 12 6	...	...	I	2	17	6	1	14	6
							I	2	18	4	1	15	0
							I	3	2	6	1	5	3
							I	2	12	6	1	12	0
							I	2	11	6	1	1	3
							I	2	17	6	1	14	6
							I	2	18	4	1	15	0
							I	3	2	6	1	5	3
							I	2	12	6	1	12	0
							I	2	11	6	1	1	3
							I	2	17	6	1	14	6
							I	2	18	4	1	15	0
							I	3	2	6	1	5	3

CHAPTER VII.

THE TENDING OF YOUNG HIGH FOREST AND PRUNING.

CLEANING AND TENDING YOUNG CROPS.

MOST young crops will in the early stages of their existence require a great deal of care. Much more so is this the case with young plantations on maiden land.

It will always be necessary to cut annually all rank growth of grass, weeds, bracken, brambles, and the like, until all fear of the young crop being choked is passed : for serious harm will be done to the young crop unless it be thus kept clean.

In a Pine district a short growth of heather is beneficial rather than otherwise ; and on exposed high altitudes a thin soil covering, even of grass, will often prove beneficial, provided it is not high enough to choke the plants.

But, in all other cases, there is no doubt that **young crops will thrive far better on land that is perfectly clean** than on land that is covered with grass or weeds, even though the latter be kept down by cutting.

The reason is somewhat obscure. To some extent it may be due to undue pressure on the roots and exclusion of air from them when the land is covered with grass, but the main reason is probably due to rapid changes of the temperature of the air near the ground level, and to the reduction in temperature of that air, owing to the presence of the covering of grass ; a reduction which in many cases will result in late spring and early autumnal frosts. In sylviculture it is impossible to incur the expense of hand or horse hoeing the young crops in order to keep them clean,

as is done in the case of farm crops; nor indeed would it be advisable, at any rate beyond the first year, for it is impossible to avoid injuring the young roots.

All that can be done is to clean or "cut out" the young plantations until the young trees are sufficiently tall, so that there is no danger of their being choked. It should be done annually until the young trees are about 4 feet in height.

Where very small trees are planted this cutting out will probably be necessary twice a year until the trees are about 2 feet 6 inches in height; after which, once a year will suffice.

Each cutting out will cost from 4s. to 6s. an acre. If the trees are very small and close together the larger amount will have to be paid, as cutting is then more difficult. This cutting out may be done with "fag hooks" or short "grubbing" scythes. A man will cut out about half an acre a day.

The following will represent the expense incurred in cleaning young plantations and filling up "blanks" caused by the death of some of the trees, and "firming" or "treading in" plants that have been swayed by the wind.

Case I.—Trees, 4 years old, 2700 per acre:—

Cutting out once a year for first 3 years, at

4s. 6d. per acre	.	.	.	.	.	£	0	13	6
Replacing dead trees ¹	.	.	.	.	.	0	15	0	
Treading in trees swayed by the wind	.	.	.	.	.	0	1	6	
Total	.	.	.	.	.	£	1	10	0

Case II.—Trees, 2 year seedlings, 7000 per acre:—

Cutting out, first year twice, at 6s. £0 12 0

" second year twice, at 6s. 0 12 0

" third, fourth, fifth year once, at 5s. 0 15 0

Total	.	.	.	£	1	19	0
-------	---	---	---	---	---	----	---

Note.—Replacing dead trees will not usually be necessary, as such a large number have been planted originally; also, the trees being very small will probably not require any "treading in."

¹ This item will often be very much more.

Now, much of this cleaning or "cutting out" could be avoided if the land had been ploughed and cleaned prior to planting; and if good enough and suitable a "cleaning" crop such as potatoes taken from it.

Often, when a young crop, consisting of a tender species up to 5 or 6 years, does not do well, it will be found very useful to plant rows of nurses every 16 feet or so, of Larch or Scots Pine or Birch; these rows should usually be planted East and West so as to screen off the hot sun; but often it will be advisable to put them at right angles to the prevailing wind.

Such a plan can often enable a valuable crop to be grown where late frosts occur; in such a case the nurses must be Birch or Scots Pine, preferably the former. The Larch would not succeed.

These nurses should be removed when no longer required. It would, however, be futile to plant the nurses, if the tender crop were already permanently injured.

Then again, backward plantations of broad-leaved trees can often be improved by cutting the trees back to the ground level 2 to 4 years after planting. (*Vide* "Pruning" at end of this chapter.)

Apart from the cleaning of a young crop and the cutting of rank grass in the first 2 or 3 years, some attention will often be necessary when from 7 to 10 years old. This is really another "cleaning" if that word should be used to express those cultural operations which do not pay for their cost, whereas the word "thinning" is usually applied only if the material cut will pay for the cost of the operation.

As already stated, the cost of cutting out rank growth until trees are 4 to 6 feet high should be considered as part of the original cost of forming the plantation; but expenses incurred after that date should be considered along with the annual outgoings.

This cleaning at 7 to 10 years of age is not always necessary; but in the case of coniferous plantations it will always be wise to go over them and cut out, collect, and burn

dead and sickly trees; with a view to aiding the suppression of insect and fungoid attacks, and of fire.

Then again, in natural regenerations or when artificial sowing has taken place, it will often be necessary to clean out much of the young crop to prevent overcrowding and to prevent the seedlings from becoming too spindly, in which case, they might be unable to support their own weight when they were a few years older, and so get bent over by the wind. This cleaning on natural regeneration areas is sometimes done by freeing individual trees, and sometimes by cutting narrow strips 2 feet wide; in this latter case the trees on the edges of the strips become stronger and so free themselves.

THINNING.

The primary object of thinning is to aid the more valuable trees in that struggle for existence, which results in the survival of the fittest, when Nature alone has her course.

In the latter stages of a rotation heavy thinnings are often made in order to increase the quarter-girth measurement and for the production of timber of larger dimensions. Such thinnings are, however, really partial clearances.¹

Now, with reference to thinnings in the early stages of a rotation:—

After an area has been planted or raised from seed, there is always a period of risk and uncertainty, especially if there is no shelter-wood over the young crop, until the young crop has closed in overhead and close canopy has been formed.

When this has taken place much anxiety is removed. From this time onwards the trees are struggling with each other for supremacy. If artificial aid is not forthcoming this struggle is continued to a dangerous extent; the trees become too thin and lanky, and, when ultimately any thinning takes place, the trees left will be unable to withstand gales of wind or heavy falls of snow.

On poor soil this prolonged struggle is especially notice-

¹ *Vide Chapter VIII.*

able ; on good soil individual trees are quicker to assert themselves.

In Nature the selection system is largely observed, and this danger is to a great extent averted in an uneven-aged wood growing under the selection system, for the patches of trees of the same age are small, and those on the outside avail themselves of more light and air.

With reference to thinning, some foresters classify trees as :—

- (1) Dominating or Vigorous.
- (2) Dominated.
- (3) Suppressed.
- (4) Dead and Dying.

Dead and dying trees should always be cut and removed from the forest, or the danger from insects, fungi, and fire is increased. For the same reason suppressed trees in coniferous woods should always be removed ; the vigorous and dominated trees, alone, being usually left. Though at each thinning, the **vigorous** trees should usually be individually considered and any **dominated** trees removed if likely to interfere with the growth of the former in the next few years.

Some dominated trees must often be removed if interfering with each other. Sometimes from bad management or other cause the **vigorous** trees have an unduly large crown and branch development in proportion to the length of their stems ; such trees should always be removed : they occupy more ground than should be allotted to them.

When, however, dealing with hardwood areas, and especially shade-bearing hardwoods, it is often a good plan to leave all the suppressed trees, provided they be healthy ; for they will shade the soil, help to preserve the humus, and keep out the wind and sun. Beyond removing dead and sickly trees, all that is necessary is to free the best-grown trees from any undue competition with their neighbours, all else being left.¹

An endeavour should be made to have vigorous quick-

¹ This is termed by French foresters :—" Éclaircie par le haut."

growing trees with moderate-sized crowns evenly distributed over the whole area.

One disadvantage of this method is that by leaving the suppressed poles whose increment is at a standstill, there is a small financial loss, as capital is left uninvested, but this is to a great extent compensated for by the fact that the soil is kept exceedingly clean, to the consequent benefit of the main crop.

It is difficult to say for certain at what periods of their lives trees require thinning. Much will depend upon the quality of the soil, the situation, and the distance apart at which the trees were originally planted.

But taking a general average with trees planted 4 feet apart, the first thinning should take place in the case of:—

	Years.		Years.
Larch . . .	at 10 to 12	Scots Pine . . .	} at 18 to 23
Douglas Fir . . .	12 „ 15	Weymouth Pine . . .	}
Ash . . .	13 „ 16	Spruce . . .	} 18 „ 24
Spanish Chestnut „ 14 „ 16		Beech . . .	}
Corsican Pine . . .	15 „ 20	Silver Fir . . .	, 24 „ 32
Oak . . .	17 „ 22		

All thinnings in the early part of a rotation should be slight, except under particular circumstances; for example, an area under Larch which is badly diseased.

"Thin little and often" is a sound saying.

After the first thinning, the operation must be repeated every 5 to 10 years, according to the kind of crop and the density required; though in the latter stages of a rotation when the principal height growth has ceased, the thinnings are often not so frequent—say, every 10 to 15 years.

Provided other considerations admit of it, light-demanding trees require more frequent thinning than shade-bearing trees, and quick-growing trees than slow-growing trees.

Trees whose side branches die quickly and easily fall off, as, for instance, Larch, can be thinned relatively more heavily, than trees whose side branches are very persistent, as, for instance, the shade-enduring trees; and also Oak and Scots Pine up to the first 30 years at any rate. For this

reason, pure Scots Pine planted at 3 feet apart, and pure Oak at 2 feet 6 inches is far preferable to 4 feet planting; so also Spruce planted at 3 feet and Silver Fir at 2 feet 6 inches will give better results than if planted at 4 feet apart.

Until the principal height growth is attained thinnings should be slight, and the trees should be close enough together to cause all side branches to die and fall off, and thus clean timber will be produced.

Light-demanding trees will usually require thinning in the pole forest stage about every 5 to 7 years, and shade-bearing trees every 8 to 12 years.

After the trees are about 45 to 55 years old, very little thinning is necessary in conifer crops unless partial clearances are desired or natural regeneration cuttings are required.

On good soil, or in sheltered positions, or on cool aspects, or at low altitudes thinnings must be begun earlier, and must be more frequent, and may be somewhat heavier than when the reverse is the case.

On poor soil, or on hot aspects unless moisture is plentiful, or at high elevations, or in exposed places, forest growth is slower than when the reverse is the case, and therefore a greater number of trees per acre should be found of any given age, if a similar density of canopy is to be produced. In the Black Forest 5 per cent. more Beech were found on southern than on northern aspects. In exposed places, the edges of the wood should be thinned heavily from the beginning, so as to encourage the growth of side branches and to get bushy trees which will form a good wind-break. Austrian Pine are often planted for this.

Now, whereas it is obvious that some thinning is necessary, any severe interruption of the canopy in the early stages of a rotation should always be avoided, except in rare instances.

A great mistake is often made by starting to thin woods too early; some people are frightened when they see the branches interlacing, but the **lower branches should interlace**; the sooner they do the better, and under proper

conditions they will kill each other off, and effect natural pruning ; there should be no need for artificial aid in pruning.

Any severe thinning in the early stages of a crop encourages the expansion of the crown and growth of side branches, to the detriment of the height growth ; though the individual trees will increase their quarter-girth measurement to a greater extent than if the canopy is close. Trees taper unduly if too heavily thinned, especially during the pole forest stage.

On the other hand, trees left unthinned too long, will probably lose even in height growth, for their vigour will be slight, and they will be liable to be blown over by the wind.

With some trees, especially Oak and Chestnut, an unduly thick canopy will often cause, especially in the latter half of a rotation, the flushing of latent buds along the stem, and **epicormic branches** will be thrown out. The reason of this is because the crown is too small, and the root system is too vigorous in proportion, and hence the excess of soil nutrients and water cause the flushing of latent buds.

On the other hand, a similar result often follows where stems grown in close canopy are suddenly exposed, especially in the case of Oak. In this case it is due to the stimulating action of sunlight on the trunks, the bark of which is comparatively thin and tender when grown in close high forest, and also to a state of hypertrophy induced by an excess of soil nutrients. Other evil effects which usually supervene if a close-canopied young crop is suddenly thinned, may be traced to exposure of the tender bark and buds to inimical influences, such as frost, cold winds, and hot sun. Often, early spring growth will be induced, and the young foliage and shoots may be injured by a late spring frost.

The thinning of pure Oak woods requires special care, partly on account of the liability of these trees to throw out epicormic branches, and partly because there is great difficulty in growing trees with tall clean boles and crowns of a moderate size.

Up to the age of 30 to 35 years they must be grown very close to stimulate height growth, and to kill off side branches ;

after that age any undue struggle for existence must be avoided or the whole crop will be a failure. After the first thinning has been made, other very slight thinnings should be made every 5 to 8 years until the principal height growth is attained ; and directly the humus disappears and weeds begin to grow, underplanting or undersowing should take place.

For this purpose, Spanish Chestnut or Beech, or a mixture of them, are the best trees to plant.

It must always be remembered that the execution of thinnings and the density of the canopy will greatly affect the amount of moisture available for the crop.

As far as the question of moisture alone is concerned, a serious interruption of the canopy will not be so harmful on fertile soils as it will be on poor soils, or wherever the conditions for the growth of timber are unfavourable.

The soil will probably contain a maximum amount of moisture when the canopy is neither too thick nor too thin.

With this object in view, the canopy should be as thin as is compatible with the retention of humus and dead leaves.

For if the canopy is unduly thick, transpiration through the leaves is at its maximum ; so also is the interception of atmospheric precipitations, rain and dew ; whilst evaporation of moisture from the surface of the soil is reduced to a minimum.

Now, if this canopy be somewhat broken, transpiration and interception are lessened, and, provided that humus does not disappear, evaporation of soil moisture will not be very much increased.

But, if the canopy be still more broken, humus will disappear, and evaporation of soil moisture will be increased ; later on, grass and a rank growth of weeds will appear, and transpiration and interception of moisture will again take place, though this time, chiefly from the soil covering of grass and weeds, instead of only from the trees as in the former case.

Having regard to this, it is obvious that the greatest care is necessary on dry soils or on hot southern aspects, where usually the soil is lacking in sufficient moisture.

Often under such conditions, especially towards the end of a rotation, it is found that only a limited number of trees can thrive, but though a heavy thinning will probably be indicated, the greatest care must be taken not to destroy the humus.

It must be evident that the aspect upon which trees are growing is a matter of great importance in determining the degree of thinning that should take place.

As already indicated, it will usually be necessary on a southern aspect to have the canopy as thin as is compatible with the retention of humus; but on northern aspects the relative density of the canopy may usually be either greater or less.

A denser canopy is admissible because, owing to the greater amount of moisture in the soil and air on northern aspects, tree-growth is more vigorous in spite of the fact that the light is less intense. This, however, would not be the case if there was plenty of moisture on any given southern aspect.

Then again, on the other hand, the canopy may be thinner on a northern than on a southern aspect, because the humus will not disappear so quickly, and any rank growth of grass and weeds will be slower to appear.

It will nearly always be preferable to have the thinner canopy, provided that the principal height growth of the crop has been attained, since the individual trees will put on a greatly increased increment; and the money realised for that portion of the crop which is removed, should earn $3\frac{1}{2}$ or 4 per cent. interest, and perhaps more.

And moreover, whenever the conditions for the growth of timber are favourable, though a somewhat thicker canopy is admissible than when the reverse is the case, it will usually be advisable to have a somewhat thinner canopy than is the case on poor soil, provided always that the principal height growth has been obtained, though not until then, for the evil effects of wind and insolation will not be so serious, and the trees will be quicker to form close canopy again.

When thinning **mixed woods**, the requirements of

different species of trees must be considered ; light-demanding trees must have relatively more growing space than shade-bearing trees. If the shade-bearing trees catch up and surpass the light-demanding trees, one class or other must be removed.

Care must always be taken to preserve the required mixture.

If other considerations admit of it, remove as thinnings such trees as are valuable and saleable when small, and not small trees of those species which are more or less valueless. It should be noted that Ash, Spanish Chestnut, and Willow are valuable even when small, and are much used for split hurdles, etc. Small Larch are nearly always saleable, and are always useful for estate purposes. But often it would be most unwise to cut these out, as they will be required as mature timber.

Finally, it may be stated that the general principles to be observed in ordinary thinning operations are, speaking generally, that thinnings should be so conducted that in the early part of a rotation the side branches are allowed to interlace and cause the death of each other, thus leaving all pruning to natural agencies and, at the same time, stimulating height growth ; and that in the latter part of a rotation, thinnings may be more severe, but, unless underplanting takes place, never so severe as to result in the disappearance of humus, and the consequent loss of soil moisture, and the growth of rank grass and weeds. For, apart from soil deterioration, a great expenditure will be incurred in cleaning the land and keeping it clean, when the time arrives for the establishment of a new crop. Whereas, under correct management, it should be possible to produce a new crop at a minimum of expense, using seedling or quite small trees, which for a year or two should be able to grow without interference by weeds or rank growth.

It is recognised by the agricultural community that farming land should be kept scrupulously clean : it is equally important to observe the same principle in connection with land used for the growth of timber.

PRUNING TREES.¹

It has already been stated that if mixtures of trees have been made with due care and if thinnings have been properly conducted, that the pruning of trees should hardly ever be necessary. However, there will always be exceptions, and young standards growing over coppice will usually require some attention.

(1) The Pruning of Green Branches.

In the case of **conifers** an almost invariable rule should be observed: namely, "never prune a green branch." One great reason is that the danger from insect and fungoid attacks is so very much increased by such an operation. The exudation of turpentine is, to some extent, a safeguard against fungoid attacks, but usually this exudation is so great that the healing of the wound is retarded. On the other hand, many injurious insects are attracted by the smell of turpentine exuding from a freshly cut surface.

However, there is one great exception to this rule, and that is in the case of Douglas Fir. This tree, if pruned, heals very rapidly and in a striking manner; for broad annual rings of new bark quickly occlude the wound, in a manner which is peculiar to this tree alone.

It would not, however, be wise to prune Douglas Fir until it is 10 to 12 years of age, on account of the danger of the Pine weevil.

As regards the other Conifers, if any pruning be done, it is less objectionable in the case of Silver Fir than in that of any of the rest of them. It is, however, necessary to cut away any double leader, whether on coniferous trees or not, which may be found in young plantations.

In the case of trees other than conifers, the pruning of green branches is not attended with such risks, and is indeed often desirable. Young hardwood trees growing as "standards" over coppice will usually require pruning and

¹ See also "Nursery Work," Chapter III.

will pay for so doing ; and even some of the branches on the older "standards" may advisably be cut if they do not exceed about 3 inches in diameter. Any exposure of heart-wood will usually result in decay.

The side branches of **young hardwood trees** in even-aged woods will often require pruning. The necessity for this will be more frequent in mixed woods than in pure woods, and especially, of course, if the trees have been planted far apart. But pruning is very expensive, and unless it is done well, more harm than good is done to the trees.

It should never be resorted to unless it is quite certain that it will not be effected by natural agencies in a reasonable time ; and even if this seems unlikely, it will often be preferable and cheaper, in the case of young hardwood trees which have not been planted more than 4 or 5 years, to cut them over very close to the ground, and to subsequently allow a single stem to grow from each of these coppiced trees. The new stem is very vigorous, and the whole of the energy of the root system appears to be largely directed in making a long leading shoot, to the detriment in growth of side branches.

Young hardwood trees thus cut over will often be far taller in 6 or 8 years' time than similar trees not cut over, and they are always cleaner and more free from side branches.

This method of cutting trees over at the "collar" is often practised in the case of Ash at the time of planting ; and it is a very usual custom in the case of planting trees to form a hedgerow ; in this latter case, however, the cut is made about 2 inches above the collar, so as to induce the throwing out of many side branches near the ground.

Where the growth of timber trees is required, it will generally be preferable, if this practice is adopted, to cut them over after they have been planted out for 2 or 3 seasons (or even more in some cases). If Beech trees were cut over at the time of planting, most of them would be killed, though Oak, Ash, Spanish Chestnut, Hornbeam, Sycamore, and

Norway Maple would not resent this treatment. But if these latter are cut over at the time of planting, their ultimate height in 6 years' time will not be so great as if they had been cut over 3 years afterwards, when the roots are thoroughly well established; for in this latter case a very long shoot will be made, whereas in the former case the first year's shoot will be small, and in the second year some of the energy of the plant will be directed to the growth of side branches.

When young crops 20 or 30 years old are pruned, it will usually be waste of money if any but the best trees or those likely to be left for the final crop are pruned.

The pruning of softwoods, such as Poplars, Willows, and Lime, is usually dangerous, as their wood generally decomposes before the wound is healed over, and in such cases can offer no resistance to the entrance of spores of fungi.

Only very small branches, which quickly heal, should be pruned off such trees. It is occasionally necessary to saw off big branches, as may happen in the tending of ornamental timber, but the cutting of branches over 3 inches diameter is attended with considerable risk.

(2) Method of Pruning.

Branches should always be **pruned absolutely flush with the stem**, except in the case of very large limbs, as mentioned hereafter.

If the branches are small, a sharp knife should be used; otherwise a small pruning saw should be used, but the circumference of the cut surface should always be trimmed round afterwards with a sharp knife, in order to encourage the bark to quickly occlude the exposed surface. If the branches are not cut quite flush with the stem, the small projections or "snags" die, and never, even when the bark has closed over, become incorporated with the live wood, but remain as dead knots in the timber.

Young standards in coppice may best be pruned with a sharp chisel fitted to the end of a long pole, and this is

pushed from below upwards. For bigger branches ladders and hand-saws must be called into requisition.

Generally speaking, trees should be pruned to $\frac{3}{5}$ of their total height, all small branches below this height being entirely removed flush with the main stem. Under no circumstances should small branches be merely trimmed back to a side twig or bud, as is practised in the case of some fruit trees.

When dealing with ornamental timber, big branches may often have to be removed. Now, whenever a big branch has to be removed, it should first be sawn through for a few inches underneath at a distance of about 2 feet from the face of the main stem ; then this cut should be completed through from the upper side. This leaves a short length of 2 feet, which is then sawn off in the ordinary way flush with the stem ; then the circumference must be trimmed round with a sharp knife and the cut surface painted over with creosote, or tar and turpentine, or some other suitable antiseptic.

It is necessary for the branch to be removed in two lengths, as otherwise there is a great chance of the heavy branch falling and tearing a long strip of bark and sapwood away from the main trunk.

Sometimes only a portion of a big limb is removed. In such a case, unless there is a large side branch on this limb, a length of 8 or 10 feet should be left between the main trunk and the cut surface ; for the flushing of latent buds will then probably take place, and this small length will continue to live. If only a short length were left, it would gradually rot and get hollow, and form a channel whereby water and the spores of fungi would enter the main trunk.

With reference to the above, it is preferable only to remove that portion of a limb beyond the first large side branch ; for this side branch will keep the rest of the limb alive, provided it be sufficiently large.

(3) Season for Pruning.

Much difference of opinion exists as to the best season for pruning. Generally speaking, the autumn is the best

time, but it should never take place during a frost. If pruning is done in the summer, the wounds generally heal quicker than if done at any other time; but the cut surface is more liable to decompose and form a suitable growing medium for fungous spores.

Where large branches are removed, there can be no doubt that autumn is the best time, for any tar or antiseptic put on the cut surface would fail to penetrate or remain on if the operation took place in the summer or spring.

Many more experiments are, however, required before this difficult question can be definitely decided.

(4) The Effects of Pruning.

The pruning of branches off young trees causes the energy of growth to be directed to the leading shoot; hence the beneficial effects seen in the case of trees in a young plantation which have hitherto made very little headway, but which, on being pruned, so often begin to "get away" almost immediately.

Trees approaching maturity which have been well pruned, either naturally or artificially will have a higher form factor—that is, they will be more cylindrical and less tapering.

The reason is because increment in girth is greatest near the top of the bole, usually just below the lowest branch of the crown, provided always that the trees are properly grown.

A tree with many side branches on the stem, will often have broader annual rings near the base than higher up, and will therefore be very tapering.

Again, the pruning of side branches will stimulate height growth even in the case of middle-aged trees, provided the period of natural height growth has not ceased and the trees be still vigorous.

The effect of pruning of big branches on old trees is at times apparently rather contradictory, though not really so. If senile decay be already approaching and the tree be beginning to become "stag-headed," the removal of side branches will determine the soil nutrients to the crown,

restore the balance between leaf and root activity, and the tree will continue to thrive.

But suppose big branches be cut off such trees as Oak (or those which have a tendency to throw out epicormic branches) when they are mature or nearly mature, and whilst they are still vigorous, the result will be to actually induce stag-headedness in a few years. The reason of this is because a state of hypertrophy will be induced; the roots will supply more water and soil nutrients to the crown than are required, and this will have the effect of flushing latent buds along the stem; when, however, these latter have grown into branches they will make an additional demand upon the roots for moisture and soil nutrients which cannot be supplied, the result being that the epicormic branches appropriate the soil nutrients, to the detriment of the crown of the tree, which consequently becomes stag-headed.

(5) The Pruning of Dead Branches.

This would always be advisable if the expense could be incurred. In young plantations, and especially Larch plantations, they are often knocked off with a stout stick. But unless additional light is required for underplanting it would be better to leave their removal to natural agencies. For if they are so small that they can be thus knocked off, they will fall off of their own weight in a few years' time, when they will probably come out at the "socket." Whereas in knocking them off a small snag will often be left; and inasmuch as it is deprived of the leverage exerted by the weight of the whole branch, it will be many more years before it finally falls or rots away.

TABLES OF THINNINGS.

The following tables give data showing how pure crops should be thinned in even-aged high forest. In all cases it is presumed that three-year old trees have been planted:—

BEECH.

Close-Canopied High Forest. Good average soil and situation.

Quality II.

Years since planted.	Poles cut.	Poles left.	Average distance in feet apart, about	Height to top of tree.
20	Rubbish.	2500	...	...
30	800	1700	5	28
40	720	980	6½	42
50	325	655	8	56
65	250	405	10½	71
80	105	300	12	81
95	100	200	14½	90
105	50	150	17	94
120	Final crop,	150 trees.	...	98

OAK.

Close-Canopied High Forest. Good average soil and situation.

Quality II.

Years since planted.	Poles cut.	Poles left.	Average distance in feet apart, about	Height to top of tree.
20	Rubbish.	1800	5	...
25	370	1430	5½	24
32	500	930	7	32
40	390	540	9	42
50	140	400	11	53
60	100	300	12½	64
75	110	190	15½	77
90	60	130	18	87
105	30	100	21	92
120	Final crop,	100 trees.	...	94

ASH.

Close-Canopied High Forest.* Good average soil and situation.

Quality II.

Years since planted.	Poles cut.	Poles left.	Average distance in feet apart, about	Height to top of tree.
13	...	1800	5,	23
20	700	1100	6 $\frac{1}{2}$	36
27	400	700	8	46
35	220	480	9 $\frac{1}{2}$	56
45	220	260	13	66
55	140	120	19	72
70	Final crop,	120 trees.	...	78

* Slight partial clearances are made at the forty-fifth and fifty-fifth years.

SILVER FIR.

Close-Canopied High Forest. Good average soil and situation.

Quality II.

Years since planted.	Poles cut.	Poles left.	Average distance in feet apart, about	Height to top of tree.
30	...	2300	4 $\frac{1}{4}$	24
35	800	1500	5 $\frac{1}{2}$	30
45	500	1000	6 $\frac{1}{2}$	42
55	400	600	8 $\frac{1}{2}$	55
65	220	380	10 $\frac{1}{2}$	68
77	100	280	12 $\frac{1}{2}$	80
90	Final crop,	280 trees.	...	90

Note.—Norway Spruce will be somewhat the same. But as it grows very much quicker while young, the thinnings will be begun earlier, and there will be a smaller number of trees at the respective dates all the way through, and the rotation may be reduced to about 77 years.

LARCH.

Close-Canopied High Forest. Good average soil and situation.

Quality II.

Years since planted.	Poles cut.	Poles left.	Average distance in feet apart, about	Height to top of tree.
12	500	1800	...	...
18	700	1100	6½	26
25	400	700	8	38
32	220	480	9½	50
40	150	330	11½	60
50	70	260	13	69
60	60	200	14½	75
70	Final crop,	200 trees.	...	80

Note.—Better results would usually be obtained if partial clearances were made from about the thirty-fifth year onwards, and the crop underplanted.

SCOTS PINE.

Close-Canopied High Forest. Good average soil and situation.

Quality II.

Years since planted.	Poles cut.	Poles left.	Average distance in feet apart, about	Height to top of tree.
20	800	1400	5½	26
30	500	900	7	39
40	300	600	8½	52
50	160	440	10	62
60	110	330	11½	69
70	70	260	13	74
80	Final crop,	260 trees.	...	77

Corsican and Austrian Pine will be about the same, though they grow very much quicker for the first 30 years; but during this period they require rather a greater relative density. Weymouth Pine will also be similar, though its height growth is finally greater than Scots Pine.

DOUGLAS FIR.

Close-Canopied High Forest. Very good soil and situation.

Quality I.

Years since planted.	Trees cut.	Trees left.	Average distance in feet apart, about	Height to top of tree.
14	...	1800	5	35
20	600	1200	6	50
27	430	770	7½	65
35	270	500	9½	79
45	250	250	13	94
55	60	190	15	106
65	60	130	18½	118
75 *	50	80	23½	128
85	Final crop,	70 trees.	...	135

* A rotation of 75 years will prove more profitable if the same price per foot can be obtained for the timber as will be realised at a later date.

Note.—The above table for Douglas Fir is based upon careful estimates made as to its rate of growth both in this country and its native country. In this country there are, however, no plantations old enough to verify the later stages of the above table.

CHAPTER VIII.

PARTIAL CLEARANCES AND UNDERPLANTING.

Partial Clearances for the production of mature timber of large girth, are often made at intervals before the final felling.

Under certain conditions this policy can be strongly recommended.

It consists in a succession of very heavy thinnings removing from $\frac{1}{2}$ to $\frac{1}{4}$ or more of the smaller trees forming the crop. These heavy thinnings should not take place until after the principal height growth has ceased, as to seriously check height growth would be very bad practice. In making these partial clearances the canopy is broken, and the trees which are left standing enjoy a maximum amount of light and air, with the result that in practically all cases a greatly enhanced increment per individual stem takes place, provided always that the trees are still vigorous, and that senile decay has not yet begun.

Often the width of annual rings will be doubled.

The actual reason for this enhanced increment is somewhat open to discussion, but probably it is due to the following reasons:—

- (1) The increased intensity of light will render the assimilation of carbonic acid gas (CO_2) more active, through the existing foliage of the crown.
- (2) Dormant buds will be flushed and new foliage produced; and hence increased assimilation.
- (3) Food supplies from the soil are required to nourish a

smaller number of trees, which correspondingly benefit thereby.

- (4) Owing to the destruction of humus food supplies are temporally increased.
- (5) An immediate utilisation of reserve food material, which was stored up in the stem whilst close canopy prevailed, takes place. (Hartig's theory.)

In connection with this latter reason, it should be noted that reserve food material is far greater in broad-leaved deciduous trees than in conifers, and greater in Larch than in the other conifers.

Sometimes this increased increment does not take place for a year or so until after the partial clearance.

In such cases the reason will often be that the trees were not vigorous enough at the time of the partial clearance. However, in a few years' time, when the foliage and roots have recovered their normal activity, and also after new foliage and new roots have grown, the trees begin to actively respond to the treatment they have received.

One result of the increased increment is the production of broader annual rings than would otherwise have been the case.

Now, in the case of conifers, broad rings are mostly made up of spring wood which is of low density, for the tracheids which are formed in the spring have thin walls and large lumina; the reverse, however, is the case with the autumn wood.

But in the case of broad-leaved trees, it happens that timber with broad annual rings consists mostly of autumn (*i.e.* summer) wood, which is, generally speaking, of greater density than the wood formed in the spring.

Especially is this the case with reference to the so-called "ring pored" trees—Oak, Ash, Elm, Spanish Chestnut, and Acacia—for the spring wood of these trees consists mostly of large "vessels," which are not nearly so strong or dense as the "sclerenchyma" or hard tissue which forms the greater part of the autumn wood.

Bearing this in mind, it will not usually be advisable to

conduct partial clearances in coniferous crops to such an extent that the annual rings will be increased beyond a normal width; though the case is different with hard-woods.

It should be remembered that timber of the highest technical value should have annual rings of the same width throughout. Generally speaking, trees will form wide rings until the canopy is close; then the rings will be narrower, and will again become wider on a thinning taking place.

In the early part of a rotation, trees growing vigorously will form wider rings than in the latter part of a rotation under relatively similar conditions; for as maturity is reached their vigour declines.

Now, whereas the vigour of a whole crop may be declining, and the annual increment on the saleable timber may represent a lower rate of interest than that which seems reasonable, and whereas in many cases it would be considered prudent to clear cut the whole crop and invest the money, realised by the sale thereof, so as to yield a higher rate of interest, it will often be possible, by making a partial clearance, to so stimulate the crop that is left, that a better investment, or one equally as good, will be effected.

By this means it is quite possible that the crop left may increase in value at the rate of 4 or 5 per cent., or even more, whereas formerly it was earning perhaps only $2\frac{1}{2}$ or 3 per cent.

Thus it is evident that the rotation for a portion of the crop can often be beneficially prolonged from a financial point of view.

It must be remembered that besides the increase in actual volume there will usually be an increase in the quality or price per foot at which the timber would sell, as the individual trees will have a larger girth than is usually the case.

By means of partial clearances, timber of large girth can be produced in a much shorter period than would usually be the case. The girth increment will be somewhat similar to that which obtains in the case of standards over coppice,

but the trees will be tall and the boles clean, instead of the short, stumpy trees that are so often seen growing as standards over coppice as usually practised.

When fellings are made for natural regenerations, the same enhanced increment usually takes place. There is, however, this distinction in the method under consideration—namely, that whereas natural regeneration fellings are effected at the end of the rotation, and entirely in the interests of the succeeding crop, the fellings or partial clearances above described are made entirely with a view to increase the value and girth of the trees left standing; they are made successively from the time when the principal height growth has ceased, so that from this period onwards the canopy is kept broken.

The method may be practised with any trees, provided they are storm proof and still growing vigorously, so that they respond to the treatment.

The method has its disadvantages.

For the canopy is seriously broken, and consequently the risk of soil deterioration, viz., the disappearance of humus, the lack of moisture, the growth of rank grass and weeds, etc., is very great.

For this reason underplanting or undersowing must almost invariably be resorted to in the case of thinly foliated trees, unless they are mixed with thickly foliated trees.

With the thickly foliated shade-enduring trees, the fellings should not be so severe as to cause the growth of weeds and grass, and thus induce the necessity for underplanting. For it would never be satisfactory, and should be avoided, however good the soil. When shade-enduring trees are partially cleared, there will often be a certain amount of natural regeneration, but it will be very uneven and usually worthless except for soil protection purposes.

Whenever pure crops of Larch, Oak, or Ash are found, they should always, if not too old, and if the soil is good enough for those crops grown pure, be partially cleared and underplanted or undersown; for even if they are not partially

cleared, the canopy always becomes broken towards the end of a rotation (except where the rotation is very short, as for instance, Larch grown for pit timber), and thus necessitating underplanting if the land is to be kept clean. The degree to which the partial clearance should take place will vary greatly. If it is desired that no trees forming the overwood should be removed until the undercrop is grown into strong stout poles, it must of course be much heavier than if several successive partial clearances are made whilst the undercrop is growing. Provided the underplanting is done thick enough, this latter method is far preferable, since the removal of older trees from amongst a young crop which is thick in the ground, does not do an enormous amount of damage, if the older trees are well grown, and have not unduly large crowns.

When pure crops of thinly foliaged trees are thus underplanted, a two-storied high forest is the result.

If the undercrop be subsequently coppiced, it would bring about the system of high forest with coppice; though this system is best brought about, except in the case of Oak on stiff soils, by arranging a proper mixture at the time of planting, and subsequently, say at 16 or 20 years of age, coppicing those trees planted for that purpose.

Scots and Corsican Pine can be underplanted, but usually the growth of these pines should be confined to the poor dry soils, where underplanting would be a failure, and where a fairly short rotation is indicated.

The **trees used for underplanting must be able to bear shade**, at any rate whilst they are young and during the pole forest stage.

Silver Fir, *Cupressus macrocarpa*,¹ Beech, Nordmann's Silver Fir, Hornbeam, and *Thuya gigantea* (*plicata*) will bear the greatest amount of shade of any timber trees. Sitka Spruce¹ (*Picea sitchensis*), Sitka Cypress¹ (*Cupressus*

¹ A great deal more experience is required with these trees in this country before they can be recommended largely for underplanting. *Cupressus macrocarpa* seems peculiarly suitable, as it will then escape its greatest enemy—cold, dry, east winds; intense frost will kill the tree. It will bear a very great amount of shade.

sitchensis), Douglas Fir, Weymouth Pine, Spanish Chestnut, and Hazel and Lime will also bear considerable shade. However, when mature, Spanish Chestnut is a light-demanding tree. Ash¹ will bear a certain amount of shade during the first 25 years of its existence; but it is a very light-demanding tree when older. Norway Spruce will bear considerable shade when the locality exactly suits it; but it requires a fairly moist soil and a very moist atmosphere to grow it to perfection. Generally speaking, it is not suited for growth in the south of England; though it will succeed on certain high table-lands; and its growth in Scotland is far better than its growth in the south of England.

But even where Norway Spruce will grow well, it cannot be recommended for underplanting, as it renders the soil intensely dry, to the detriment of the overwood.

The age at which underplanting takes place is a matter of the greatest importance. It will depend upon the species and the condition of the overwood. It should be done before the soil covering of humus has disappeared, and concurrently with the first partial clearance.

Regard should be had to the rate at which the undercrop will probably grow, or the overwood may be caught up and its growth interfered with, before it is ready for the axe.

Cupressus macrocarpa, Douglas Fir, and Sitka Spruce are the quickest growing of the shade-enduring trees mentioned, and for the first 30 years an average growth of 2 feet to 2 feet 9 inches may be relied upon, per annum.

Of the other trees, *Thuya gigantea* and Weymouth Pine are the quicker growing, when an average growth of 1 foot 3 inches to 1 foot 9 inches may be expected, per annum.

The cost of underplanting is very small, since the land is always very clean, or should be so, and therefore no subsequent cleaning of the young crop is necessary. The chief item will be for fencing against rabbits.

¹ Ash, when sown *in situ*, and so also most other trees, will bear more shade than when planted; because in subdued light trees, which are only moderate shade bearers, will often fail to recover from the shock of being transplanted.

The following is a fair estimate when the plants are produced in a home nursery :—

3000 2 year seedling Beech, at 4s.* per 1000	<u>£0 12 0</u>
Planting with spike and trowel, or with "dibble,"	
at 4s. 6d. per 1000	<u>0 13 6</u>
	<u>£1 5 6</u>
Add for fencing (say)	<u>1 10 0</u>
	<u>£2 15 6</u>

* The price of the plants is very variable, as it depends so much upon seed years.

Now, if the overwood be not removed for another 40 years, the undercrop will merely be a debtor, at that date, to the original cost of planting, accumulated at compound interest. For this undercrop must be considered as growing free of all rent and annual charges, which must be debited to the overwood alone.

Now, £2, 15s. 6d. will amount in 40 years at 4 per cent. to £13, 6s. od.

Hence when 40 years old, the undercrop will only be debtor to the amount of £13, 6s. od., if 4 per cent. on the outlay is required.

It will usually be found that this has been more than earned, and when the enhanced financial position of the overwood, and the condition of the soil has been taken into account, it will be evident that underplanting is not always conducted at a financial loss, as has been stated by some.

Even if a loss of £2 or £3¹ were incurred up to the time that the overwood was removed or that both crops were simultaneously felled, the underplanting of the crop will have been justified, for the additional cost of planting and establishing a crop on foul land with 4-year-old plants, will be at least £4 or £5 an acre, or even more, than the cost of planting

¹ In some cases even a greater debit sum is justifiable, as it will be made good in the latter part of the rotation of the undercrop.—*Vide Chapter XII.*

and establishing a crop on perfectly clean land with seedling plants.

And it may be pointed out that an additional outlay of £1 at the beginning of a 90-year rotation will, at 4 per cent., amount to £34, or at $3\frac{1}{2}$ per cent. to £22, thus rendering the final crop at the end of the rotation debtor to that additional amount.

Hence it will be seen how essential it is to keep the land clean, if it can be effected without additional expense.

Other benefits derived from underplanting can, for the most part, be traced to the effects of the soil covering of **humus** which results from the growth of an undercrop. Now, humus prevents rapid changes in the soil temperature; and also lessens the danger from late spring frosts, both by preventing excessive radiation of heat from the soil, and by delaying active vegetation in the early spring. This delaying of spring growth will often result in the production of denser spring wood, as the weather, when active growth begins, will usually be warmer. It will also have the effect of reducing the proportion of spring wood to autumn (or summer) wood, which, in the case of all timbers is, generally speaking, a very important matter, since the smaller the proportion of the spring wood, the more valuable will be the timber.

Then again, a layer of humus will tend to prolong the growing season.

Humus, by its own decomposition, affords a gradual supply of plant food in an easily available state; though if it decays at a greater rate than it is formed by the annual fall of leaves, soil deterioration will quickly follow. Then also, as it decays, it provides a constant supply of CO_2 , which is instrumental in gradually setting free hitherto insoluble plant food.

Humus also assists in the percolation of water through the soil. It absorbs water like a sponge, and prevents the rain water from running too quickly off the land, and retards evaporation, and thus insures a more plentiful and constant supply of moisture.

It should be noted that a soil covered with grass¹ involves a greater loss of moisture than if covered by trees; and more moisture is lost by transpiration from a soil covering of either grass or trees than would be lost by evaporation from clean open ground such as a ploughed field. But if this open area be covered with a layer of humus, the loss of moisture will be still further diminished. For this reason self-sown seedlings or young nursery plants thrive much better where there is a layer of humus than where it is absent, if other conditions be equal. Then again, humus exerts a mechanical condition on the soil which is beneficial to young seedlings. It renders the surface soil less hard and more easy of penetration; and on clay soils it is especially valuable, as it prevents them from "setting."

In the previous chapter it was stated that a woodland area will contain a maximum amount of moisture when the canopy is as thin as is compatible with the retention of humus. Hence, since by underplanting the canopy becomes more dense, the total amount of moisture in the soil will be lessened. But the exhaustion will take place from the subsoil, and will hardly be noticeable in the surface soil.

It is, however, very probable that this lessening of the available supply of moisture for the overwood will cause them to become less tapering, as the moisture and soil nutrients they absorb will only be sufficient for the formation of broad rings in the upper part of the boles, instead of, perhaps, an equally broad ring all the way down the stem.

From this it is evident that on soils too dry for underplanting any attempt to that effect would be likely to cause the overwood to become stag-headed, as well as being a failure as far as the underwood itself is concerned.

Underplanting will never of itself stimulate the increment of the overwood; but it will prevent the falling off in increment which would take place if the ground became covered with grass and weeds.

A consideration of the foregoing leads to the conclusion

¹ Certain woodland grasses do not transpire moisture to the same extent as ordinary grasses, and therefore are not so harmful.

that underplanting and partial clearances should **never be attempted on poor soils lacking in moisture.** For in such soils the overcrop would probably be injured and the undercrop would not thrive; for all trees are less tolerant of shade on dry soils or where the conditions are not suitable for their growth. On such soils a short rotation of even-aged high forest will generally be indicated.

But on the other hand, whenever the soil is deep and good and has a sufficiency of moisture, it is undeniable that crops consisting of only thinly foliaged trees, such as Oak, Ash, and Larch, will yield better returns if partially cleared and underplanted; whereas crops consisting of only thickly foliaged trees may have slight partial clearances made if large girthed timber is required, but not to such an extent as to cause the growth of grass and weeds; and they should not be underplanted.

NOTES AND TABLES FOR PARTIAL CLEARANCES.

Oak.—The first heavy thinning or partial clearance may be made at about 60 years of age, though on stiff clay lands it may be delayed till about 80 years.

From the 50th to 80th years, the clearances should be repeated every 10 years; after that every 15 years. The early thinnings must not be too severe, or epicormic branches will appear, though this danger is lessened as the bark becomes thicker.

Underplanting should take place before any rank growth appears. On most soils a mixture of Beech and Spanish Chestnut will probably be most suitable; or Spanish Chestnut alone. On stiff clays, Hornbeam will probably succeed the best, and, in places where there is much light, a few Norway Maple and Sycamore. Alder will also often be advisable, especially if the land is wet; it should, however, be periodically coppiced.

The fast-growing conifers should not generally be used, unless the underplanting is long delayed, for otherwise the Oak will be overtaken.

TABLES FOR PARTIAL CLEARANCES 173

However, *Thuya gigantea* will often be successful, as its ultimate height growth is not excessive.

On average soil the following table will show the number of trees cut, etc. :—

TABLE OF CLEARANCES.—Average soil and situation.

Years.	Trees before a thinning.	Trees removed.		Trees left.	
		Ratio.	Number.	Per acre.	Feet apart.
50	540	...	140	400	10½
60	400	½	100	300	12
70	300	⅓	100	200	15
80	200	¼	50	150	17
90	150	⅓	50	100	21
105	100	⅓	33	69	26
115	69	⅓	23	46	30
130	Final crop,	46 trees.	...	...	...

Note.—The best trees with long clean boles should always be left. If high forest with coppice is formed, the cuttings should be about every 15 or 20 years, corresponding with the length of rotation.

Larch should be partially cleared from 30 to 35 years onwards; though sometimes, on account of Larch Disease, it will be begun much earlier.

The cuttings may be rather heavy.

Douglas Fir is one of the best trees to use for underplanting the Larch, and probably also Sitka Spruce. If underplanting is done before the 30th year, slower growing trees should be used. Beech is very excellent, also Spanish Chestnut and *Thuya gigantea*.

If high forest with coppice is required, the conifers must of course be excluded, so also should Beech; Spanish Chestnut is the most suitable for the underwood. Sometimes sowing may be tried instead of planting; but there is really little to recommend it. Its first cost is a little cheaper than

174 CLEARANCES AND UNDERPLANTING

planting seedlings; but the results are uncertain, and time may be lost, and there is considerable danger from mice and other vermin, which cannot very well be remedied on a large area.

TABLE OF CLEARANCES.—Soil and situation very good.

Years.	Trees before a thinning.	Trees removed.	Trees left.	
			Per acre.	Feet apart.
35	600	250	350	11
45	350	83	267	12½
55	267	½ = 133	134	18
65	134	½ = 67	67	26
— 75 to 80	Final crop,	67 trees.	...	...

Ash may be partially cleared and underplanted in much the same way; but instead of underplanting with another species of tree, it will often be possible to have a **two-storied high forest consisting entirely of Ash**, and the undercrop can be naturally regenerated, provided the soil is not too moist. If, however, the soil is too moist, it will be found that the seedlings will get choked by weeds, etc. If naturally regenerated, the seedlings will bear far more shade than if trees are planted.

Scots Pine, if it is found growing on good soil, may be partially cleared like Larch, but the first partial clearance should not take place until it is 38 to 45 years of age. It may also be underplanted with the same trees as may be used for underplanting Larch.

Silver Fir and **Spruce** (if the latter be in a very sheltered locality) may be partially cleared from the 45th year onwards.

TABLES FOR PARTIAL CLEARANCES 175

TABLE OF CLEARANCES.—Average soil and situation.

Years.	Trees before a thinning.	Trees removed.		Trees left.	
		Ratio.	Number.	Per acre.	Feet apart.
45	900	$\frac{1}{3}$	300	600	8½
52	600	$\frac{1}{3}$	200	400	10½
60	400	$\frac{1}{3}$	133	267	12½
70	267	$\frac{1}{2}$	133	134	18
85 to 90	Final crop, 134 trees.		...	...	...

Care must be taken not to allow the introduction of grass and weeds. Underplanting must of course not be attempted.

Beech may have the first partial clearance made when about 50 years of age. It will often be found at the end of the rotation that there is a certain amount of natural regeneration. In such a case it will often be advantageous to leave it and form a mixed wood by artificially introducing other species.

TABLE OF CLEARANCES.—Average soil and situation.

Years.	Trees before a thinning.	Trees cut.	Trees left	
			Per acre.	Feet apart.
50	580	$\frac{1}{3} = 193$	387	10½
60	387	$\frac{1}{3} = 129$	258	13
70	258	$\frac{1}{3} = 86$	172	16
85	172	$\frac{1}{3} = 57$	115	19½
100	115	$\frac{1}{3} = 38$	77	24
120	Final crop, 77 trees.		...	...

CHAPTER IX.

NATURAL REGENERATION OF HIGH FOREST.

IT has previously been stated that the natural regeneration of high forest may take place under :—

- (1) The Selection System ;
- (2) The Group System ;
- (3) Compartments of Even-Aged High Forest.

THE SELECTION SYSTEM.

This system is chiefly suited to the regeneration of Beech. In order to insure its success, it is essential that the young trees should be able to bear a great amount of shade. Some of the shade-bearing conifers might be regenerated in this manner, especially on exposed south-western aspects, where a maximum amount of shelter is required. The coniferous timber thus produced would very often be of poor quality, as there would be a minimum amount of natural pruning of the trees by each other ; and as the older trees became isolated, the annual girth increment would probably be too rapid to produce timber which is really strong and dense.

The system is not generally suited to very dry soils, though Beech prove an exception on poor chalky or limestone soils.

Unless the soil is really good, rotations under the selection system should be fairly short.

Fellings and thinnings should not be made upon the

same area more than about once in every 15 years; though these periodic cuttings vary from 10 to 20 years.

Where a large area is being dealt with, it will be advisable to divide it up into a number of equally productive areas, corresponding in number with the number of years that elapse between the fellings which take place over any single area. Thus an equal yearly income may be looked for and the management of the area will be more methodical.

Whenever grass and weeds appear on vacant spots, it should either be removed, and the ground broken up so as to form a seed-bed, or else artificial aid should be given by way of planting.

Rabbits must always be exterminated from the woods.

The number of trees, which will vary more or less in age classes, since fellings and thinnings take place periodically (and consequently the regeneration will also be more or less periodical), will be determined by the length of the rotation.

The canopy should be about as dense as that found in even-aged high forest, except that the relative density of the older trees should be somewhat less, so that the younger trees may have rather more light and growing space. If this relative density is required, it may be ascertained by comparing the number of trees in any age class with the number of like age that would be occupying a similar area under close-canopied high forest, supposing always that the trees of the particular age class under the selection system are all growing together on a confined area.

In order to make this comparison per acre, it is necessary to multiply the number of trees per acre in an age class under the selection system, by the number of age classes; and that will show the number of trees which an acre fully stocked with that age class will be supporting.

Thus, supposing that Beech are grown under the selection system, and that the oldest trees are cut when 105 years, and that cuttings are made every 15 years, and that the following

number are found per acre of the different age classes, just before a felling will take place :—

Years.	Trees.
15	700
30	357
45	188
60	103
75	57
90	43
105	23

Then, as the number of age classes is 7, the number of trees found per acre, if stocked with only one age class, will be as shown in the following table, where the number per acre in close-canopied high forest is also shown :—

JUST BEFORE A FELLING.

Age Class, Years.	Number of Trees represented, if one acre stocked with one class.	Trees per acre, Even-Aged High Forest.
15	$700 \times 7 = 4900$	...
30	$357 \times 7 = 2499$	2500
45	$188 \times 7 = 1316$	1300
60	$103 \times 7 = 721$	770
75	$57 \times 7 = 399$	475
90	$43 \times 7 = 301$	330
105	$23 \times 7 = 161$	200

Thus it will be seen that, in the above case, the relative density is about correct ; the older age classes being somewhat more thin on the ground.

Now, if it be desired to perpetually retain this density at each felling, some of the trees in all the younger age classes must always be thinned out at the same time that the mature trees are cut.

The correct principle to observe is to first remove from these younger age classes such trees as appear likely to form large crowns and are occupying more space than their

height growth merits, and also any visibly suppressed trees of any class.

The following table, referable to the previous example, shows the number of trees that should be removed at each thinning and the number that should be left in order to attain this ideal standard :—

TABLE FOR FELLINGS OF BEECH WOOD UNDER SELECTION SYSTEM. Rotation, 105 years. Average soil and situation.

Age Class, Years.	Just before a felling.	Trees cut every 15 years.	Trees left.
15	700*	343*	357
30	357	169	188
45	188	85	103
60	103	46	57
75	57	14	43
90	43	20	23
105	23	23	...

* This number will obviously depend upon the efficiency of the previous regeneration.

THE GROUP SYSTEM.

This system must **only** be attempted in the case of shade-bearing trees which are also fairly storm proof; for although the young crop has a maximum amount of shelter, the old trees exposed by the felling are liable to suffer unless indeed the groups are very small.

It is a most excellent system to pursue on poor dry soils, in places not too much exposed; for the young crop will obtain a maximum amount of moisture and shelter combined, as the side shade and protection will help to preserve humus, and diminish evaporation of moisture from the surface of the soil that would otherwise take place owing to direct heat and air currents.

On very dry soil the groups must be larger than would be admissible on good land.

Whenever an area is being dealt with under this system, it is advisable, if possible, to obtain from that area an equal yearly income; as indeed is the case under all systems of forest management.

Thus, supposing there be an area of 432 acres treated on the group system with a rotation for the timber of 72 years, and that an interval of 9 years between neighbouring groups is desirable, it could be treated in the following way:—

The whole area may be divided into 18 compartments of 24 acres each, and the area may be considered as comprising two woods or blocks of 9 compartments each, one of which blocks, that to the leeward of the prevailing winds, should be regenerated in the first 36 years, and the other block in the next 36 years.

Now, as regards this block of 216 acres, one method would be to take 54 groups of 1 acre each, at intervals throughout the whole block, and regenerate them in the first year; then 9 years hence to make 54 fresh fellings by enlarging these groups; then 9 years hence, and again 9 years after that, to repeat the operation, when the whole block will have been regenerated within the 36 years.

But such a method would give an intermittent income from the area managed under this system.

It would be far preferable to enter a different compartment each year for 9 years, and then to return to the original compartment. And this would insure an equal annual income from the whole area, and little difficulties arising over the rearing of game might be avoided, as only 1 compartment out of the 9 would be disturbed in any one year.

Thus in the first year, 6 groups of 1 acre¹ each (or 12 groups of $\frac{1}{2}$ acre each) may be felled in Compartment No. I.; in the 2nd year, 6 groups (or 12) in Compartment No. II.; and so on, until in the 10th year, Compartment No. I. will again be entered, and the original groups enlarged by making fresh fellings. This scheme is continued until by the 36th year the whole 9 compartments have been

¹ One acre groups will in many cases be too large.

regenerated, after which the other block will be treated in the same way.

This method, however, of cutting groups somewhere in the wood every year, could not be adopted in the case of Beech, as it would be necessary to wait for the seed years, otherwise the vacant patches would become covered with a rank growth of weeds if a seed year were long delayed. This might, however, be avoided by artificial means, or possibly by making the groups very small, when practically the selection system would be adopted.

The whole essence of the group system is that the cleared areas are small, and that the **feelings of neighbouring groups** are always **intermittent**. The great advantage of having small groups is that the young crop gets a very great amount of protection from the older trees, and in the case of conifers the danger of ravages from the Pine weevil (*Hylobius abietis*) is greatly lessened by having these intermittent fellings and small areas, and a good seeding is assured.

In as much as rides or roads do not lead through all the groups—such a thing would be impossible—it is necessary that a long interval should elapse between the regeneration of outside groups and the time when the centre groups are again felled, for this will enable the timber from the centre groups to be drawn out through a crop which is at least 35 or 40 years old, and thus excessive damage is avoided.

In cases where the groups are very large, some mother trees should be left overhead as a shelter wood; but these very large groups must, to all intents and purposes, be considered as small irregular shaped compartments.

The timber grown under the group system should be of higher technical value than that grown under the selection system, as there will be a smaller proportion of unpruned trees.

This group system must not be confounded with the method of mixing trees by patches or groups, as is practised when planting mixtures in even-aged high forest.

NATURAL REGENERATION OF WHOLE COMPARTMENTS OF EVEN-AGED HIGH FOREST.

The usual method of effecting natural regeneration under a shelter wood of mother trees is by making several fellings and gradually clearing the mother trees off the ground. It will be convenient to consider this method under three headings :—

- (1) Preparatory Fellings.
- (2) A "Seed Felling" or "Regeneration Felling."
- (3) Gradual Clearance of Mother Trees.

(1) **Preparatory Fellings.**—These consist of very heavy thinnings, and may or may not be necessary, according to the state of the land and the density of the crop.

The great object is to obtain a good seed-bed, and trees which will bear plenty of seed towards the end of the rotation, when it is desired to bring about the natural regeneration. If the trees are growing very close together, there will probably be a thick soil covering of undecayed leaves, or "raw" humus, as it is termed. Such a condition would be quite unsuitable for a germinating bed for tree seeds, supposing a "seed felling" were attempted at one operation. When such conditions prevail, it is necessary to make a preparatory felling, so as to cause the humus to decay more quickly. But in many cases, especially on very dry silicious soils, the land will have become acid or sour owing to the slow decay of dead leaves. Such surface soil would never produce a crop of seedlings of broad-leaved trees, as long as it remained sour. The mere opening up of the canopy will not suffice to sweeten the soil, but it will be necessary to cultivate the land and, in most cases, especially if Beech are to be regenerated, to apply lime.

Furthermore, trees growing in close canopy would, if suddenly exposed, be liable to suffer from sunburn, and also to be thrown by the wind. And again, they would not be likely to bear much seed (if any) for some years to come.

Hence one or more preparatory fellings, or partial clearances, are often necessary when the trees are approaching

maturity, so as to induce the production of seed, to accustom the trees to isolation, and to form a good seed-bed.

It will, however, often be found that the woods have already been sufficiently thinned, and that the humus has already disappeared, and the ground is covered with a growth of rank grass and weeds.

In such a case, if natural regeneration be attempted, the grass must be broken up, and the seed-bed prepared, and the seed felling made immediately, or, in the case of Beech, when a good seed year comes. It is quite impossible to obtain a good regeneration while the land is covered with a mat of grass; so also is it impossible on very "hard" land, even though clean.

It is an excellent plan to turn **pigs** on to any area that is thus covered with grass, but their snouts should not be ringed; for then they will root up the grass, and prepare an excellent seed-bed. If pigs cannot be procured, a forest plough must be used.

It should be remembered that humus will disappear more quickly on southern aspects than on northern aspects, other conditions being similar. It will also decay quicker on soils containing lime than on other soils. Heat and moisture combined favour its decomposition, whilst excessive wet in the soil retards it. On exposed places, it will often be a good plan to dig or plough small surface trenches in order to catch the leaves and prevent them from being blown away. These surface trenches or ditches should be in short parallel lengths, and each series should alternate with a series crossing at right angles:—



It must be remembered that the land always becomes hard unless the surface soil has a layer of decomposing leaves in it.

(2) **A Seed Felling or Regeneration Felling** is made when a good seed year has come. As its name implies, it is the felling made for the actual regeneration of the area.

It consists in the removal of all the trees except a few, which are left as mother trees, to seed the whole area ; and also, to form a light canopy or shelter wood for the young crop.

In the case of those trees which bear an abundant crop of seed very frequently, there is no need to wait for a seed year ; but different areas may be felled annually, and thus worked so as to produce an equal yearly income.

Scots Pine, Ash, Norway Maple, Sycamore, Douglas Fir, and Spruce bear abundant crops of seed every 2 or 3 years, and Oak every 3 to 5 years.

But Beech produce good crops of seed very spasmodically, from every 5 to 12 years, and in their case it is always necessary to wait for a good seed year ; thus making it impossible to obtain an equal yearly income from any area under Beech only, though preparatory fellings and gradual clearances of mother trees tend to minimise this defect.

The age at which trees produce seed is a matter of very great importance. The best seed is generally produced about 10 to 20 years after the trees have completed their principal height growth. Seed from very young trees should not generally be used, and seed from very old trees that have long passed maturity should never be countenanced. Oak, Beech, and Silver Fir produce good seed from the 60th year onwards.

Most other trees bear seed very much earlier, say from the 15th to 30th year, and often very much earlier, when the conditions under which they may be placed are inimical to their proper growth and development, or when they enjoy a maximum amount of light and air, as when situated on the edges of ridges, etc.

When making a felling, great care should be taken that the seed trees should be distributed evenly over the whole area.

(3) **Gradual Clearance of the Mother Trees.**—The dates at which the shelter wood of mother trees should be removed, will depend on the requirements of the young crop, and upon the soil, locality, aspect, altitude, and the rate of growth of the young crop, and many other considerations.

The gradual clearance will usually begin in the 2nd or

3rd year after a good crop of seedlings appears on the ground, and will be continued about every 3 years up to the 15th year, or even longer in some cases. However, where the seedlings are intolerant of shade, the mother trees must be removed almost immediately.

And even if the seedlings will bear shade, the majority at any rate should be removed when the undercrop is well established, and before it is more than 4 or 5 feet high; then the young trees are supple and pliant, and little damage need be feared. Some of the young trees will be ruined, but with many thousands of young trees per acre this does not matter.

However, the removal of any old trees when the young crop is from 20 to 35 feet high, must do a great deal of damage, for the latter are too stout to bend over without breaking. Hence, when old trees have still to be cut, it will probably be best to wait until the pole forest stage is advanced, when the poles will be capable of withstanding considerable weight.

If the mother trees are removed too early, the young crop will not get that shelter from hot sun and late and early frosts which is so essential. If the seedlings are light-demanding and hardy, it is best to remove the shelter wood quickly: the reverse for slow-growing, tender species. On very dry soils, all trees require more light, and are less tolerant of shade than they would be if the supply of moisture were plentiful. And on high altitudes where the growing season is shorter, more light is necessary than at low altitudes. Therefore, other conditions being equal, on very dry soils, or at high elevations, the mother trees should be thinner on the ground, and should be removed when the young crop is smaller than when the trees are growing in good moist soil, or at low altitudes.

A consideration of the aspect should also affect the density of the mother trees and the dates of their removal.

Though southern aspects are hot and dry, the intensity of the light is greater than on northern aspects, which are cool and usually moist, and it will usually be found that a

thinner canopy is admissible on northern aspects than on southern aspects, if other conditions are similar.

There is a greater necessity for shelter on southern aspects than on northern aspects, for there is a greater liability to early spring and late autumn frosts; and humus will disappear more rapidly, and the soil will more quickly get heated. But if there is a reasonable shelter wood, it will of itself, directly, afford protection from frosts, and also indirectly, by preserving humus, and thereby delaying the date of active vegetation in the spring.

When, however, an area is well seeded, there should be no unnecessary delay in removing the mother trees, and the sooner their shade can prudently be dispensed with, the more moisture will the young crop obtain, in the shape of rain and dew, and also from the soil. But if the removal of the shelter trees were to cause the appearance of grass and weeds, there would be less moisture available for the young seedlings.

However, when the young crop is once well established, and thick on the ground, it will of itself prevent much of the evil effect that would otherwise result to the soil on account of the removal of the mother trees.

Natural regeneration sometimes fails owing to a rank growth of grass, which is either due to bad management, or to a seed year having been insufficient, or the quality of the seed being bad, or to some unavoidable circumstance. In such cases, artificial aid in the shape of soil preparation, and usually of planting seedlings, should be given.

It is not easy to get an even natural regeneration over any large area. It will usually be necessary to complete the process by artificial means.

Usually a wood is regenerated for one species only, but a mixture can be produced by introducing artificially other species, when the mother trees (or most of them) have been cleared.

For instance, on an area naturally regenerated for Beech, quick-growing trees, such as Larch, Ash, Poplars, may be planted singly, or in groups or patches, but slow-growing

trees, like Oak, should only be planted in groups or patches; for otherwise they would be outgrown before they were fit to fell.

The system of natural regeneration under mother trees, with the gradual clearness of those trees, is only suitable for trees which are storm proof, and generally speaking, for those whose seedlings can endure shade.

However, Oak may be thus regenerated, but the mother trees must be very thin on the ground, and must be very quickly removed. Scots Pine is sometimes treated in this way, but the method cannot be recommended.

Occasionally, the system of high forest with standards is brought about by leaving some of the mother trees for a second rotation, but the method can never be recommended.

There is a modification of the compartment system just described, which is sometimes referred to as the "**strip**" **system** of natural regeneration. By this method, a strip of a compartment is taken in hand, and regenerated under mother trees just as the whole compartment might have been.

It is usual, however, to treat three adjoining strips at the same time. One strip being in the preparatory stage, another in the regeneration felling stage, and another in the stage at which the trees are being gradually cleared. By this method the possibility of an incomplete seeding is somewhat lessened, and operations are more concentrated; but in the case of certain conifers, the danger from injurious insects, especially the Pine weevil, are much increased.

THE NATURAL REGENERATION OF BEECH.

There is no doubt that it is far preferable to regenerate an area of Beech naturally along with the shelter of the mother trees, than to clear cut and resort to artificial planting.

For, during the first few years of their existence, young Beech are very susceptible to late spring and early autumn frosts, and also to hot sun in the summer; hence it is always most beneficial to have a shelter wood over the young crop.

The same may be said of Silver Fir. And other trees—

Spruce, Douglas, *Thuya gigantea*, Weymouth Pine, Ash, and Spanish Chestnut—find a little shade when young more beneficial than otherwise. On the other hand, Oak, Scots Pine, Corsican Pine, and Larch are always very light-demanding.

Beech may be naturally regenerated under the three systems already referred to; but in no case is the natural regeneration likely to be a success if the soil is in the least degree sour. So exacting is Beech in this respect, that it has been said that it will not naturally regenerate unless there be plenty of lime in the soil. This, however, is not strictly correct; but there is no doubt that natural regeneration is far more certain on a soil which is distinctly calcareous.

The selection system has already been dealt with in a general way. But it may be noted that unless the soil is good, a short rotation of about 90 years will usually give the best results, unless bigger timber is especially desired.

Great care should be taken not to "overcut" the trees in the older age classes; for such a course is equivalent to spending capital instead of income.

The following table will show the number of trees under the selection system that should form the growing stock per acre, and the number that may be cut, if cuttings be made every 15 years, and if the oldest timber be cut at 90 years:—

BEECH UNDER SELECTION SYSTEM. Rotation, 90 years.
Average soil and situation.

Years.	Trees just before felling.	Trees cut every 15 years.	Trees left.
15	820 *	407 *	413
30	413	194	219
45	219	99	120
60	120	54	66
75	66	16	50
90	50	50	...

* This must depend upon the efficiency of the previous regeneration.

If the rotation for mature timber be 120 years, and cuttings are to be made every 15 years, the number of trees will be as follows :—

BEECH UNDER SELECTION SYSTEM. Rotation, 120 years.
Average soil and situation.

Years.	Trees just before a felling.	Trees cut every 15 years.	Trees left.
15	Per acre. 620 *	308 *	312
30	312	148	164
45	164	74	90
60	90	41	49
75	49	11	38
90	38	18	20
105	20	8	12
120	12	12	...

* This must depend upon the efficiency of the previous regeneration.

Regeneration of Whole Compartments of Beech High Forest.—When regenerating an area consisting chiefly of Beech, all other species growing as a mixture are generally removed before the seed felling, and thus the Beech only are regenerated. Then, if a mixture be required, other trees, of which Larch is the most suitable, and also Ash, may be planted when the gradual clearance is complete, or nearly so.

Often there is an "advance" growth of seedlings. These, if healthy and thick on the ground, may be left; if not more than about 8 years old. If older, they will usually have been suppressed, and may never develop into strong, healthy trees, even when the shade of the older trees no longer exists; therefore, they must be removed in the first preliminary felling. In many cases no other felling or thinning will be necessary until a good seed year has come, but the particular conditions of the soil and crop will determine this. The edges of the wood should be left denser than the rest,

especially if the area lie exposed to gales or dry winds. Now, suppose that up to 110 years old a wood has been merely thinned in the ordinary manner, and that there were found 210 trees to the acre, it would probably be advisable to cut out 60 of the smallest, leaving 150. If in 3 or 4 years' time the dead leaves have nicely decayed, well and good; but if the admission of a little more light seems desirable, another 30 trees should be cut. Probably all can then go on until a good seed year comes; then about 65 trees should be cut, leaving 55 on the ground. The biggest trees and those with big crowns should be cut, and clean-grown tall trees, about 12 feet quarter girth at breast height, should be left as seed and shelter trees.

The gradual clearance should usually begin about the 2nd year after the fall of the seed, and should be made about every 3 years; all the mother trees being removed by the 11th or 12th year, if possible.

If the regeneration be more or less of a failure, it will often be necessary to postpone the gradual clearance, and to wait for another seed year. But the best plan is to resort to artificial means, and either to sow or to plant 1 or 2 year seedlings. It will be the cheaper method, for otherwise rank grass will make its appearance, and soil preparation will be necessary, and the crop will be uneven, and time will be lost.

The utmost care is necessary in removing the mother trees. They should not be removed during a frost (unless there is deep snow) for the young crop is then very brittle. Again, they should always be removed by the home staff of workmen; and, if cut into short lengths, they are more easily handled.

With trees other than Beech, the various fellings are not so clearly defined. The seed years are more frequent; and when once the surface soil is in good condition, seeding will probably soon take place, other conditions being fulfilled. Furthermore, the ground is not so likely to deteriorate if the 1st year fails; it will have a chance of seeding the next year or the year after that. But, in the case of Beech it might be fallow for 10 years or more.

Good seed years can be foretold in the case of Beech, and to some extent in the case of Oak, by the thickening of the future flowering buds in the autumn and winter; it is more common after hot summers.

THE NATURAL REGENERATION OF OAK AND OTHER TREES.

A pure Oak forest, mature and ready for the axe, will seldom be found in good forestry, but it will often be found mixed with Beech and other trees. If the Oak be evenly distributed, it may sometimes be advisable to attempt regeneration of a pure Oak wood. About 25 trees will be enough to leave per acre for the shelter wood; but, when the young crop is covering the ground, they must be quickly removed, for the seedlings are intolerant of shade. By the end of 6 years, all the shelter trees should be removed.

All big branchy Oaks should be removed at the seedling felling, leaving only those that have clean stems, and crowns which are not too spreading.

Once in 3 or 5 years a good Oak seed year usually comes, and it is necessary that the acorns get well buried by 1 to 2 inches of soil covering. The removal of trees at the seed felling will effect this to a great extent; otherwise raking by hand or other cultural operations must often be resorted to.

It is an excellent plan to turn pigs on to the land for a few months.

On soils of average or inferior quality, natural regeneration is often successful; whereas, on the best soils containing more moisture, and on southern aspects, the growth of rank grass often proves too troublesome.

If success is not achieved at the first good seed year, artificial means should be adopted at once.

The Natural Regeneration of Ash is rare over any extensive area; but in many cases it can be very profitably resorted to, as it produces abundance of seed very frequently. If, however, it has been grown in a mixed wood, it must often be cut before the other trees, as it is mature at about 65 to 70 years of age; and if it has been grown pure and then

underplanted with other trees, the undercrop will not be mature by the time the Ash has to be cut; but when grown as a pure crop, it may often be partially cleared and an undercrop of Ash obtained naturally. Both crops can then grow as a **two-storied high forest of Ash**. When the older trees are ready to be felled, in say 30 years' time, it will be possible to obtain another undercrop of Ash in a few years' time. Thus a perpetual two-storied high forest may be grown. This natural regeneration of Ash will hardly be possible on very moist soils, as there is almost certain to be a strong growth of nettles and other weeds on such soils, however dense the overwood of Ash may be kept.

Ash may also be regenerated under the selection or group systems; and of these two, the latter is preferable.

Sycamore and Norway Maple would seldom be profitable as pure woods or as forming the greater part of a mixture. They are not usually valuable enough when young; therefore they should only be introduced sparingly by planting.

Each of these trees, however, produce abundance of seed, and readily regenerate naturally, if the soil be suitable.

The **Natural Regeneration of Corsican Pine or Scots Pine** is rare under a shelter wood, and should not be attempted; for the young trees are intolerant of shade, and do not require the shelter. Also, when growing under mother trees, they are very liable to fungus attacks of *Hysterium pinastri*—the leaf-shedding disease,—and of *Botrytis cinerea*.

Then again, any seedlings that have once suffered from shade, never recover.

If, however, it is attempted, only about 12 trees per acre should be left, and these must all be removed by the time the young crop is 3 or 4 years old.

In most cases, the soil under a pure crop of Scots Pine will be covered with rank grass, unless the crop were only about 40 years old. This strong grass will appear even on soils, which, when originally planted, were so poor as to produce only heather; since the soil will have become better aerated, and somewhat enriched in plant food.

The **best method** of naturally regenerating Scots Pine

or Corsican Pine, is to clear cut strips of from 40 to 70 yards wide, and allow the seed to blow on to the cleared portions from trees on a neighbouring area. These strips should be to leeward, with respect to the prevailing winds, of the trees from which the seed is expected. As soon as one strip is well seeded, and free from the danger of the Pine weevil, another strip may be cleared, and so on.

When grass and weeds appear, artificial aid must always be resorted to; the cheapest plan to adopt is to notch in seedlings. If heather only cover the ground, it is not detrimental; in fact, in moderation it is somewhat beneficial, unless, indeed, it grows very big. It will always be advisable to plant the edges of these strips, if they lie on the shady side of older trees, with some trees that will bear shade; for this purpose, Weymouth Pine is often very suitable.

Larch could be regenerated in the same way. It would be more likely to be successful on Northern aspects, but, generally speaking, the seed does not ripen sufficiently in this country to make it ever advisable.

THE NATURAL REGENERATION OF THE SHADE-BEARING CONIFERS.

In this category may be included Silver Fir, Nordmann's Silver Fir, *Thuya gigantea*, Douglas Fir, *Cupressus macrocarpa*, Norway Spruce, Sitka Spruce, Sitka Cypress, and Weymouth Pine.

Before attempting the natural regeneration of these trees on any considerable scale, it is necessary that more information be forthcoming as to their seed-bearing capabilities in this country; and also as to the quality of the seed they will bear.

For, though all these trees may bear abundant crops of seed, it by no means follows that they will produce strong, healthy plants.

It may require centuries of acclimatisation before some of them will produce seed in this country that can be relied upon.

In reference to this matter, the greatest caution should be observed when contemplating the growth from home-grown seed of such trees, the climate, of whose native habitat, is

marked by very cold winters and very hot summers. In many cases, trees from such climates are shy of bearing seed in this country; or even if they bear seed in abundance in this country, as many of them do, there is a great probability that only weakly and tender trees will be produced therefrom. Whereas those trees introduced from a country where the climate is somewhat similar to that of this country, are far more likely to produce seed that will grow into strong, healthy, vigorous plants. A consideration of the foregoing may explain the reason why Silver Fir is often so shy of reproducing itself naturally in this country; and it will explain the inferiority of home-grown Larch seed.

It is probably always preferable to obtain foreign seed of Silver Fir, Nordmann's Silver Fir, Norway Spruce, Weymouth Pine, and *Cupressus macrocarpa*. This latter produces abundance of seed in this country, but it would not be wise to use it largely, until more experience is gained with reference to trees produced from home-grown seed.

On the other hand, there is every likelihood that home-grown seed of *Thuya gigantea*, Douglas Fir, Sitka Spruce, and Sitka Cypress will produce strong, healthy trees.

There is, indeed, much young Douglas Fir, self-sown and otherwise, which, so far as present experience goes, is perfectly healthy and vigorous.

When seed from these four species of trees is imported,¹ it is very essential that it should have been collected in the damp regions near the coast in British Columbia. Such seed of *Thuya gigantea* and Douglas Fir would be far more likely to give better results altogether, than seed obtained from higher altitudes in the Rocky Mountains; though experience may prove even the contrary to be the case.

The natural regeneration, however, of these coniferous trees whose seed admit of it and make it desirable in this country, may, with the exception of Norway Spruce, be effected under either of the three systems.

Norway Spruce is not suitable for natural regeneration, as

¹ This matter of the importation of seed is also referred to in Chapter III.

it is not storm proof, though it might be naturally regenerated in a mixture along with other shade-bearing conifers whose height growth is somewhat similar. It is sometimes thus regenerated along with Silver Fir on the Continent.

The group system is peculiarly suited to the regeneration of these conifers, for their seed is light and easily carried by the wind, and as long as the felled patches remain free from grass, the young crop gets a maximum amount of moisture ; and the older trees give protection on all sides from cold winds, and thus lessen surface evaporation. If the soil be dry, the patches or groups must be larger than would otherwise be admissible ; though the danger from windfall will be increased.

When the compartment system of regeneration under a shelter wood is resorted to, the procedure will be much the same as in the case of Beech. But Douglas Fir and Weymouth Pine will not bear so much shade, and the canopy must be thinner, and the mother trees removed earlier.

In the case of Douglas Fir it is very essential to gradually accustom the future mother trees to isolation, otherwise they are rather liable to have their tops broken off by gales. For this reason the group system will usually be preferable.

THE COMPARATIVE MERITS AND DEMERITS OF THE SYSTEMS.

Compartment System :—

Merits—

- (1) Operations are concentrated ; therefore supervision is easier ; and damage caused by the removal of timber is more cheaply repaired—*e.g.*, roads.
- (2) Side shade is avoided ; therefore it is not so detrimental to light-demanding seedlings.
- (3) The greatest proportion of good timber is produced.

Demerits—

- (1) Soil deterioration is quicker, both on account of side light and of dry winds.
- (2) In exposed places, windfall is to be feared.
- (3) If a seed year fails, a greater loss is incurred ; therefore the risks are greater.

Group System :—**Merits—**

- (1) There is a greater amount of protection to the young crop and a maximum amount of moisture.
- (2) Soil deterioration is not so rapid.
- (3) It is the most suitable system for dry soils.
- (4) Side light and wind are excluded from the felled area.
- (5) There is a greater likelihood of success in the case of shade-bearing conifers.

Demerits—

- (1) Operations are scattered; therefore expenses are increased.
- (2) The older trees on the windward side of prevailing winds are liable to be thrown unless the groups are very small.

Selection System :—**Merits—**

- (1) There is a maximum amount of protection to the soil and young crop from wind and sun; therefore it is advantageous in exposed localities.

Demerits—

- (1) Operations are very scattered.
- (2) It produces the least amount of timber of high technical quality; though the total production is about the same as under the other two methods.
- (3) It is not generally suited for very dry soils; though Beech on thin calcareous soils is an exception.

The regeneration of Scots Pine and Corsican Pine from neighbouring areas on to cleared strips, though the best method to adopt for the natural regeneration of these light-demanding trees, will not often give very uniform results, and artificial aid must generally be given. Usually the land quickly becomes covered with rank grass, and the soil thus quickly deteriorates.

But if only heather appeared, the result would usually be satisfactory.

CHAPTER X.

TREATMENT OF COPPICE SYSTEMS.

SIMPLE COPPICE.

THERE can be no doubt that the system of simple coppice must in the near future almost disappear, if not entirely so, unless some more profitable use for its produce should present itself than is at present in vogue. The treatment, however, may be considered in some detail, since the management of the underwood grown under the other coppice systems will be largely governed by the same principles.

When dealing with an area under coppice, one of the most important points to settle is the length of the rotation that should be adopted.

This will depend upon the species of coppice grown and the purposes to which it is intended that the produce should be put.

The following will show some of the rotations that are suitable under certain circumstances :—

	Length of Rotation. Years.
Pure Oak coppice, grown for bark	16
Alder coppice (suitable on wet soils)	25 to 30
Ash and Spanish Chestnut, for hop poles	14 „, 16
Ash and Spanish Chestnut, for split hurdles and crate wood	10 „, 15
Ash and Spanish Chestnut, for barrel hoops	6 „, 10
Hazel	6
Coppice poles, for pit props	25 to 30

The reproductive power of trees when coppiced is a matter of much importance.

This reproduction is usually from stool shoots, but in the case of Aspen Poplar, White Poplar, White Alder, and Acacia, it is chiefly from root suckers thrown out from the stoloniferous roots of these trees. Usually trees will only produce stool shoots when coppiced early in life; but they vary much in this respect. And the manner in which they have been coppiced, the quality of the soil in which they are growing, and the exposure of the stools to strong sunlight or otherwise, will greatly affect their reproductive powers. Generally speaking, Ash, Beech, Birch, Norway Maple, and Sycamore should not be grown on a longer rotation than 25 years, or they will not stool satisfactorily; though a longer rotation might sometimes be advisable for Alder, Spanish Chestnut, Oak, and Hornbeam.

Spanish Chestnut is often found to produce vigorous stool shoots when trees 100 years of age are cut down.

On good soil, or when exposed to sunlight, stools will produce shoots more readily than when the reverse is the case.

Continual coppicing has usually a prejudicial effect on most trees, though Hornbeam and Oak stools will last for centuries. Stools of Ash, Birch, Willow, and Beech do not, as a rule, survive many rotations. After about 4 or 5 rotations their vigour has usually disappeared.

Again, the stool shoots of Oak, Ash, Alder, and Spanish Chestnut are usually very vigorous whilst the stools are still healthy; but the stool shoots of Beech are not possessed of the same vigour. The common conifers have practically no power of reproduction by stool shoots.

Great care is necessary in coppicing the stools at the end of each rotation; if badly done they will soon decay. They should always be cut sloping or pointed, so that water will easily run off; for decay would soon set in if water were to remain on the surface. And the stools should also invariably be cut as close to the ground as possible, except on low land subject to floods. They should always be cut with a sharp instrument; small coppice with a hand-bill, and larger stuff with an axe.

When the area has been cut, it should be carefully looked

over, and any stools carefully dressed with a hand-bill wherever they present a jagged or split face, or wherever the bark has become separated from the wood.

An owner of coppice sometimes cuts and converts coppice produce, and puts it upon the market himself. But the usual practice is to sell the underwood unconverted to small dealers, who have a special knowledge of the retail market. But it is always preferable to have the coppice cut by the home staff of workmen, and not to allow the buyer to cut it as he chooses.

The cost of cutting underwood per acre must vary considerably. It will be rather more for areas under simple coppice than for the smaller amount of coppice grown along with standards.

But coppice 25 years old will cost about £1 per acre; 20 years old, 16s. per acre; 16 years old, 12s. 6d. per acre; 12 years old, 10s. per acre.

The season for cutting does not usually matter very much provided the leaf is off.

Oak coppice for barking will be cut when the bark will peel—*i.e.*, the end of April or the beginning of May.

In localities subject to late spring frosts the coppice should not be cut until somewhat late, as by so doing the young coppice shoots will be delayed in their growth, and thus may escape a late frost. Otherwise it is best to cut it in the autumn, for the sooner that it is cut, converted, and removed, the better.

As regards the general management of simple coppice, there is not a great deal that calls for special attention. It is the easiest of all systems to manage.

Perhaps the most important point is to insure that a full stock of healthy stools is always present.

There should be about 600 stools per acre, and thus on an average they should be about $8\frac{1}{2}$ feet apart. Any deficiency in this respect should be made good either (1) by planting, (2) by "layering" or "plashing."

(1) **Planting.**—If planting is adopted it will generally be necessary to plant out about 100 trees every time the coppice is cut over; though this will depend upon the species

grown, and for Spanish Chestnut 50 should be ample. Four- or five-year-old plants should be used, and each must be protected from rabbits. Small guards of wire netting put round each tree and kept in place by a stake will cost about 1d. each. But a cheaper method is to make a similar guard of tarred felt, which will cost about $\frac{1}{2}$ d. each, and be equally effective.

Sometimes bigger trees are planted out with a view to lessening the liability of their being choked by the quick-growing shoots from the stools; but there is really no advantage in this method.

Large trees, say 7 feet high, usually make only a small growth until their roots are established and the extra expense of planting these large trees would be far greater than the expense incurred in cutting back any strong shoots that threaten the smaller trees after they have been planted out for 3 or 5 years.

The cost of planting 100 4-year-old plants, each protected with a piece of tarred felt, will be about 10s. 6d., or say 1 $\frac{1}{2}$ d. each, provided the plants be raised in a home nursery; except in the case of Spanish Chestnut, when the cost would be about 12s. 6d. per 100, or 1 $\frac{1}{2}$ d. each.

In many cases the wire netting or tarred felt is omitted, as it is not so serious if plants grown for coppice are bitten by rabbits as is the case if they have been planted for the production of timber; but it is usually very indiscreet to omit this protection.

The plants are sometimes cut over at the collar at the time of planting, with a view to numerous stool shoots being thrown out during the current rotation, but it is best generally to wait and cut them over at the beginning of the next rotation.

Occasionally sowing is resorted to instead of planting, and in the case of Oak it has proved very successful. The acorns should be dibbled in, where the underwood is thin, during the autumn the underwood is cut; and all underwood should be cleared off the area by the middle of April.

It is usually impossible to get the underwood converted

and removed in time to plant during the current spring, but every effort should be made to enable the planting to take place as it is most important not to lose a year's growth.

(2) **Layering or Flashing.**—This is a favourite means of increasing the growing stock of stools of Ash and of Spanish Chestnut; it has been largely practised in Sussex and Kent.

To effect this end, long stool shoots, not more than $2\frac{1}{2}$ inches in diameter at the base are cut partly through close to the ground, bent over and pegged down at one or more points near where the soil has been bared, and then covered at these places with a small mound of earth. Longitudinal slits may be made in the bark to encourage the formation of roots. This layering should be done as early as possible and before the stools begin to flush their latent buds.

It will usually be best to effect this layering during the autumn, when the underwood is cut, though often it is done about 6 years afterwards in places where the coppice appears unduly thin.

The cost of thus **layering** stool shoots will be about 3s. 6d. per 100 "mounds." Hence it is very much cheaper than planting; but protection from rabbits cannot very well be given.

Other details of management¹ include cleaning ditches, hedging, repairs to gates and dead fences, trimming and brushing rides, etc.

Wherever coppice is grown, whether as simple coppice or otherwise, it will always be advisable to avoid having it mixed in a promiscuous manner.

Oak, if grown, will usually be for its bark, and should always be so grown quite pure. Hazel is only suited to a very short rotation, and is therefore quite unsuited for being mixed with other species.

Spanish Chestnut and Ash may be grown together and usually afford the most remunerative kind of underwood that can be grown. But the local markets must be studied, and buyers for a local industry involving the use of a particular species will give a relatively greater price for pure under-

¹ The laying out and selling of coppice is dealt with in Chapter XIV.

wood of that species than for mixed underwood ; for in the latter case they have to seek another outlet for produce they do not require.

Alder coppice wood will almost invariably be grown pure ; not only on account of its special market, but also because the soil to which it is suited will not admit of the usual species being grown.

The cultivation of Osiers can hardly be regarded as a branch of forestry ; very useful information with reference to its cultivation will, however, be found in the *Board of Agriculture Leaflet*, No. 36.

COPPICE WITH STANDARDS.

Having regard to the low prices that obtain for coppice produce, there can be no doubt that when dealing with an area under coppice with standards, every effort should be made to produce a maximum amount of standards, and to insure that they are of the highest quality that can be grown.

The quantity of underwood that may be produced is a matter of small importance in comparison with the overwood. The underwood should be looked upon chiefly as a means of naturally pruning the young standards and of drawing them up ; of protecting the soil from the effects of wind and insolation ; and of affording sufficient covert for game.

If strict attention be paid to this, an area under coppice with mixed standards of Larch, Ash, and Oak will prove far more remunerative than an equal area under even-aged high forest of Oak ; and very nearly as profitable as a similarly grown crop of Ash or Larch.

With this object in view, it is imperative to have a long rotation for the underwood, especially in the case of Oak and Ash, otherwise these trees soon cease in height growth and develop crowns in early life.

These latter trees can often be grown to perfection along with Alder coppice (on a long rotation).

A rotation of from 18 to 26 years should generally be adopted to effect this end ; by such means the standards will be well pruned by the underwood to a height of about

40 feet. There will be an additional advantage in that the underwood being of big dimensions will generally fetch a relatively higher value and be more marketable; though for certain purposes, as for instance, hop poles, the majority of it will be far too big; another advantage is the fact that the soil is not laid bare so frequently.

One great disadvantage, however, in having a long rotation, is the fact that the young trees planted out at the last felling are very apt to get suppressed, and in the case of Ash to be too drawn up and to become too thin and lanky, as the underwood grows so much faster; but this can easily be prevented by cutting back any shoots that threaten the young trees from time to time. This attention must never be omitted.

Previous to each cutting over of the coppice, all healthy, well-grown seedling trees, known also as "Saplings," "Stores," "Standils," and also a few very clean, well-grown stool shoots, or "tellers," of Oak or Ash, should be carefully marked with a ring of white paint or otherwise, so that they are not cut over along with the coppice. When the coppice is cut, these may be thinned out to the required number, but a full stock of them should always be left. It is better to have too many than too few. When the underwood is all cleared off, the area must be restocked with young trees to form future standards, and also to replenish some of the worn-out stools. It will sometimes happen that many seedling plants appear; if this be the case, the necessary number of trees to plant may be perhaps only 70 Larch. But usually with a 20-year rotation, 50 to 70 Larch, 50 Oak, and 50 Ash may be planted per acre for standards, provided of course the soil be suitable; and besides this, 60 Spanish Chestnut to replenish the underwood stools; or these may be increased by plashing.

If Spanish Chestnut is not suited to the soil, some more Ash may be planted, and some Sycamore and Norway Maple, or perhaps Hornbeam will be advisable. Generally speaking, Spanish Chestnut and Ash are the most valuable trees for coppice growth, and Alder on suitable soils. Trees 4 years old should be planted choosing of course the vacant spaces. No young tree should be planted nearer than 7 feet

204 TREATMENT OF COPPICE SYSTEMS

to any healthy stool, and the trees themselves should be planted 4 feet apart from each other, and in small pure patches of from 5 to 9 trees each; though the miniature groups of Larch may be fringed with Ash, especially if a stool is near, for the Ash will bear some shade when young, and may ultimately be coppiced if necessary.

It is necessary to plant out many more trees than are wanted at the next cutting over of the coppice, because many will die and only exceptionally vigorous trees are required to grow on for mature standards in the future; therefore a large number to select from is imperative.

If the rotation is shorter than 25 years and it is intended to grow mature timber of the same age as when the underwood is grown on a larger rotation, it will not be necessary to plant out so many trees at each felling, nor will so many trees of the various age classes be left per acre.

The following tables will indicate the approximate density for various rotations, and results after their manner should be aimed at; though it is impossible to obtain mathematical accuracy in forestry operations:—

TABLE FOR OAK STANDARDS ONLY.

Average soil and situation.

Rotation of Standards, 100 years. Rotation of Underwood, 25 years.

Years.	Oak Trees just before a fall.	Oak Trees cut.	Oak Trees left.
25	Per acre. (say) 150	83	67
50	67	44	23
75	23	15	8
100	8	8	...
Total .	248	150	98

Trees planted for standards . 200 at each felling.

" " coppice . . 60 " "

Total . 260 trees.

TABLE FOR OAK STANDARDS ONLY.

Average soil and situation.

Rotation of Standards, 100 years. Rotation of Underwood, 20 years.

Years.	Oak Trees just before a fall.	Oak Trees cut.	Oak Trees left.
20	(say) 125	55	70
40	70	40	30
60	30	17	13
80	13	7	6
100	6	6	...
Total .	244	125	119

Trees planted for standards . . 170 at each felling.
 " " coppice . . 60 " "
 Total . . 230 trees.

TABLE FOR OAK STANDARDS ONLY.

Average soil and situation.

Rotation of Standards, 96 years. Rotation of Underwood, 12 years.

Years.	Oak Trees just before a fall.	Oak Trees cut.	Oak Trees left.
12	(say) 110	40	70
24	70	22	48
36	48	20	28
48	28	12	16
60	16	5	11
72	11	3	8
84	8	4	4
96	4	4	...
Total .	295	110	185

Trees planted for standards . . 140 at each fall.
 " " coppice . . 50 " "
 Total . . 190 trees.

206 TREATMENT OF COPPICE SYSTEMS

TABLE FOR MIXED LARCH AND ASH STANDARDS (in equal proportions).

Average soil and situation.

Rotation of Standards, 75 years. Rotation of Underwood, 25 years.

Years.	Larch and Ash just before a fall.	Larch and Ash cut.	Larch and Ash left.
25	(say) 150	100	50
50	50	35	15
75	15	15	...
Total .	215	150	65

Trees planted for standards . . . 200 at each felling.
 " " coppice . . . 60 " "
 Total . . 260 trees.

TABLE FOR MIXED LARCH AND ASH STANDARDS (in equal proportions).

Average soil and situation.

Rotation of Standards, 80 years. Rotation of Underwood, 20 years.

Years.	Larch and Ash just before a fall.	Larch and Ash cut.	Larch and Ash left.
20	(say) 120	60	60
40	60	28	32
60	32	21	11
80	11	11	...
Total .	223	120	103

Trees planted for standards . . . 170 at each felling.
 " " coppice . . . 60 " "
 Total . . 230 trees.

TABLE FOR MIXED OAK, ASH, AND LARCH STANDARDS.

Soil and situation—*Quality I.*

Rotation for Standards : Oak, 100 years ; Larch and Ash, 80 years.

Rotation for Underwood, 20 years.

Years.	Just before a fall.		Trees cut.		Trees left.	
	Oak.	Larch and Ash.	Oak.	Larch and Ash.	Oak.	Larch and Ash.
20	(say) 40	(say) 64	20	28	20	36
40	20	36	10	18	10	18
60	10	18	4	10	6	8
80	6	8	1	8	.5	...
100	5	...	5	...	...	...
Total.	81	126	40	64	41	62
	<u>207</u>		<u>104</u>		<u>103</u>	

	Oak.	Larch.	Ash.	
Trees planted for standards	.	<u>60</u>	<u>50</u>	40 at each felling.
Total standards	.		<u>150</u>	
Trees planted for coppice	.		<u>60</u>	
Total	.	<u>210</u>		trees.
		<u> </u>		

About one or two years after the coppice is cut, all young standards should be pruned¹ which are in need of it; and a year or two after that, the young trees just planted should be freed from any coppice shoots which threaten them.

As regards the species of tree that may be planted for standards, they must always be **thinly foliaged trees**, and as already stated, Oak, Ash, and Larch are usually selected.

But on clay soils Black Poplar and Black Italian Poplar will usually prove most valuable; though they should never be grown in conjunction with Oak. The White Poplar may also be planted on **very stiff clay soils**, where it seems to thrive better than the other Poplars; but generally it is not

¹ See Chapter VII.

so suitable, as it is rather more branchy and spreading in its habit, especially when young. The Picardy Poplar (probably a variety of *P. canescens*) is also admirably suited as a standard over coppice.

Other trees which are admirably suited for standards over coppice are the Black Walnut, Tulip Tree, White Ash (*F. Americana*) and the Oregon Ash. These latter trees suffer much from early and late frosts, and there is no method so suitable for insuring success with tender species as to plant them over a coppice area.

There is every probability that these trees, especially the Black Walnut and the Oregon Ash, would prove very remunerative; though it is impossible as yet to anticipate with what favour or otherwise their appearance upon the market would be regarded by timber merchants.

The Tulip tree requires a stiffish soil, and grows rather faster than the Oak. The other three trees grow very rapidly, if not affected by adverse circumstances; the Black Walnut has, however, much difficulty in ripening its wood when young, and is therefore very liable to be cut back by autumn frosts. The White Ash will probably succeed better than any other Ash on light soils lacking in moisture.

The expenses of management of an area under coppice with standards are greater than those of an area under ordinary high forest.

These expenses must vary a great deal; but on a normally stocked area—that is, where all stages of the overwood and underwood are equally represented from youth up to maturity—the minimum net expenses will average about 6s. 3d.¹ per acre per annum, or say 4s. per acre per annum, over and above a sum of 2s. 3d. represented by the annual value of the sporting,² provided the areas are large.

This sum of 6s. 3d. includes, however, the average cost of replanting a certain number of trees every time the under-

¹ This does not include the cost of felling the standards, or of haulage.

² In many cases this will be too low a figure for the sporting; but with large compact areas the sporting will be worth a much smaller sum per acre, than where the woods consist of small scattered coverts.

wood is cut, and also auction expenses ; so that it is hardly comparable with the average expenses incurred under high forest, which, as stated elsewhere, may be taken as 2s. per acre per annum, over and above a sum of 1s. 3d. represented by the value of the sporting.¹

These minimum expenses on a normally stocked area may be detailed as follows :—

Planting 250 trees at end of rotation of 20 years . . .	£1 7 0
Expenses of sale, advertising, and half-year's * credit allowed to underwood buyers	0 17 0
Cutting underwood	0 16 0
Total	<u>£3 0 0</u>
Or, average per annum equals 3s.	£0 3 0
Add—For hedging, ditching, brushing rides, and repairs to dead fences and gates (on large areas).	0 1 8
Rates	0 0 10
Attention to young crop, pruning, general super- vision (on large areas), etc.	0 0 9
Total per acre per annum	<u>£0 6 3</u>

* This half-year's credit is included, as it must be deducted from the gross receipts when considering the net financial returns from coppice with standards ; though not properly speaking an outgoing.

In the above estimate, nothing has been allowed for felling the standards, although it is far preferable that they be felled by the home staff of woodmen, yet the branch and cordwood, and faggots will about equal the cost of felling. It is almost always advisable to sell the standards separately from the underwood.

With a view to increasing the sporting amenities of a wood, so-called "covert plants" are often planted. There is generally more necessity for planting these in woods grown under high forest systems than where coppice is grown, but their employment may be considered here.

¹ The sporting value of land under ordinary high forest is never so great as is the case when the system of coppice with standards is followed.

Even in well-managed coppice with standards, it will often be advantageous, especially on level ground, to have a thick screen of evergreen shrubs at the end of any area over which the pheasants are driven. This will hide the "guns" from view, and the birds are not so likely to turn back; and in order to make them rise better this screen may be cut as a bank, starting from ground level about 40 feet within the boundary and sloping upwards, and the top of this sloping screen may be made still higher by planting one or two rows of trees on the very edge of the boundary.

For such a screen, Laurel, Holly, and Rhododendron and *Thuya gigantea* may be recommended, provided the soil be suitable. These shrubs and trees, and so also Yew, Box, Privet, Snowberry, and Gaultheria (*G. Shallon*)—the latter a dwarf growing shrub of rambling habits—will bear a great deal of shade, and are very suitable to plant as affording "covert" in even-aged high forest, where the canopy is too dense for ordinary coppice trees.

The Conversion of Coppice or Coppice with Standards into High Forest.

There are many who advocate the conversion of coppice or coppice with standards into high forest, with a view to obtaining greater profits.

There is no doubt that nearly all areas under simple coppice could produce a far greater income under some other system; but the system of coppice with standards should not be too hastily altered for one of even-aged high forest.

On very poor dry soils there is no doubt that an even-aged forest of conifers is far more suitable, since hardwoods, and especially the coppice shoots of such trees, require and extract from the soil far more food nutrients than coniferous trees.

But on stiff clay soils an attempt to convert the area into an even-aged high forest, would, with timber at its present price, result in a great failure.

On such soils coppice with standards of Oak or of Poplar will give better returns than any even-aged forest. Coppice with Larch and Ash standards will be about as

remunerative as, and far safer than, an even-aged high forest of pure Larch. It should be noted that there are many soils too poor to grow mature standards of exacting trees such as Ash and Spanish Chestnut,¹ but which will readily grow 30- or 40-year-old poles of such trees, which are usually very saleable.

The foregoing is often observed to be the case on shallow soils in which deep-rooted trees may be growing.

Where conversion into even-aged high forest is determined upon, it may be done :—

- (1) by planting the desired crop among the coppice stools ; or
- (2) by taking a short rotation of the best stool shoots and clear cutting the area when they have reached their maturity.

In any case, if there are existing standards over the coppice they should be left unless nearly mature, or unless, for young trees, they have unduly large crowns.

By the latter method of selecting the best stool shoots excellent results are often obtained, and at a minimum of expense.

But it should not be tried if the majority of stools are old and enfeebled.

When attempted, about 3 stools' shoots should be allowed to grow for the first 3 years to prove which is the most vigorous and valuable ; then the best should be selected and the other two removed. Any deficiency in the desired number of shoots should be made good by planting.

HIGH FOREST WITH COPPICE.

The great advantages of this system have already been referred to as a means of growing timber, of the thinly foliated trees, of the highest technical quality, and still preserving the advantages that an undergrowth of coppice presents for game preservation.

Plantations made *de novo* with this object in view might

¹ To grow really fine timber free from shakes, Spanish Chestnut requires a deep loam with plenty of moisture.

on suitable soil consist of a mixture in about equal proportions of Larch, Ash, and Spanish Chestnut. They should be gently thinned in the ordinary way, removing first of all the Larch that do not show exceptional vigour, until the twenty-fifth year, when all the Chestnut should be carefully coppiced and only the best Larch and Ash left.

The underwood may then be treated on a rotation of 16 years or as may seem suitable, but it can hardly have any more pruning effect on the standards, as they will be out of its reach by the time it has grown up again. At this first felling of the underwood, no trees should be planted to increase the number of stools as the overhead canopy will be rather thick, and it is better to wait until just before grass begins to appear or until the next rotation, when about 100 to 150 should be planted and a like number the rotation after, if found necessary; they will then grow vigorously, as the canopy will be much broken, and by the time the standards are mature at (say) 73 years, there should be about 500 vigorous stools per acre.

Table for High Forest with Coppice.—Grown as even-aged high forest for the first 25 years; then an overwood of Larch and Ash left, and an underwood of Spanish Chestnut and some Ash coppiced periodically every 16 years.

TABLE FOR HIGH FOREST WITH COPPICE.
Average soil and situation.

Years.	Trees just before a fall. Larch and Ash.	Trees cut. Larch and Ash.	Trees left. Larch and Ash.
25	800	400	400
41	400	240	160
57	160	105	55
73	55	55	...

At 41st year (or previously) and at 57th* year, 150 Spanish Chestnut to increase coppice stools.

* As may seem necessary; but the Chestnut trees originally coppiced at the 25th year may prove sufficient.

At the end of the rotation of the overwood there should be about 500 vigorous stools per acre, and amongst these about 650 Ash and Larch should be planted so as to perpetuate the system. They should be evenly distributed over the whole area; no tree should be planted nearer than 6 feet to any healthy stool; and the trees should generally be in small groups of 5 to 9, each species kept separate and planted 4 feet apart from each other.

A rotation of 14 to 16 years will be quite enough for the underwood,¹ or the Larch and Ash will get suppressed, and even with this length of rotation the underwood must be very carefully kept from injuring the future overcrop.

When the Ash and Larch are planted, it will be cheaper to fence the whole area against rabbits, provided it is over 10 acres in extent, and provided the trees were otherwise going to be protected with small wire guards, costing 1d. each.

If guards of tarred felt could be erected at a cost of $\frac{1}{2}$ d. each, the fencing of the whole area would only be cheaper if it were 30 acres in extent or over.

TABLE showing the working of above example *in perpetuo*.

Years.	Trees just before a fall. Larch and Ash.	Trees cut. Larch and Ash.	Trees left. Larch and Ash.
15	(about) 600 *	100	500
30	500	150	350
45	350	190	160
60	160	105	55
75	55	55	...

About 70 trees to be planted at the 30th year, and again at the end of each rotation of underwood, as may seem necessary in order to increase number of coppice stools.

* This of course depends on the success of the previous planting.

If, when the coppice is first cut over, it appears that the

¹ A longer rotation is indicated for ordinary coppice with standards, as the standards are of various ages, and the trouble of freeing the youngest age class is comparatively little.

Larch and Ash have been unduly drawn up, a fringe of coppice should be left all round the area for some 4 or 5 years longer, as a protection from wind until the young standards have become strengthened; and, as a screen for game, the coppice should always be encouraged near the rides and roads.

Where Oak are grown under this system, it will be necessary to plant, on existing coppice areas, a larger number of trees per acre (about 1000); as usually such a small proportion develop into strong, vigorous trees, and as they are slower growing, they must be present in greater numbers at the respective dates.

The first rotation should not be more than 10 or 12 years, otherwise the trees will be suppressed. The subsequent rotations of the underwood may conveniently be 16 to 20 years or 25 years, though such a plan rather complicates the management. A similar plan may be adopted in the case of Larch and Ash, though it is not so essential.

CHAPTER XI.

AVERAGE YIELDS FROM FOREST LAND.

THE following yields from particular crops may be expected on certain soils and situations, provided the crops escape damage from insects, fungi, and fire. As regards the values attached to the timber and the thinnings, it must be remembered that these are subject to great variation; the value of thinnings has in many cases been placed somewhat low since they can usually only be disposed of locally, and any increase in the area under timber would probably be accompanied by a diminution in the amount per acre received for thinnings. The soil and situation are made referable to one of four qualities—Quality I. being the best, and Quality IV. the worst. Quality II. represents soil and situation of good average quality.

The identical soil and situation may be of different quality for different species of trees.

The number of cubic feet of thinnings is reckoned down to 2 inches quarter girth under bark, so that measurements may be compared with continental data which, for timber only, are reckoned down to 3 inches diameter over bark. The value placed upon the final yields, presupposes that the purchaser fells the timber; whereas the thinnings are cut out by the home staff of woodmen.

In all cases it is presumed that 3-year-old trees have been planted:—

OAK.¹Close-Canopied High Forest. Soil and situation—*Quality II.*

Years since planted.	Thinnings removed.		Cubic feet left to 2 in. q. g.	Average per tree, cub. ft., 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.		
20	...	£ S. D.	...	...
30	30	1 0 0	...	...
40	70	2 10 0	1060	2
50	150	5 10 0	1460	4
60	200	7 10 0	1890	7
75	450	17 0 0	2340	13
90	480	24 0 0	2730	21
105	460	34 0 0	2930	29½
120	Final crop, 100 trees.		3000 cub. ft. to 6 in. q. g.	35½

Value of final crop, 3000 cub. feet, at 1s. 9d.

$$= \underline{\underline{L}262}, 10s.$$

Total yield of thinnings = 1840 cub. ft. to 2 in. q. g.

$$\text{, , , final crop} = \underline{\underline{3550}} \text{ cub. ft. to 2 in. q. g.}$$

$$\text{Total} = \underline{\underline{5390}}$$

$$\text{Average annual increment} = \frac{5390}{120}$$

$$= \underline{\underline{45}} \text{ cub. ft.}$$

Note.—Much more satisfactory returns would be obtained by making a partial clearance at about the 60th or 70th year, and then under-planting, if such has not already taken place.

¹ The yield of Oak Bark is dealt with in Chapter XIV.

BEECH.

Close-Canopied High Forest. Soil and situation—*Quality II.*

Years since planted.	Thinnings removed.			Cubic feet left to 2 in. q. g.	Average per tree, 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.	£ s. d.		
20	...	...	...	...	...
30	...	...	...	420	$\frac{1}{4}$
40	30	0 10 0	990		1
50	130	3 0 0	1660		$2\frac{1}{2}$
65	250	6 10 0	2500		$6\frac{1}{4}$
80	400	16 15 0	3400		$11\frac{1}{2}$
95	500	23 0 0	4000		20
105	350	16 0 0	4350		29
120	Final crop,	150 trees.	4800 cub. ft. to 6 in. q. g.		36

Value of final crop, 4800 cub. feet, at 1s.

$$= \underline{\underline{\text{£} 240.}}$$

Total yield of thinnings = 1660 cub. ft. to 2 in. q. g.

,, " final crop = 5400 cub. ft. to 2 in. q. g.

$$\text{Total} = \underline{\underline{7060}}$$

$$\text{Average annual increment} = \frac{7060}{120}$$

$$= \underline{\underline{58\frac{1}{4}} \text{ cub. ft.}}$$

SILVER FIR.

Close-Canopied High Forest. Soil and situation—*Quality II.*

Years since planted.	Thinnings removed.		Cubic feet left to 2 in. q. g.	Average per tree, 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.		
30	...	£ s. d.	...	...
35	...	Nil	700	½
45	200	2 10 0	1400	1½
55	280	3 10 0	2550	4½
65	320	4 0 0	3900	10½
77	360	6 0 0	5140	18½
90,	Final crop,	280 trees.	6050 cub. ft. to 6 in. q. g.	24

Value of final crop, 6050 cub. ft., at 6½d.

= (say) £164.

Total yield of thinnings = 1160 cub. ft. to 2 in. q. g.

, , , final crop = 6700 cub. ft. to 2 in. q. g.

Total = 7860

$$\text{Average annual increment} = \frac{7860}{90}$$

$$= 87\frac{1}{3} \text{ cub. ft.}$$

Norway Spruce.—The total yield of Norway Spruce will be rather less. The thinnings will yield rather more, and be begun earlier, but the final crop will not be so great. Usually a rotation of 70 to 80 years will be sufficient for the Spruce.

Norway Spruce on an 80-year rotation should give an average annual increment of 80 cubic feet on soil and situation of Quality II.

SCOTS PINE.

Close-Canopied High Forest. Soil and situation—*Quality II.*

Years since planted.	Thinnings removed.		Cubic feet left to 2 in. q. g.	Average per tree, 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.		
20	...	£ s. d.	...	...
30	30	0 10 0	1000	1 $\frac{1}{2}$
40	200	2 10 0	1900	3 $\frac{1}{2}$
50	220	4 0 0	2600	6
60	300	5 0 0	3080	9 $\frac{1}{2}$
70	300	6 5 0	3460	13 $\frac{1}{2}$
80	Final crop,	260 trees.	3450 cub. ft. to 6 in. q. g.	16

Value of final crop, 3450 cub. ft., at 7d.

$$= \underline{\underline{\text{£} 100, 12s.}}$$

Total yield of thinnings = 1050 cub. ft. to 2 in. q. g.

" " final crop = 4150 cub. ft. to 2 in. q. g.

$$\text{Total} = \underline{\underline{5200}}$$

$$\begin{aligned}\text{Average annual increment} &= \frac{5200}{80} \\ &= \underline{\underline{65 \text{ cub. ft.}}}\end{aligned}$$

Corsican Pine.—The yield from Corsican Pine should be considerably greater, as much more will be yielded by thinnings; the final crop may be expected to yield about the same. An average annual increment of 75 cubic feet should be given on Quality II. soil, on an 80-year rotation.

WEYMOUTH PINE.

Close-Canopied High Forest. Soil and situation—*Quality I.*

Years since planted.	Thinnings removed.		Cubic feet left to 2 in. q. g.	Average per tree, 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.		
20	...	£ s. d.	...	...
30	40	0 14 0	1100	1½
40	260	3 5 0	2000	3½
50	300	5 0 0	2650	6¾
60	350	6 10 0	3300	10½
70	400	9 15 0	4010	15½
80	Final crop,	260 trees.	4270 cub. ft. to 6 in. q. g.	19

Value of final crop, 4270 cub. ft., at 7½d.

= (say) £133, 10s.

Total yield of thinnings = 1350 cub. ft. to 2 in. q. g.

,, , final crop = 4950 cub. ft. to 2 in. q. g.

Total = 6300

Average annual increment = $\frac{6300}{80}$ = 79 cub. ft.

ASH.

Close-Canopied High Forest. Soil and situation—*Quality II.*

Years since planted.	Thinnings removed.		Cubic feet left to 2 in. q. g.	Average per tree, 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.		
13	...	£ S. D.	...	...
20	10s. 100 poles	3 10 0	...	...
27	20s. 100 poles	4 0 0	870	1 $\frac{1}{4}$
35	50s. 100 poles	5 10 0	1200	2 $\frac{1}{2}$
45	430	21 10 0	1430	5 $\frac{1}{2}$
55	700	35 0 0	1440	12
70	Final crop,	120 trees.	1900 cub. ft. to 6 in. q. g.	20

Value of final crop, 1900 cub. ft., at 1s. 6d.

$$= \underline{\underline{\text{£142, 10s.}}}$$

Total yield of thinnings = 1380 cub. ft. to 2 in. q. g.

" " final crop = 2400 cub. ft. to 2 in. q. g.

$$\text{Total} = \underline{\underline{3780}}$$

$$\text{Average annual increment} = \frac{3780}{70}$$

$$= \underline{\underline{54 \text{ cub. ft.}}}$$

Note.—It would be far preferable to partially clear the Ash from the 35th year onwards; though, in the above case, the thinnings have been very heavy at the 45th and 55th years.

LARCH.

Close-Canopied High Forest. Soil and situation—*Quality II.*

Years since planted.	Thinnings removed.		Cubic feet left to 2 in. q. g.	Average per tree, 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.		
12	8s. 100 poles	£ 2 o o	...	...
18	17s. 100 poles	6 o o	...	...
25	80	5 o o	870	1 $\frac{1}{4}$
32	240	7 o o	1380	2 $\frac{3}{4}$
40	275	8 o o	1850	5 $\frac{1}{2}$
50	309	9 o o	2450	9 $\frac{1}{2}$
60	450	15 o o	2800	14
70	Final crop,	200 trees.	3000 cub. ft. to 6 in. q. g.	17

Value of final crop, 3000 cub. ft., at 1s.

$$= \underline{\underline{\text{£150.}}}$$

Total yield of thinnings = 1360 cub. ft. to 2 in. q. g.

" " final crop = 3400 cub. ft. to 2 in. q. g.

Total = 4760

 Average annual increment = $\frac{4760}{70}$
= 68 cub. ft.

Note.—In nearly every case more satisfactory results would be obtained by making partial clearances from about the 35th year and underplanting, than by keeping a close-canopied high forest.

LARCH.Soil and situation—*Quality I.*

Partially cleared at the 35th year, and underplanted.

Years since planted.	Thinnings removed.		Cubic feet left to 2 in. q. g.	Average per tree, 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.		
12	...	£ S. D. 2 0 0	...	...
18	25	7 0 0	...	...
26	120	7 0 0	1050	1 $\frac{3}{4}$
35	375	11 0 0	1460	4 $\frac{1}{8}$
45	332	10 0 0	2286	8 $\frac{1}{2}$
55	1197	45 0 0	2345	17 $\frac{1}{2}$
65	1260	55 0 0	1876	28
80	Final crop, 67 trees.		over 3200 over 6 in. q. g.	50

Value of final crop, 3200 cub. feet, at 1s.

$$= \underline{\underline{\text{£}160.}}$$

Total yield of thinnings = 3309 cub. ft. to 2 in. q. g.

" " final crop = 3350 cub. ft. to 2 in. q. g.

$$\text{Total} = \underline{\underline{6659}}$$

$$\text{Average annual increment} = \frac{6659}{80}$$

$$= \underline{\underline{83\frac{1}{4}}} \text{ cub. ft.}$$

Note.—The value of a cleaning at the 8th year has been taken as nil.

DOUGLAS FIR.¹Close-Canopied High Forest. Soil and situation—*Quality I.*

Years since planted.	Thinnings removed.		Cubic feet left to 2 in. q. g.	Average per tree, 2 in. q. g.
	Cubic feet to 2 in. q. g.	Value.		
14	...	£ s. d.	...	...
20	17s. 100 poles	5 0 0	1800	1½
27	540	9 0 0	3465	4½
35	1080	17 10 0	5000	10
45	3000	75 0 0	6750	27
55	1800 at 9d.*	60 0 0	8930	47
65	3000 at 9d.*	101 0 0	9180	70½
75	Final crop,	130 trees.	11,200 cub. ft. to 6 in. q. g.	89

* For that which is over 6 inches quarter girth.

Value of final crop, 11,200 cub. ft., at 9d.

$$= \underline{\underline{L420.}}$$

Total yield of thinnings = 9,620 cub. ft. to 2 in. q. g.

" " final crop = 11,570 cub. ft. at 2 in. q. g.

Total = 21,190Average annual increment = $\frac{21,190}{75}$

$$= \underline{\underline{282\frac{1}{2}} \text{ cub. ft.}}$$

¹ There are no mature crops of Douglas Fir in this country, but the author submits the above table after careful study of the rate of growth of young crops in this country, and also after careful study of the rate of growth in its native country, where in many cases the climate is very similar.

Sitka Spruce is another very fast-growing tree, and though its height growth is somewhat similar to that of Douglas Fir, it will not probably increase in girth measurement at the same rate as Douglas Fir when growing under similar conditions. However, the out-turn per acre should be about half-way between that of Douglas Fir and of Silver Fir.

Cupressus macrocarpa is another tree which in suitable localities should give a somewhat similar out-turn.

Tree Willows and Poplars are very fast-growing trees, especially the Black Poplars. These will produce a greater quantity of timber in a short time than any other broad-leaved trees.

With reference to all the previous tables, it may be stated that a greater final yield is in nearly all cases possible, by restricting the thinnings in the latter half of any rotation. But the adoption of such a course would result in committing the common continental error of striving after maximum final yields which, in most cases, results in a net monetary loss, when compared with the results of crops which have been somewhat heavily thinned, from the time that the principal height growth was attained.

The above data may all be represented graphically, both as to volume or value, by dividing a circle into segments the area of which is proportionate to the volume or value of the thinnings removed at any time and of the final yield—the dates of the respective thinnings and their volume or value are marked, as also are particulars of the final yield, in their respective segments.

226 AVERAGE YIELDS FROM FOREST LAND

YIELD FROM STANDARDS OVER COPPICE
Standards, Mixed Oak, Larch, and Ash.

Oak on a 100-year rotation. Ash and Larch on an 80-year rotation.
 Coppice on a 20-year rotation. Soil and situation—*Quality I.*

Cubic feet cut to 6 in. q. g.			Standards felled.	Age. Years.	Average per tree, to 6 in. q. g.
Oak.	Larch.	Ash.			
155	...	...	5 Oak . . .	100	31
16	...	...	1 Oak } . . .		16
...	320	...	5 Larch }	80	64
...	...	99	3 Ash }		33
24	...	...	4 Oak . . .		6
...	108	...	4 Larch }	60	27
...	...	120	6 Ash }		20
5	...	...	10 Oak . . .		$\frac{1}{2}$
...	45	...	9 Larch }	40	5
...	...	36	9 Ash }		4
200	473	255	Totals.		

Total yield every 20th year = 928 cub. ft. to 6 in. q. g.

which = 1091 cub. ft. to 2 in. q. g.

Average annual increment* for standards only from a normal area

$$= \frac{1091}{20} = 54\frac{1}{2} \text{ cub. ft.}$$

* The contents of the young standards of 20 years' growth has been left out of account.

Standards, Mixed Ash, and Larch.

Rotation of Standards, 75 years. Rotation of Coppice, 25 years.

Soil and situation—*Quality II.*

Cubic feet cut to 6 in. q. g.		Standards felled.	Age. Years.	Average per tree, to 6 in. q. g.
Larch.	Ash.			
256	...	8 Larch } . . .	75	{ 32
...	147	7 Ash }		21
170	...	17 Larch } . . .	50	{ 10
...	117	18 Ash }		6 $\frac{1}{2}$
...	...	50 Larch } . . .	25	{ ...
...	...	50 Ash }		...
426	264	Totals.		

Total yield every 25th year = 690 cub. ft. to 6 in. q. g.

which = 980 cub. ft. to 2 in. q. g.

Average annual increment for standards only from a normal area

$$= \frac{980}{25} = 39 \text{ cub. ft.}$$

YIELD FROM COPPICE.

Any statement of the yield from various coppice areas in cubic contents will not be of much practical advantage, as it is all "small stuff." And it will vary not only with the soil and species of trees, but also with the length of rotation adopted. But on areas under simple coppice with a 16-year rotation it will vary on average soil from 50 to 70 cubic feet quarter girth measure (reckoning down to 1 inch diameter) for Ash and Spanish Chestnut, and 35 to 55 cubic feet for Oak.

The yield from coppice growing under standards will not be so great, on account of the overshadowing by the standards.

It is of far more importance to know the yield in money value that may be expected from coppice. This value, however, is subject to extraordinary variations; much more so than the variations in the price of large timber.

In many parts of the country coppice produce is almost unsaleable, while in other parts of the country £12 to £16 is still realised for the best coppice of Ash when about 16 to 20 years old.

The prices obtained for coppice depend almost entirely upon **local demand**. So that unless there is a local demand, either from some local factory for some special purpose, or else from some large town for firewood, etc., only a nominal sum can be expected per acre by the sale of coppice.

Pure Ash coppice is generally the most saleable, and then pure Spanish Chestnut or a mixture of Spanish Chestnut and Ash. But ordinary mixed coppice, consisting largely of Hazel, is almost unsaleable except near large towns. Alder coppice occasionally pays well *per se*, but not often; it is, however, often extremely valuable as an aid for growing other trees, especially Oak or Ash. It will thus be seen that the value of coppice depends upon the uses to which it can be put. Buyers of coppice have to base their price upon the retail demand in the neighbourhood. The saleable value of the coppice will be represented by the

difference in the value of the gross receipts for the "made up" produce and the working expenses, after deducting a fair profit for the underwood buyer.

Thus, to take an example:—

Some coppice under standards is for sale. It is 3 miles from an agricultural town. There is no market for hop poles or crate wood or hoops. It is 11 years old.

What price will an underwood buyer give for it?

The Gross Receipts from the sale of the produce when made up are estimated to be:—

1100 faggots, at 8s. per 100	£4 8 0
30 bundles pea-sticks (25 in a bundle), at 3d. per bundle	0 7 6
24 bundles bean-sticks (25 in a bundle), at 4½d. per bundle	0 9 0
35 bundles Thatcher's rods for "spicks" and "ledgers" (50 in a bundle), at 3d. per bundle	0 8 9
16 bundles "glatting" rods for fences (25 in a bundle), at 10d. per bundle	0 13 4
2000 fencing stakes, at 3s. 9d. per 100	3 15 0
4 cords of firewood (8 × 4 × 4), at 9s. per cord .	1 16 0
	<u>£11 17 7</u>

The Expenses:—

Cutting underwood	£0 10 0
Tying up 1100 faggots at 4s. 6d.* per 100. . .	2 9 6
Cutting-out and tying (including withies):—	
30 bundles pea-sticks, at 1d. per bundle . . .	0 2 6
24 " bean-sticks, at 1½d. per bundle . . .	0 3 0
35 " Thatcher's rods, at 1¼d. per bundle	0 3 8
16 " " glatting" rods, at 2d. per bundle	0 2 8
2000 fencing stakes, at 8d. per 100	0 13 4
Cording 4 cords of firewood, at 3s. 6d. per cord	0 14 0
	<u>£4 18 8</u>

Plus a sum for buyers' profit, risk, bad debts,
etc.

Therefore, **saleable value of coppice**

or (say) £2, 10s.

* This includes withies.

The above example shows the small value of coppice in the absence of any special market. If the underwood had been cut by the home staff, the saleable value would of course be increased by the 10s. reckoned for cutting it.

So also, occasionally, an owner may convert his own coppice, and thus save the dealer's profit, but such a course will seldom be advisable, as it requires a life-long experience to dispose of the made-up produce of coppice to the best advantage. It may be objected that £4, 10s. is a very large profit for the dealer, considering the small value of the gross receipts. But it must be remembered that it is not all profit, and that the dealer has considerable risks, and would prefer not to be burdened with the trouble of converting unless he saw his way to obtaining a fair profit. In cases where the produce is more saleable, he would not look for a much greater profit—perhaps another pound or two—for he would be subjected to greater competition.

Thus, when hop poles are required, it is still possible to obtain from £4 to £7 an acre for 16-year-old coppice. So again, in the neighbourhood of turning factories, where toys, chair legs, etc., are made, from £6 to £10 an acre may be expected for well-grown coppice, 16 to 18 years old. Or, where pit props are in demand, £10 to £16 an acre may be obtained for coppice, 22 to 25 years old.

However, all other things being equal, the distance from a consuming centre is the determining factor regulating the price.

And in a general way it may be stated that if the produce has to be hauled by road, a depreciation will be witnessed amounting to 15s. to £1 per acre for 18-year-old coppice, for every single mile by which the coppice area is separated from the consuming centre.

In cases where there are large areas under coppice for which there is perhaps only a very poor sale, landowners could in many cases increase the demand by initiating or rendering financial support for the starting of some local industry; such, for instance, as the manufacture from

Spanish Chestnut of the so-called "cheap economic" split fencing.¹

So also it is probable that the dry distillation of wood would also prove profitable.²

¹ This manufacture of fencing has already been started by the Stanley Underwood Company.

² The author hopes in another volume to give some details of investigations he has recently made in Sweden (1906). However, considerable capital would be required for the venture. In all probability, the best means would be to distil over once in portable retorts in the woods, and then to have a central plant (which is very expensive) where the crude product can be refined and thereafter fractionally distilled.

CHAPTER XII.

THE FINANCIAL ASPECT OF AFFORESTATION.

AN estimation of the exact financial position which attends the execution of any planting operations is one of the most important subjects relating to Sylviculture.

It is unlikely that any extensive works of afforestation will ever be carried out, unless there be sufficient evidence to prove that a reasonable return may be anticipated on the outlay expended. Occasionally those who contemplate works of this nature seek expert advice as to the probable financial returns ; but, only too often, the advice tendered is absolutely worthless, and the estimated returns are never likely to be realised.

In many cases, those tendering advice would appear to be happily ignorant of the elementary principles relating to actuarial calculations ; they often make the most random statements, which are usually accepted without a challenge ; whereas a moment's consideration should convince any thoughtful person that such hypertrophied estimates are merely the illusory product of the fond imagination of some over-zealous, self-styled expert.

There can be no doubt that much of the advice given with reference to schemes of afforestation can only lead, if followed, to grave financial losses ; unless, indeed, the prices realised for home-grown timber should advance very considerably above those that obtain at present.

Now, even if the estimate of the rate of growth of the timber, and the amount that can be removed as thinnings, and the value of the final crop, be quite correct, there are

several methods of presenting a statement showing the financial result of such a crop. Some of these methods are correct, but others, though plausible and often made use of, are, unfortunately, absolutely incorrect.

FALLACIOUS METHODS OF PRESENTING FINANCIAL STATEMENTS.

Initial Outlay Credited with the Income which is Receivable only after a Period of Years.—It is of no uncommon occurrence for those who seek advice as to the probable profits that may be anticipated from any planting operations, to be advised of the annual revenue derived from continental forests, and to be told that a similar annual return may be expected on an outlay of only a few pounds, spent in planting and fencing.

For example, an owner who contemplates planting is told that the revenue from some existing forest is £1, 10s. per acre per annum. Then he is advised that the cost of establishing a crop will be perhaps £8 an acre ; that the land is now valued at £12 an acre ; and that, on this proposed investment of £20 an acre, he may hope to secure the same returns. An increased rental of (say) £1, with an additional capital expenditure of only £8 ! Over 12 per cent. interest ! What more profitable undertaking can be embarked upon ?

Another method, often employed, is to suggest that the net annual return on the initial outlay will be equivalent to the value of the final crop, divided by the number of years in the rotation, it being presumed that the various sums of money received from time to time from the sale of thinnings will be equivalent to the annual outgoings.

And again, yet another method, often adopted, is to assume that the gross annual return on the initial capital invested per acre is equivalent to the value of the average annual production of timber per acre, and that, if from this sum a deduction of from 2s. to 4s. be made, on account of rates and other annual outgoings, the remaining sum will be equivalent to the net annual return which the investment will yield.

The following example will illustrate these two latter

methods. It is intended to plant Scots Pine on grass land worth £10 per acre. It is estimated that the cost of establishing the crop, including cleaning for the first 3 or 4 years, and replacing dead trees, will be £8 an acre; and when 30 years old the thinnings will yield 10s. an acre; at 40 years, £2, 10s. an acre; at 50 years, £4; at 60 years, £5; at 70 years, £6, 5s.; and that, when 80 years old, there will be a final crop of 3450 cubic feet, over 6 inches quarter girth measure, which, at 7d. a cubic foot, will yield £100, 12s.; also, it is assumed that, at the end of the rotation, the value of the land remains unaltered.

The total number of cubic feet (down to 3 inches top diameter) which will be produced, is estimated at 5050 cubic feet, which gives an average annual production of 63 cubic feet. And the average annual outgoings, over and above any sum received as a sporting rent, are estimated at 2s. an acre.¹

Now, by adopting the first of these two methods it would appear that the initial outlay of £18 would yield a net annual return of approximately £1, 5s.

For the

$$\frac{\text{Value of final crop}}{\text{Number of years in rotation}} = \frac{\underline{\underline{\text{£100, 12s.}}}}{80} \\ = \underline{\underline{\text{£1, 5s. (nearly)}}}.$$

This equals, apparently, nearly 7 per cent. interest on the outlay of £18.

And by the second method, the average annual production of 63 cubic feet of timber would, at 7d. a cubic foot, be worth £1, 16s. 9d.

Hence—

The gross annual return equals	.	.	.	.	<u>£1</u>	<u>16</u>	<u>9</u>
<i>Less</i> , for annual outgoings	.	.	.	.	<u>0</u>	<u>2</u>	<u>0</u>
The net annual return equals	.	.	.	.	<u>£1</u>	<u>14</u>	<u>9</u>

Now, this £1, 14s. 9d. equals, apparently, about $9\frac{2}{3}$ per cent. interest on the initial outlay of £18.

Methods, such as these, though plausible, are absolutely

¹ This does not include any sum representing the cost of felling the timber or making up cordwood, or of cleaning the young crop.

fallacious. They compare favourably with certain literature emanating from some financial "house" whose reputation is doubtful, and they should be as carefully avoided as are the latter's solicitations.

The whole fallacy of the principle of the above valuations lies in the fact that it is assumed that money can be borrowed for 80 years without any interest ever being charged upon it, which, of course, is utterly absurd.

In the above example, if all monies received or spent during the rotation be debited with 4 per cent. compound interest, the correct net annual rental that may be anticipated is only 3s. 2d.; or if 3 per cent. interest be assumed, the net annual rental will be 6s. 1d. per acre. This is surely a poor return on an outlay of £18.

CORRECT METHODS OF PRESENTING FINANCIAL STATEMENTS :—

Statement of Income obtained on Average Accumulated Capital which has been Sunk in Normally Stocked Areas.—In cases where it is desired to make a comparison with the returns obtained in continental forests, it must be remembered, that these returns represent the yearly income from a fully developed **normally stocked area**, which, of necessity, has a large capital debit account per acre; and a net return of £1, 10s. per acre per annum will not usually represent a very high rate of interest. This capital debit sum will depend upon the original value of the land, the cost of planting, and the length of the rotation, etc.

Thus, with reference to the previous example, where Scots Pine are grown on an 80-year rotation, it will be necessary, in order to find the average capital sum per acre invested in a normally stocked area, to imagine that 1 acre is planted per annum until the 80th year, and to calculate at compound interest, all the monies spent and received till the end of the 80th year, and then to divide the total debt by 81.¹

¹ This is to allow of having 1 acre fallow, as, finally, when a crop is felled, the land is not planted till the year after. The cost of planting this 1 acre is accounted for in the average outgoings of the 81st year.

Hence, calculating compound interest as $3\frac{1}{2}$ per cent. :—

Debtor account to the end of the 80th year :—

1 acre planted every year, for 80 years, involving an outlay of £18 per acre (land, £10; plant- ing, £8) = £18 × 434	<i>Dr.</i> £7812 0 0
Value of 1 acre of land, taken at 80th year*	10 0 0
Outgoings at 2s. per acre per annum on all land planted up = 2s. × 10,114	1011 8 0
	<u>£8833 8 0</u>

* This is to allow of having 1 acre fallow, as, finally, when a crop is felled, the land is not planted till the year after. The cost of planting this 1 acre is accounted for in the average outgoings of the 81st year.

Creditor account to the end of the 80th year :—

Thinnings valued at 10s. received from off 1 acre,	<i>Cr.</i> £67 15 0
every year from the 30th year = 10s. × 135·5	218 15 0
Thinnings, £2, 10s. from 1 acre, every year from the 40th year = £2, 10s. × 87·5	213 12 0
Thinnings, £4 from 1 acre, every year from the 50th year = £4 × 53·4	146 5 0
Thinnings, £5 from 1 acre, every year from the 60th year = £5 × 29·25	75 0 0
Thinnings, £6, 5s. from 1 acre, every year from the 70th year = £6, 5s. × 12	100 12 0
Final crop, taken from the acre first planted, £100, 12s.*	<u>£821 19 0</u>

* It is presumed that the cost of felling is defrayed by the sale of the branch wood and tops under 6 inches quarter girth.

Now, the actual debt equals the difference between the debtor and creditor accounts :—

<i>£8833 8 0 Dr.</i>
<u>821 19 0 Cr.</u>
<u>£8011 9 0</u> actual debt on the whole area.

Therefore the average debt per acre in the example under consideration :—

$$= \frac{\underline{£8011, 9s.}}{81} \\ = (\text{say}) \underline{£100}.*$$

* It is really somewhat more, if strict account be taken of the non-productive land occupied by rides and roads.

Now it will be quite correct, in principle, to state that the value of the average annual increment is equal to the gross annual revenue which is yielded on this average capital charge per acre of £100.

E.g., the average annual production per acre is 63 cubic feet, that is (say)—

$$\begin{array}{rcl} 50^* \text{ cub. ft., at } 7d. & = & \underline{\underline{\text{£1 9 2}}} \\ 13 \text{ cub. ft., at } 3\frac{1}{2}d. & = & \underline{\underline{0 3 10}} \\ & & \underline{\underline{\text{£1 13 0}}} \end{array}$$

* It would not be correct to value the 63 cubic feet at 7d., as a portion of this average annual increment is small "stuff" and therefore worth less per foot.

Hence, the gross return equals £1, 13s. and the net return is obtained by deducting the outgoings from the gross return.

Now, the **minimum outgoings per acre** on a normally stocked area, will include the 2s. over and above any sum receivable as a sporting rent, as already described, and, also, an average sum per acre for replanting an area equal to that annually cut; and also an average sum per acre to defray the cost of felling the final crop.¹

Thus, the annual outgoings will be about as follows:—

	Per acre.
Ordinary outgoings, as mentioned	£0 2 0
Proportionate charge for replanting	0 1 6*
" " for felling	0 2 1
Total net outgoings	<u><u>£0 5 7</u></u>
 Hence, the actual net return per acre equals	
Less	0 5 7
Net return per acre	<u><u>£1 7 5</u></u>

* The cost of replanting the land just cleared, and establishing the crop, is placed at £6 an acre.

¹ This is necessary, as, in arriving at the gross returns, the timber has been valued down to 3 inches diameter; and the faggots, etc., made from any smaller "stuff" will usually only pay for the making up.

Hence, in the above example, the net return on the average accumulated capital per acre of £100 will only be £1, 7s. 5d.; that is $1\frac{3}{8}$ per cent.¹

From the foregoing, it will be evident that whenever afforestation is advocated, and the returns from fully stocked normal areas are instanced, as a proof of the profits that may be anticipated, it is always necessary to remember that these annual profits represent the annual income from a large accumulated capital per acre, and are not the immediate annual profits that may be looked for as arising from the initial outlay, represented by the value of the land and the cost of establishing a crop.

The following table shows the average accumulated capital per acre expended in forming some normally stocked areas;² all calculations being made at $3\frac{1}{2}$ per cent.

	If Value of Land and Cost of establishing a Crop equals	Average accumulated Capital per acre equals (about)
Scots Pine.*	£6	£35
80-year rotation.	12	68
Soil and situation— <i>Quality II.</i>	18	100
	27	156
 Oak.†	£6	£39
120-year rotation.	12	135
Soil and situation— <i>Quality II.</i>	18	235
	27	400

* *Vide* table in Chapter XI.

† The area of land occupied by rides and roads has not been taken as exactly the same in all cases.

¹ Assuming, as already stated, that, until the area be normally stocked, all monies received or spent are credited or debited with $3\frac{1}{2}$ per cent. compound interest.

² A normally stocked area presumes, here, that a succession of mature crops, of equal area and value, can be felled, annually, from the present date, onwards.

The above table will serve as a rough guide for estimating the average capital per acre that will accrue by the time that any area, which it is intended to plant, becomes normally stocked and capable of yielding a sustained annual yield, provided that the rotation be either 80 or 120 years; and that the dates of thinnings and their value be somewhat similar to Scots Pine, if an 80-year rotation be adopted; or to Oak, if a 120-year rotation be adopted. If, however, the accumulated value of thinnings and the final crop be respectively greater, the capital debt will be reduced, and *vice versa*.

Statement of the Gain in Capital after charging Compound Interest.—Another method, occasionally adopted, for presenting a financial statement is to state that, after charging compound interest on all monies, spent and received up to the end of the rotation, there will remain as additional profit a lump sum of £—.

For instance, a landowner is advised that on an outlay of £25 (which includes the value of the land) he may, by planting conifers on a 70-year rotation, obtain compound interest at the rate of $2\frac{1}{2}$ per cent., and, at the end of the 70 years should also have an extra profit of £105.

Now, an ordinary individual will usually imagine that this extra £105 at the end of 70 years is equal to an additional profit of $\frac{105}{70} = \text{£1}, 10\text{s. per annum}$; which, on the outlay of £25, is equal to an additional interest of 6 per cent. Thus, without asking any further questions, he imagines that he may get 6 per cent. *plus* the $2\frac{1}{2}$ per cent. already accounted for, which equals $8\frac{1}{2}$ per cent. altogether. In all probability, he will think this a good investment. And, though he may regard the suggested final yield from the crop as too optimistic, he feels confident that he may safely expect to get 5 or 6 per cent. on his outlay; and forthwith gives instructions for the planting to be carried out.

Needless to say, this line of argument on the part of one's client is absolutely fallacious. The extra £105 at the end of the 70 years, only equals about 11s. 6d. per annum on the $2\frac{1}{2}$

per cent. tables ; or 7s. 4d. per annum on the $3\frac{1}{2}$ per cent. tables ; so that the investment is not nearly so good as it would appear at first sight. Now, although the advice tendered is quite correct, it is, as already explained, very misleading, and its adoption should never be countenanced by any one.

Statement of the Rate of Compound Interest.—Another method, perfectly correct in principle, and advocated by many, is to state the rate of compound interest which any proposed investment in afforestation may be expected to yield, by the end of the rotation.

Now, in order to find this rate of compound interest, it is necessary to add together the net value received for the final crop and the various sums of money received from time to time by the sale of thinnings, such sums being reckoned as accumulating at compound interest to the end of the rotation. From this gross credit sum must be deducted the accumulated value, at compound interest to the end of the rotation, of all the annual outgoings. Then, add the value of the original cost of the land,¹ and the resulting sum will represent the increased value of the original outlay. Then, from tables,² find the rate of compound interest at which the original outlay will amount at the end of the rotation to the present net credit sum. The rate of compound interest at which the value of the thinnings and the annual outgoings is reckoned will make a difference to the ultimate result. If a high rate be taken a better result will generally be shown than if a low rate be taken, unless, indeed, the thinnings be very slight, and their accumulated value is less than that of the annual outgoings.

The above may be thus illustrated by reference to the data given for a crop of Larch (Soil and Situation, Quality II.) in Chapter XI., when, if the land cost £12 per acre;

¹ It is presumed that the value of the land remains the same at the end of the rotation. The original cost of planting is left out, as it is capital lost for ever.

² *Vide Appendix.*

planting £8; and the net annual outgoings be 2s., and if 4 per cent. compound interest be reckoned:—

£2 value of thinnings at 12th year will amount in 58 years* to $\text{£}2 \times 9.7$ =	£19 8 0
£6 value of thinnings at 18th year will amount in 52 years to $\text{£}6 \times 7.7$ =	46 4 0
£5 value of thinnings at 25th year will amount in 45 years to $\text{£}5 \times 5.8$ =	29 0 0
£7 value of thinnings at 32nd year will amount in 38 years to $\text{£}7 \times 4.4$ =	30 16 0
£8 value of thinnings at 40th year will amount in 30 years to $\text{£}8 \times 3.2$ =	25 12 0
£9 value of thinnings at 50th year will amount in 20 years to $\text{£}9 \times 2.2$ =	19 16 0
£15 value of thinnings at 60th year will amount in 10 years to $\text{£}15 \times 1.5$ =	22 10 0
Value of final crop, 3000 cub. ft., at 1s. . . .	150 0 0
	(say) £343 0 0
Deduct outgoings, 2s. per acre per annum (over and above any sum received as a sporting rent), for 70 years = 2s. $\times 364^{\dagger}$ (say)	36 0 0
Add original value of the land	£307 0 0
Net Credit Sum	£319 0 0

* If compound interest be reckoned at 4 per cent., £1 amounts to 9.7 in 58 years.
 † £1 per annum amounts to £364 in 70 years. Therefore 1s. amounts to 364s. in 70 years.

Now, the original outlay was £20 per acre. Therefore, £20 has amounted to £319 in 70 years; and £1 has amounted to 15.9 in 70 years.

And by reference to tables¹ it is seen that, at 4 per cent. compound interest, £1 amounts to 15.57 in 70 years.

Therefore, it follows that the rate of compound interest that has been yielded is just over 4 per cent.

In the above case, if the sums received for thinnings, and the cost of the annual outgoings, had been reckoned at $3\frac{1}{2}$ per cent. compound interest instead of 4 per cent., the net credit sum would have been £292, which would have represented about $3\frac{7}{8}$ per cent. compound interest, on the original outlay.

With reference to the former case, where the value of thinnings, and the cost of outgoings is calculated at 4 per

¹ *Vide Appendix.*

cent., the following rates of interest will be yielded, varying according to the original value of the land :—

	If the land be worth £1 *	Rate of compound interest yielded will be
Rotation, 70 years	5	5 $\frac{1}{8}$ per cent.
	12	4 $\frac{1}{8}$ "
	18	4 "
	22	3 $\frac{5}{8}$ "
	32	3 $\frac{1}{8}$ "
		3 $\frac{1}{8}$ "

* Though good land will not be sold for such a sum, yet the soil value of land from which a crop of timber has been cleared can not for forestry investigations be put at a higher value, for generally it would cost £20 to £30 to stub up the roots and convert it into agricultural land, and unless it were replanted it would only be worth about 9d. to 1s. per acre per annum for rough shooting, unless indeed it had some other special value.

In the above case, if the rotation had been prolonged to 100 years, when, at the 75th year, thinnings to the value of £16 might have been cut, and a final yield of 3800 cubic feet (over 6 inches quarter girth) attained, and worth, at 1s. a cubic foot, £190, the rates of interest yielded would have been as follows :—

	If the land be worth £1	Rate of compound interest yielded will be
Rotation, 100 years	5	4 $\frac{1}{8}$ per cent.
	12	4 $\frac{1}{8}$ "
	18	3 $\frac{5}{8}$ "
	22	3 $\frac{1}{8}$ "
	32	3 "
		3 "

If, on the other hand, the Larch were to be grown on a short rotation of (say) 38 years for pit props, the results would be much better. The thinnings would be rather heavier, so as to encourage an early girth increment, and the following might be expected, on the same quality land :—

Value of thinnings at the 12th year = £2.

"	"	18th "	=	7.
"	"	25th "	=	7.
"	"	31st "	=	7.

Final crop at the 38th year worth standing (say) £50.

These results would yield the following rates of interest :—

	If the land be worth £1	Rate of compound interest yielded will be
Rotation, 38 years	5	5 " "
	12	4 $\frac{1}{8}$ " "
	18	3 $\frac{5}{8}$ " "
	32	2 $\frac{3}{4}$ " "
		2 $\frac{3}{4}$ " "

In comparing the foregoing tables it would appear that, if a high price (*e.g.*, £32) be paid for the land, it would be more advantageous to have a long rotation of 100 years, than a short rotation of 38 years.

Such, however, is not the case. But it serves to illustrate the inadvisability of adopting this method of showing the comparative financial results of works of afforestation; and it also shows how misleading calculations may be, unless all points be carefully considered.

The two cases are not directly comparable. The apparent advisability of the long rotation is explainable thus:—

In both cases the planting, etc., cost £8, and the land is worth £32, and up to the end of the 38th year the results are practically identical—*i.e.*, $2\frac{3}{4}$ per cent. compound interest has been earned on the initial outlay. However, had the land been worth nothing, the £8 spent on planting and establishing the crop—which may be termed the “live” capital—would have earned over 6 per cent. compound interest; but the large proportion of “dead” capital in the land (*e.g.*, £32) brings the interest earned down to $2\frac{3}{4}$ per cent. compound interest. Now, if the rotation be continued to the 100th year, the interest earned for the next 62 years on the “live” capital, which is now a far greater sum than the value of the land, and which is represented by the value of the net credit sum, less the value of the land at the end of the 38th year, is very much more than $2\frac{3}{4}$ per cent.—say 5 per cent. for the next 20 years, then 4 per cent., then 3 per cent., and finally at the end of the rotation, perhaps only $1\frac{1}{2}$ per cent. or 2 per cent.—so that, as the proportion of dead capital is comparatively small from the 38th year, an increased rate of interest beyond the $2\frac{3}{4}$ per cent. is shown on the total capital—both live and dead capital—by the end of the 100th year.

Now, in order that the two cases may be made directly comparable, it is necessary that the calculations should be spread over the same number of years.

By this means, the result of a succession of 38-year rotations up to the 100th year may be directly compared with the result of the single 100-year rotation.

Thus, a succession of 38-year rotations for 100 years, on

land worth £1 an acre, returns $4\frac{7}{8}$ per cent. compound interest, and not 6 per cent. compound interest, as was yielded on a small capital in a single 38-year rotation; for with a succession of 38-year rotations, it is only a small amount of the capital that is re-invested at 6 per cent.; the rest is calculated at 4 per cent., the same rate as the value of the thinnings and the cost of the outgoings is reckoned at.

The above compares with $4\frac{1}{2}$ per cent. compound interest yielded by a single 100-year rotation; and just over $4\frac{3}{4}$ per cent. compound interest yielded by a succession of 70-year rotations.

In the above cases, the net credit sums at the end of the 100th year are:—

	Net Credit Sums, <i>i.e.,</i> = Original outlay. + Accrued profits. - Accrued outgoings.
With a succession of 38-year rotations . . .	£1070
" " 70 " . . .	1015
With the 100-year rotations . . .	737

Thus, there is only a little difference between the financial advantages of the 38- or 70-year rotations where monies can be borrowed or lent at 4 per cent.; but the disadvantage of the long rotation of 100 years is very marked.

The foregoing method of presenting the financial aspect of planting operations, *i.e.*, by stating the rate of compound interest which it is anticipated may be yielded upon the initial outlay, is, while quite correct in principle, open to several grave **objections**, viz.:—

- (1) The results obtained by long and short rotations are not directly comparable.
- (2) The general public do not fully comprehend all that compound interest involves; they do not realise the enormous difference in capital value, which a difference of $\frac{1}{2}$ per cent. makes at the end of a long term of years; and hence they may be misled.

- (3) No data are provided which are in any way comparable with the ordinary methods of estimating the value of agricultural land.
- (4) The rate of interest yielded varies whenever the cost of planting or the value of the land varies, and thus, in each individual case, it is necessary to refer to tables before the rate of interest can be ascertained.
- (5) And since, *cæteris paribus*, the interest varies along with the original outlay, it raises the presumption that, even in the case of the same species of tree, the annual income receivable is re-invested at different rates of interest, whenever the initial outlay differs.

Statement on the Yearly Rental Principle.—By far the best method of presenting a financial statement of the profits likely to be realised by an investment in afforestation, is to state the equivalent yearly rental that could be obtained if the profits or net credit sum at the end of the rotation were discounted into a yearly payment.

The yearly rental thus obtained from areas under even-aged high forest represents the yearly interest yielded upon the cost price of the land, and also upon the capital invested in planting and establishing the crop.

In order, however, to admit of these rentals being directly compared with existing agricultural rents, it is necessary to make a further deduction, representing the yearly interest on the extra capital spent on planting. After such deduction has been made, the remaining sum will be equal to the "land rental" which will be obtained.

The advisability or not of afforestation can thus generally be seen from a comparison of these "land rentals" with the existing rents obtained under agriculture, provided always that there be no appreciation or depreciation in the price per foot of timber. There may, however, be special reasons for afforestation when direct profits are not looked for, as for example, the planting of water catchment areas.

Now, in order to find the net annual rental that any even-aged high forest crop will yield, the credit sum at the end of the rotation is found in the same way as already described when finding the rate of compound interest yielded,

except that the value of the land is not added, and the original cost of planting and establishing the crop is deducted.¹ Then, this net credit sum is discounted into a yearly payment, at the same rate of interest as is reckoned on monies received for thinnings or spent as outgoings.

Thus, in the case of the Larch with a 38-year rotation:—

The accumulated credit from the sale of timber =	£91 0 0
<i>Less</i> , accumulated outgoings*	<u>8 10 0</u>
	£82 10 0
<i>Less</i> original cost of planting	<u>8 0 0</u>
Total net credit sum to be discounted into a yearly payment	<u>£74 10 0</u>

* The outgoings are taken to be 2s. per acre per annum over and above any sum received as a sporting rent. These outgoings do not include the cost of felling the final crop, or any sum for planting or cleaning the crop in the first year or so.

Now, by reference to the 4 per cent. tables,² it will be seen, that in 38 years £1 per annum amounts to £85.97:—

$$\begin{array}{lcl} \text{Hence, } £85.97 & = & \text{the accumulated value of } £1 \text{ per annum} \\ & & \frac{1}{I} \\ I & = & " & " & 85.97 \\ £74.5 & = & " & " & \frac{I \times 74.5}{85.97} \\ & & & & = \frac{1490}{85.97} \text{ s.} \\ & & & & = \underline{\underline{17s. 4d.}} \end{array}$$

Hence, the yearly rental representing a rent for the land, and interest on the cost of planting and establishing the crop, is equal to 17s. 4d. per acre, if the 4 per cent. tables be used.

And if the 3½ per cent. tables be used throughout, the net credit sum to be discounted is £72, 15s., which is equivalent to an annual rental of 18s. 10d. per acre. And if the 3 per cent. tables be used throughout, the net credit sum is £70, 16s., which is equivalent to an annual rental of £1, os. 5d. per acre.

The following tables show the maximum rentals³ that may be obtained from large areas under even-aged high forest.

¹ The reason for this difference is, that the credit sum, which is to be discounted into a yearly payment, must include only deferred profits, after paying back the original sum spent on planting.

² *Vide* Appendix.

³ These rentals are all referable to the data for crops given in Chapter XI., unless otherwise stated.

TABLE A.
All calculations made at 3 per cent. compound interest. Even-Aged High Forest.

Kind of Tree.	Price per foot of Mature Timber.	Quality of Soil and Situation.	Rotation.	Full Rental from Land and Cost of Planting.*	Equivalent rentals for Land only, after deducting interest on the cost of establishing the crop, if such cost be :—			Remarks.
					£	s.	d.	
Douglas Fir .	0 9	I.	75	3 7 10	3 3 0	3 5 0	3 6 4	...
Larch .	1 0	I.	80	1 8 4	1 3 6	1 5 6	1 6 10	Partially cleared.
Larch .	1 0	II.	70	1 2 0	0 17 2	0 19 3	1 0 7	...
Ash .	1 6	II.	70	1 1 10	0 17 0	0 19 1	1 0 5	{ Slight partial clear- ances made.
Larch† .	{ 2000 ft. Pit Timber, £50 }	II.	38	1 0 5	0 15 7	0 18 3	1 0 0	...
Larch† .	1 0	II.	100	0 15 7	0 10 9	0 12 8	0 13 11	...
Weymouth Pine .	0 7½	II.	80	0 8 11	0 4 1	0 6 3	0 7 5	...
Oak .	1 9	II.	120	0 8 1	0 3 3	0 5 1	0 6 4	If winter felled.
Silver Fir .	0 6½	II.	90	0 6 8	0 1 10	0 3 9	0 5 1	...
Norway Spruce .	0 6½	II.	75	...	About the same as Silver Fir.			...
Scots Pine .	0 7	II.	80	0 6 1	0 1 3	0 3 3	0 4 6	...
Beech .	1 0	II.	120	0 5 11	0 1 1	0 2 11	0 4 2	...

* It is presumed that the cost of planting and establishing the crops is £8 per acre.

† *Vide Example ante.*

TABLE B.
All calculations made at $3\frac{1}{2}$ per cent. compound interest. Even-Aged High Forest.

Kind of Tree.	Price per foot of Mature Timber.	Quality of Soil and Situation.	Rotation.	Equivalent rentals for Land only, after deducting interest on the cost of establishing the crop, if such cost be:—				Remarks.
				£s.	d.	£s.	d.	
Douglas Fir	. 0 9	I.	75	2 17	3	2 11	8	2 15 5
Larch.	. 1 0	I.	80	1 4	7	0 19	0	1 2 9
Larch.	. 1 0	II.	70	0 18	11	0 13	4	0 15 8
Larch†	. { 2000 ft. Pit Timber, £50	II.	38	0 18	10	0 13	3	0 16 1
Ash	. 1 6	II.	70	0 18	6	0 12	11	0 15 3
Larch†	. 1 0	II.	100	0 13	4	0 7	9	0 9 10
Weymouth Pine.	. 0 7½	II.	80	0 6	9	0 1	2	0 3 4
Oak	. 1 9	II.	120	0 5	4	0 0	3	0 1 10
Silver Fir	. 0 6½	II.	90	0 4	7	0 1	0	0 3 4
Norway Spruce	. 0 6½	II.	75	...		0 1	2	0 2 8
Scots Pine	. 0 7	II.	80	0 4	5	0 0	1	0 2 7
Beech	. 1 0	II.	120	0 3	3	0 2	4	0 1 3
						0 0	0 2	

* It is presumed that the cost of planting and establishing the crops is £8 per acre.

† *Vide Example ante.*

TABLE C.
All calculations made at 4 per cent. compound interest. Even-Aged High Forest.

Kind of Tree.	Price per foot of Mature Timber.	Quality of Soil and Situation.	Rotation.	Equivalent rentals for Land only, after deducting interest on the cost of establishing the crop, if such cost be:—				Remarks.
				£. s. d.	£. s. d.	£. s. d.	£. s. d.	
Douglas Fir .	s. 9	I.	75	2 8 0	2 1 7	2 4 1	2 5 10	...
Larch. .	i o	I.	80	i 1 1	o 14 8	o 17 2	o 18 10	Partially cleared.
Larch † .	{ 2000 ft. Pit Timber, £50	II.	38	o 17 4	o 10 II	o 14 0	o 16 1	...
Larch. .	i o	II.	70	o 16 5	o 10 0	o 12 7	o 14 3	...
Ash . .	i 6	II.	70	o 15 8	o 9 3	o 11 10	o 13 6	{ Slight partial clear- ances made.
Larch † .	i o	II.	100	o 11 8	o 5 3	o 7 8	o 9 4	...
Weymouth Pine .	o 7½	II.	80	o 5 0	o 1 5	o 1 1	o 2 9	...
Oak . .	i 9	II.	120	o 3 5	... Minus	o 3 0	o 1 0	If winter felled.
Scots Pine . .	o 7	II.	80	o 3 1	... Minus	o 3 4	o 0 10	...
Silver Fir . .	o 6½	II.	90	o 2 11	... Minus	o 3 6	o 1 0	...
Norway Spruce .	o 6½	II.	75	...	... Minus	...	o 0 8	...
Beech . .	i o	II.	120	o 1 9	... Minus	o 2 3	... Minus	...

* It is presumed that the cost of planting and establishing the crops is \$8 per acre.

The full rentals given, representing interest on the cost price of the land and upon the capital spent on planting and establishing the crop, presume that planting, etc., cost £8 an acre (the cost price of the land is immaterial to the calculations if it be worth the same at the end of the rotation as at the beginning).

The rentals given for the land only, when planting costs £5 or £3, could also be approximately arrived at by deducting the yearly interest on the cost of planting from the full rentals given. If the rotation be long, the difference from the actual land rental is very small, but on a short rotation of 50 years, the land rental would be (on the 4 per cent. tables) about 8d. per acre too little if the planting cost £3, and (say) 5d. if the planting cost £5; and about 3d. and 2d. respectively on a 70-year rotation.

On the 3 per cent. tables these deficiencies are rather greater.

If, on the other hand, the cost of planting and establishing the crops be greater than £8 per acre, the land rentals obtained, after deducting interest on the cost of planting, would be slightly too great.

In the foregoing tables, it is presumed that only 3-year-old trees are planted. Hence, when younger trees are planted, as when planting, fencing, etc., costs only £3 per acre, there will be a slight discrepancy, and the rentals, as stated, will be slightly too high, unless the extra density of the crops so planted makes good the advantage of the 1 or 2 years' growth which the older plants possessed at the time of planting.

The same discrepancy presents itself when applying the tables to naturally regenerated areas, but the error is slight, in as much as thickly sown naturally regenerated areas will often when 20 years old show nearly as good growth as a plantation 20 years old made by planting 3-year-old trees.

The error can, however, be eradicated by adding to the cost of planting, fencing, etc., 2 or 3 years' interest on such cost, and then considering the land rentals as referable to this increased cost of planting.

Furthermore, no allowance has been made for loss of capital in land occupied by rides.

The rentals, as stated in these tables, are for crops grown in close canopy, except in the case of the Larch on the 80-year rotation, and to a less extent in the case of the Ash. **Better rentals** will, however, always be shown, especially in the case of Oak, whenever partial clearances or very heavy thinnings can advisedly be made.

It is, in most cases, a great mistake to strive after obtaining maximum final yields, by leaving a maximum number of trees per acre. The rule to observe, though somewhat oracular, is: "Leave a minimum number of trees per acre, after the principal height growth has been attained, as is consistent with sound principles."

Short Rotations.—The advisability of always having, in close-canopied high forest, relatively short rotations instead of long rotations, provided that there be no increase in the price per foot obtained for the timber, is very important, as is shown in the case of Larch in the above tables.

So too, Douglas Fir grown on a rotation of 55 years, will, if 9d. a foot can be obtained for the timber over 6 inches quarter girth, give a far better result than when grown on a 75-year rotation, the timber being sold at the same price per foot.

Thus, adopting the data given in Chapter XI., the following comparisons may be made for Douglas Fir grown on 1st quality soil and situation.

Interest Tables.	Rotation.	Full Rental, Cost of Land,* and Planting, etc.	Land Rentals if Planting, etc., costs		
			£. s. d.	£. s. d.	£. s. d.
3 per cent. {	55	£ 3 16 0	£ 3 11 2	£ 3 13 5	£ 3 14 11
	75	3 7 10	3 3 0	3 5 0	3 6 4
3½ per cent. {	55	3 5 11	3 0 4	3 2 9	3 4 5
	75	2 17 3	2 11 8	2 13 11	2 15 5
4 per cent. {	55	2 17 0	2 10 7	2 13 3	2 15 1
	75	2 8 0	2 1 7	2 4 1	2 5 10

* If planting, etc., costs £8 per acre.

Finally, it may not be out of place to summarise the great advantages which this method of finding the yearly rentals possesses over any of the other methods which are sometimes adopted for expressing the financial results of afforestation.

Advantages of the Annual Rental Principle:—

- (1) Data are given which are directly comparable with existing agricultural rents, if from the full rental a sum be deducted as representing interest on the cost of planting.
- (2) The yearly rental shown on any given interest tables is practically the same (unless the rotations are very short) whatever the cost of planting may be; and of course it is immaterial what the value of the land may be.
- (3) No other method presents the case in such an easily understood manner.
- (4) If the rental is stated, any person can easily (without reference tables) satisfy himself as to the advisability of the undertaking in various cases where the value of the land may differ: *e.g.*, a rental of 8s. per acre can perhaps be anticipated by planting Weymouth Pine; then, if the cost of the land and of planting were £8, a yearly interest of 5 per cent.¹ would be obtained. But if the land and planting cost £16, a yearly interest of only 2½ per cent.¹ would be obtained, and so on.
- (5) The yearly interest receivable is presumed to be re-invested at the same rate of interest as is reckoned on any monies received for thinnings, or spent to defray annual outgoings; whereas if the final result be expressed as yielding a certain rate of compound interest, the rate at which the yearly income is deemed to be re-invested will vary with the rate of compound interest yielded.

¹ Each yearly rental being re-invested at 3½ per cent. or 4 per cent., according to the discount tables upon which the net credit sum is discounted.

UNDERPLANTING.

The financial result of underplanting may also be shown by stating the yearly rentals that may be expected. The method, however, of presenting these rentals is somewhat complicated, since unless both crops be felled at the same time, they are apt to be deceptive.

If both crops be felled at the same time, there is no difficulty; the rental of the undercrop merely increases (or decreases) the rental of the overcrop, for such period as the undercrop has been planted.

If, however, both crops be not felled at the same time, great care is necessary, if the exact financial position of the undercrop is to be accurately conveyed.

Thus, supposing that a crop of **Larch** 35 years old be **underplanted with Silver Fir**, and that the Larch be all removed in 45 years time, and that the Silver Fir be allowed to remain on for another 45 years—that is, until they be 90 years old—and that the cost of planting and fencing will be (say) £4 an acre. The same yield may be expected as is given in Chapter XI. for Silver Fir grown pure, except that at the 45th year 1400 cubic feet may be expected instead of 1600 cubic feet. These 1400 cubic feet at the 45th year should be worth about £22. Hence, on the **4 per cent. tables**,—

By the 90th year there will be a credit sum as follows:—

£3, 10s. received at the 55th year amounts in	
35 years to	£13 12 0
£4 received at the 65th year amounts in 25 years to	9 4 0
£6 received at the 77th year amounts in 13 years to	9 12 0
Final crop, 6050 cub. ft., at 6½d.	164 0 0
	£196 8 0
<i>Less</i> , outgoings, 2s. per annum for 45 years*.	12 2 0
	£184 6 0
<i>Less</i> , debit to cost of planting	4 0 0
Therefore, the net credit sum =	£180 6 0

* The cost of felling early thinnings will be defrayed by the sale of faggots.

This equals a yearly payment on the 4 per cent. tables of

$$\begin{aligned}\frac{\text{£}180.3}{828} &= \frac{3666}{828} \text{ shillings} \\ &= 4\text{s}. 4\text{d}. \text{ per acre (full rental).}\end{aligned}$$

This equals a rental for the land only of

$$\begin{aligned}4\text{s}. 4\text{d}. - 3\text{s}. 2\text{d}.^* \\ = 1\text{s}. 2\text{d}. \text{ per acre (land rental).}\end{aligned}$$

* Equals 4 per cent. on the cost of planting.

If this statement only were given, it would appear that after paying 4 per cent. on the cost of planting, fencing, etc., an additional land rental of 1s. 2d. would be earned, both for the last 45 years of the Larch rotation, and also afterwards for the next 45 years whilst the Silver Fir are growing alone.

This, however, is not, strictly speaking, correct, and it is necessary to have regard to this matter, for otherwise a forester might argue that though up to the end of the Larch rotation the underplanting were advisable, yet the Silver Fir should also be cut at this date, and the land rental of 1s. 2d. sacrificed for some other crop which, when planted on the vacant land, will return a greater land rental.

The explanation of the above lies in the fact that the land rental of 1s. 2d. is the average for the whole 90 years, and most of this rental will be actually earned after the Larch have been removed.

Thus, to analyse the facts more closely:—

The exact financial position of the Silver Fir at the end of the 45th year will be as follows:—

Value of timber . . .	£22	0	0
<i>Less</i> , cost of planting, etc.	4	0	0
Net credit sum .	<u>£18</u>	0	0

This equals a full yearly rental on the 4 per cent. tables of 3s. per acre.

But the planting cost £4 an acre, and 4 per cent. paid on this outlay equals 3s. 2d., so that the land rental shown will be 3s. — 3s. 2d.

This equals minus 2d. per annum for the first 45 years.

But during the next 45 years (*i.e.*, after the Larch are removed), the financial position of the Silver Fir will be as follows :—

Credit from sale of timber (as already stated) .	£196 8 0
<i>Less</i> , annual outgoings, 2s. for 45 years	12 2 0
	<hr/>
	£184 6 0
<i>Less</i> , debit capital in the growing timber at the 45th year	22 0 0
	<hr/>
	£162 6 0

This equals a yearly payment on the 4 per cent. tables of :—

$$\frac{\text{£}162\cdot3}{121} = 26\text{s. 10d.}$$

Now, 4 per cent. on the debit capital of £22 equals 17s. 7d. So that the rental for land only, equals

$$\begin{aligned}\text{£}1, 6\text{s. 10d.} - 17\text{s. 7d.} \\ = 9\text{s. 3d. per acre}\end{aligned}$$

land rental earned during the last 45 years.

Thus, it will readily be seen that, in the above case it would have been absolute folly to have felled the Silver Fir along with the Larch.

It will be observed that the Silver Fir, when used as an undercrop, will have paid 4 per cent. on the outlay, and in addition will have returned an average land rental of 1s. 2d. for the 90 years. This is equal to an additional capital value of £48. Now, this compares very favourably with the results of a crop grown by itself at the same expense when the land rental returned is nil, interest on the cost of planting alone being earned.

The rental thus shown for Silver Fir, when used for underplanting, would of course be correspondingly better on the $3\frac{1}{2}$ or 3 per cent. tables.

With reference to the foregoing two methods of showing the financial position of underplanting, it is really necessary to make the two valuations as shown, whenever the two crops be not felled simultaneously. For, as already explained, the former is misleading without the latter; and the latter will

often be misleading without the former, especially where a "minus" land rental is shown for the first period.

The following shows the financial position of an under-crop of Beech where the soil and situation are Quality II.:-

Thus, suppose that a crop of Oak, grown on a 120-year rotation, be underplanted with Beech at the 50th year, and that the Beech be allowed to stand for 50 years after the Oak are removed, thereby being also grown on a 120-year rotation; and that the Oak be partially cleared from the 50th year onwards, and that the cost of underplanting will be £3 an acre, the following yields¹ may be expected:-

At the 50th year	£1	{ Net, after cost of
" 65th "	3	} felling is paid for).
" 80th "	12	
" 95th "	23	
" 105th "	16	
" 120th " final crop worth £220.		

At the 70th year, when the Oak are removed, it is estimated that the standing crop of Beech will be worth £80.

By the 120th year the net credit sum will, on the $3\frac{1}{2}$ per cent. tables, be as follows:-

£1 received at the 50th year amounts in 70	
years to	£11 2 0
£3 received at the 65th year amounts in 55	
years to	19 18 0
£12 received at the 80th year amounts in 40	
years to	47 8 0
£23 received at the 95th year amounts in 25	
years to	54 5 0
£16 received at the 105th year amounts in 15	
years to	26 14 0
Final crop	220 0 0
	£379 7 0
Less, outgoings, 2s. per annum for 50 years .	13 2 0
	£366 5 0
Less, cost of planting	3 0 0
Therefore, net credit sum =	£363 5 0

¹ These yields are comparable with the data given in Chapter XI., but owing to the overwood of the Oak they are not so great.

256 FINANCIAL ASPECT OF AFFORESTATION

This equals a yearly payment on the $3\frac{1}{2}$ per cent. tables of:—

$$\frac{7265}{1736} = 4s. 2d. \text{ per acre}$$

full rental throughout the whole rotation.

This equals an average rental, for the **land only**, of:—

$$\begin{aligned} 4s. 2d. - 2s. 1d. \\ = 2s. 1d. \text{ per acre} \end{aligned}$$

land rental throughout the whole rotation.

But at the 70th year, when the Oak are removed, the result will be as follows:—

Accumulated value of timber	<u>£85 10 0</u>
<i>Less</i> , cost of planting	<u>3 0 0</u>
Therefore, net credit sum =	<u>£82 10 0</u>

This equals a full rental on the $3\frac{1}{2}$ per cent. tables of 5s. 8d. per acre.

But the planting cost £3 an acre, and $3\frac{1}{2}$ per cent. on this outlay equals 2s. 1d., so that the land rental shown will be:—

$$\begin{aligned} 5s. 8d. - 2s. 1d. \\ = 3s. 7d. \text{ per annum for the first 70 years.} \end{aligned}$$

And during the last 50 years, after the Oak will have been removed, the financial position of the Beech will be as follows:—

Credit from sale of timber (as already stated) .	<u>£379 7 0</u>
<i>Less</i> , outgoings, 2s. per annum for 50 years .	<u>13 2 0</u>
	<u>£366 5 0</u>
<i>Less</i> , debit capital in accumulated value of timber at the 70th year, as previously stated	<u>85 10 0</u>
Therefore, net credit sum =	<u>£280 15 0</u>

This equals a yearly payment, on the $3\frac{1}{2}$ per cent. tables, of £2, 2s. 1od.

Now, $3\frac{1}{2}$ per cent. on the debit capital of £85, 10s. equals £2, 19s. 1od.

So that, the rental, for land only, equals minus 17s. per acre **for the last 50 years** of the rotation.

Thus, in the above case, it would not be correct to leave the Beech as close-canopied high forest for another 50 years; for such a course would result in a direct loss of 17s. per acre per annum (on the $3\frac{1}{2}$ per cent. tables). Either the Beech must be felled along with the Oak, or else, perhaps, a partial clearance will be indicated.

It will be noticed that, up to the time that the Oaks were to be removed, the Beech will have paid very well indeed, leaving an additional land rental of 3s. 7d. per acre per annum for the 70 years, since planted; and this equals an additional capital sum after paying $3\frac{1}{2}$ per cent. interest on the cost of planting, of nearly £52.

A perusal of the foregoing data with reference to underplanting will serve to show that a substantial profit can, often, be secured by introducing, as an undercrop, even such crops as Beech and Silver Fir, crops which, when planted by themselves, will seldom more than pay for the accumulated expenses of planting, unless, indeed, a very low rate of interest be looked for.

The reason why a better result is usually thus shown for an undercrop is that it is growing rent free, as it were, and free, also, of all rates and, practically, of all annual outgoings for so long as the overcrop remains; and, then again, the crop can be planted and established at a minimum cost, as the land is (or should be) perfectly clean.

In addition to the actual profits secured, the indirect benefits to be derived from underplanting, under suitable conditions, are very numerous and must not be forgotten.

COPPICE WITH STANDARDS.

The financial aspect of crops grown under this system may, also, be shown by calculating the annual rentals obtainable.

Thus, with reference to the crop of mixed standards of Oak, Larch, and Ash, grown over coppice, cut on a 20-year

258 FINANCIAL ASPECT OF AFFORESTATION

rotation, where the soil and situation are Quality I. (for details see Chapter XI.) the rental may be arrived at in the following manner :—

Receipts at the end of each rotation :—

200 cub. ft. of Oak*	.	.	.	.	.	£16 14 0
473 cub. ft. of Larch*	.	.	.	.	.	23 4 0
255 cub. ft. of Ash*	.	.	.	.	.	18 4 0
= (say)						£58 0 0
Underwood (mixed underwood) cut for sale	.				5 0 0	
						<u>£63 0 0</u>

* The cost of felling the timber is balanced by the sale of the cordwood, etc., below 6 inches quarter girth.

Expenditure :—

Annual outgoings,* 1s. per acre per annum on the 4 per cent. tables (this includes all expenses not otherwise accounted for)	.	£1 10 0
Expenses at the end of the rotation †	.	3 0 0
	Total	£4 10 0

* Over and above a sum of 2s. 3d. received for sporting. † *Vide Chapter X.*

Hence, the net credit sum, at the end of the rotation	.	.	.	.	.	£63 0 0
					Less	4 10 0
						Therefore, the net credit sum * = £58 10 0

* The capital left in the land is presumed to be the same at the end of each rotation.

Now, on the 4 per cent. tables, this equals a yearly payment of £1, 19s. 3d.

But, part of this represents interest on the capital left in the land, at the end of each rotation.

This capital left at the end of each rotation equals :—

In Standards (say)	.	.	.	.	.	£26 5 0
Add, for live stools and newly-planted trees (say)	.	.	.	.	.	3 15 0
Therefore, the total capital left at the end of each rotation	.	.	.	.	.	£30 0 0

and 4 per cent. on £30 equals £1, 4s.

Hence, the **rental for land only**,

$$\begin{aligned} &= \text{£1}, 19s. 3d. - \text{£1}, 4s. \\ &= 15s. 3d. \text{ per acre per annum} \end{aligned}$$

land rental on the 4 per cent. tables.

On the $3\frac{1}{2}$ per cent. tables, the rental yielded for the land, only, would be £1, 0s. 5d. per annum.

So, again, with reference to the crop of Larch and Ash standards grown over coppice, cut on a 25-year rotation (for details, see Chapter XI.), the rental may be arrived at as follows :—

Receipts every 25th year :—

426 cub. ft. of Larch	£21 6 0
264 cub. ft. of Ash	19 16 0
By sale of young standards	4 8 0
	<hr/>
	£45 10 0
Underwood (chiefly Ash) cut for sale	10 10 0
	<hr/>
	£56 0 0

Expenditure :—

Annual outgoings, 1s. per acre per annum for 25 years, equals (say) on 4 per cent. tables	£2 2 0
Expenses at end of rotation	3 8 0
	<hr/>
	£5 10 0

Hence, the net credit sum at the end of the rotation = £56 0 0

Less 5 10 0

Therefore, the net credit sum = £50 10 0

On the 4 per cent. tables this equals a yearly payment of £1, 4s. 3d. per acre.

But, the capital left in the land, at the end of each rotation, equals :—

Value of standards	£15 5 0
Live stools and newly-planted trees	3 15 0
Total	<u>£19 0 0</u>

Now, 4 per cent. on £19 equals 15s. 3d.

Hence, the **rental for the land only**,

$$\begin{aligned} &= \text{£}1, 4s. 3d. - 15s. 3d. \\ &= 9s. \text{ per acre per annum} \end{aligned}$$

land rental on the 4 per cent. tables.

On the $3\frac{1}{2}$ per cent. tables, the rental yielded, for the land only, would be 12s. 9d. per acre per annum.

These **rentals for the land only**, when **under coppice with standards**, may be more clearly seen from the following tabular statement :—

Coppice, with Standards of	Quality.	Rotation of Coppice.	Land Rentals.	
			At 4%.	At $3\frac{1}{2}\%$.
Oak (100 years)	I.	Years.	s. d.	£ s. d.
Larch and Ash (80 years)		20	15 3	1 0 5
Larch and Ash (75 years).	II.	25	9 0	0 12 9

Now, these results compare very favourably with the rentals for pure crops of Oak, or Larch, or Ash, when grown under even-aged high forest, viz. :—

Pure High Forest of	Quality.	Cost of Planting and Establishing.	Land Rentals.	
			At 4%.	At $3\frac{1}{2}\%$.
Larch (80 years), partially cleared	I.	£.	s. d.	s. d.
		8	14 8	19 0
Larch (70 years)	II.	8	10 0	13 4
Ash (70 years)	II.	8	9 3	12 11
Oak (120 years)	II.	8	Minus 3 0	Minus 0 3

Hence, it is evident that the cultivation of Oak, Larch, or Ash, as standards¹ over coppice is far more remunerative

¹ Owing to the prevalence of Larch Disease, it is almost imperative, unless great risks are to be incurred, to abandon the cultivation of pure Larch (European) in close-canopied high forest. Its success, as standards over coppice, is far more assured.

than is usually supposed; and, the conversion of existing areas of coppice with standards into ordinary close-canopied high forest should seldom be undertaken, unless, indeed, the land be really too poor for any growth but coniferous high forest; or, unless the cultivation of Douglas Fir, or some other tree yielding a better land rental than Larch or Ash, be desired.

However, the system of high forest with coppice can always be recommended in preference to that of coppice with standards.

COMPARISON OF ACTUAL LAND RENTALS WITH THE NET RETURNS FROM NORMALLY STOCKED AREAS.

It will be instructive to compare the actual land rentals, as already given for various crops, with the (approximate) net annual returns which would be received from the same crops from normally stocked areas, in which, of course, the average invested capital per acre is usually very great (*vide* page 237). It is assumed that the areas are large.

It is hoped that such a comparison of the results of the same crops, expressed by two different methods, will help to remove much of the ambiguity which at present so often envelopes the statements of the financial results of afforestation as usually placed before the public.

In all cases the returns include the value of any sporting rights, estimated at 1s. 3d. per acre in the case of high forest and 2s. 3d. per acre in the case of coppice with standards.

These returns must be looked upon as the **maximum** that can be obtained at the given prices from the given quality of soil under the respective systems and rotations. The crops have been placed in the table in their order of merit. Outgoings are reckoned at a minimum.

It will be noticed that these net returns from normally stocked areas afford no criterion of the pecuniary advantage of planting one crop in preference to another.

Kind of Crop.	Forest System.	Quality of Soil and Situation.	Length of Rotation. Years.	Price per cub. ft. of Timber over 6 inches quarter girth.	s. d.	Equivalent Land Rental (including value of sporting), receivable from the date of planting, after charging interest on cost (£S) of Planting, etc. All calculations made at 3½ per cent. compound interest. Per acre.	£ s. d.	Maximum net Returns (including value of sporting) from such areas of normally stocked forest as are actually under timber crops. Per acre.	£ s. d.	Returns (including value of sporting) from such areas of normally stocked forest as are actually under timber crops. Per acre.	Remarks.
							s. d.	£ s. d.			
Douglas Fir	.	High forest	I.	75	0 9	2 11 8	8 14 0	...	...	...	Oak, winter felled.
Oak, Larch, and Ash	{ standards}	Coppice with	I.	{ 100* 80†	Oak, 1 9 Larch, 1/; Ash, 1/6	{ 1 0 5‡	2 17 0	Partially cleared.	3 8 0	3 8 0	Partially cleared.
Larch	.	High forest	I.	80	1 0	0 19 0	3 8 0	3 8 0	3 8 0	3 8 0	3 8 0
Larch	.	High forest	II.	70	1 0	0 13 4	2 12 0	2 12 0	2 12 0	2 12 0	2 12 0
Larch	.	High forest	II.	38 {	2000 feet pit timber, £50	{ 0 13 3	1 11 0	1 11 0	1 11 0	1 11 0	1 11 0
Ash	.	High forest	II.	70	1 6	0 12 11	2 15 0	2 15 0	2 15 0	2 15 0	2 15 0
Larch and Ash	.	Coppice with standards	II.	75 {	Larch, 1 0 Ash, 1 6	{ 0 12 9‡	2 0 0	2 0 0	2 0 0	2 0 0	2 0 0
Larch	.	High forest	II.	100	1 0	0 7 9	2 7 0	2 7 0	2 7 0	2 7 0	2 7 0
Weymouth Pine	.	High forest	II.	80	0 7½	0 1 2	1 13 0	1 13 0	1 13 0	1 13 0	1 13 0
Oak	.	High forest	II.	120	1 9	0 0 3	2 13 0	2 13 0	2 13 0	2 13 0	2 13 0
Silver Fir	.	High forest	II.	90	0 6½	0 1 0	1 14 0	1 14 0	1 14 0	1 14 0	1 14 0
Norway Spruce	.	High forest	II.	75	0 6½	0 1 0	1 10 0	1 10 0	1 10 0	1 10 0	1 10 0
Scots Pine	.	High forest	II.	80	0 7	0 1 2	1 6 0	1 6 0	1 6 0	1 6 0	1 6 0
Beech	.	High forest	II.	120	1 0	0 2 4	2 5 0	2 5 0	2 5 0	2 5 0	2 5 0

* Oak.

† Larch and Ash.

‡ From the date when age classes are normal.

CONCLUSION.

A study of all that has been dealt with in this chapter leads to the conclusion, that, unless there be a substantial rise in the price of timber, there is little inducement to plant maiden land with Oak, Beech, the Pines, Norway Spruce, or Silver Fir. In fact, if the land were to be had **rent free**, the planting of such crops would, on the average, only pay 3 per cent. to $3\frac{1}{2}$ per cent. interest on the cost of planting and establishing the young crops.

On the other hand, it may be stated that the cultivation of Douglas Fir, Black Poplars, Ash, Larch, and Spanish Chestnut will often pay well; returning, not only $3\frac{1}{2}$ to 4 per cent. interest on the cost of planting, but, also, the equivalent of a handsome yearly rental for the land occupied by them.

Furthermore, it is practically always advisable and profitable to replant land from which a crop has just been removed, for, the land must be considered as practically valueless, except for the purpose of tree growth. And greater profits may be anticipated usually from such land, for, if it has been properly managed, the expenses of replanting should be much less than the expenses of planting a crop on maiden land.

Wherever natural regeneration, or the planting of seedlings can be adopted, it will generally be possible to pay, even in the case of Oak, Beech, the Pines, Norway Spruce, or Silver Fir, not only 3 per cent. or $3\frac{1}{2}$ per cent. interest on the cost of establishing the crop, but, also, the equivalent of a small yearly rental for the land as well.

And again, certain crops, when used for underplanting, may often pay, although, when grown by themselves, a direct loss will usually be experienced.

And lastly, standards of Oak, Larch, and Ash, grown over coppice, will generally yield as good results as pure crops of such trees when grown as close-canopied high forest. Especially is this the case with the two latter species.

CHAPTER XIII.

TIMBER MEASURING.

SQUARE OF QUARTER GIRTH MEASUREMENT.

THERE are various methods by which the contents of timber may be measured; but the method in general use for measuring timber in the round in this country is that known as the **square of quarter girth measurement** (or simply, as quarter girth measurement).

Stated briefly, the method is to take a quarter of the girth in inches at the centre of an evenly tapering tree; make an allowance for bark; and then square this (under bark) quarter girth; divide by 144 to bring to feet; and then multiply by the length of the tree in feet.

This method is sometimes known as the quarter girth measure with 144 divisor in order to distinguish it from a method often adopted by the railway companies, and known as the quarter girth measure with 113 divisor; which latter method gives the true contents of a tree; whereas, the contents as computed by the former method, are very much less than the true contents.

Now, when measuring large timber, as, for instance, when it is sold at so much per foot, it is not usually the custom to measure, as timber, anything that is less than 6 inches quarter girth under bark (or sometimes 5 inches according to

custom); for all under these dimensions is considered as cordwood.

However, when measuring small timber, pitwood, and the like, such an allowance would be absurd. And, if sold at per foot, the conditions of sale should stipulate that all measurements be taken down to 3 inches diameter over bark.

However, it will seldom be that such small poles are measured and sold at per foot; they will usually be sold by weight, or by the 100, etc.

1. Measurement of Felled Timber.

When timber has been felled and is being sold at so much a foot according to measurement, the very greatest care and accuracy is necessary in order to arrive at the correct contents.

Occasionally a third party, as for instance an auctioneer, is agreed upon by the vendor and purchaser to measure the timber, and it is agreed that the purchase money shall be based upon his measurements; but, usually, the vendor's agent and the purchaser meet and measure up the timber together, and a certain amount of bargaining as to measurements is in some cases adopted. For, sometimes, it will be impossible to take the girth at the correct place; then again, small girthed pieces and tops are often guessed at, in order to save time, and so on.

The actual *modus operandi* of measuring a felled tree will depend upon the shape of the tree or log.

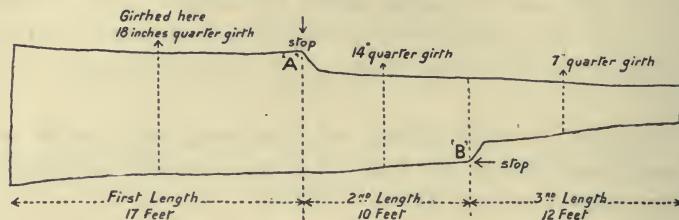
If the log tapers evenly from the butt to where it is cut off at the top, it is measured in one length, and the girth is taken at the centre of the log.

If, however, the log does not taper evenly—that is, if there be many “stops”—each length from stop to stop must be measured and booked separately, unless, indeed, both parties agree to measure any length beyond a stop.

A stop is a projection or a point where the girth measurement suddenly alters; as, for instance, just

below where a big branch has grown out from the main stem.

The following illustration will explain this:—



Thus, in the above case the log is 39 feet long, but there are two stops at "A" and "B."

Therefore, the first length of 17 feet is taken up to the beginning of the first stop, and at half-way along this length the girth is taken and the quarter girth under bark ascertained, viz., 18 inches.

Then a second length of 10 feet to the next stop is taken, and the quarter girth under bark at half-way along is found to be 14 inches. And then the third length of 12 feet is taken, and the quarter girth at half-way along is found to be 7 inches. All these measurements are separately booked, and the contents afterwards worked out in the office by reference to tables.¹

Occasionally, in order to save time, a measurement is made beyond a stop. But in such cases the greatest judgment is necessary; and, without a great deal of experience, it is never safe to go beyond a stop.

In the above example, if the log had been taken in one single length, the quarter girth measurement would have been (say) $14\frac{1}{2}$ inches, and the contents would have been computed at nearly 2 cubic feet more than the correct contents. But supposing that the first length of 17 feet had been taken separately; and that then, the buyer suggested, that the rest of the log should be taken in one length "so as to save time." The vendor would thereby lose considerably, for the girth would come just above the second stop and

¹ *Vide Appendix.*

would be (say) $8\frac{1}{2}$ inches. Thus the contents of the last 22 feet of length would be 11 cubic feet (if measured in one length) instead of $17\frac{1}{2}$ cubic feet if properly measured.

A loss of perhaps 10s. for 2 minutes' work!

So again, some logs have no distinct stop, but if the taper is not even and falls away very much after about $\frac{2}{3}$ the length of the bole, it will often be advisable, from the vendor's point of view, to suggest not measuring, in the length, the last few feet of the log, so as to get a greater quarter girth measurement (taken before the taper begins to fall away).

It should be remembered that there is no commercial immorality in suggesting the taking of the measurements in a certain way so as to work out to one's own advantage;¹ but that, according to the custom of the country, no length shall be measured beyond a stop at any single time unless both parties agree.

In measuring the length, a tape is the most accurate method, though it is rather liable to get entangled and injured, and it takes rather much time. A quicker method is to have an 8-foot rod with the feet marked on it. The length can then be taken by this, and a scribe mark, indicating each rod's length, should be made on the log.

Great accuracy is, however, necessary in measuring the length with a rod; as mistakes are very easily made.²

No attempt at undue haste in using the rod should ever be countenanced.

The lengths are generally measured to the nearest foot or half-a-foot; odd inches being disregarded. Directly the lengths are measured they must be carefully booked.

In measuring the Quarter Girth, a string is nearly always used except by Railway Companies (in many cases), or if there is a special agreement to measure with a tape.

¹ It will be admitted that in the majority of cases, buyers and merchants whose experience in timber measuring is usually far greater than that of any land agent or forester, are more likely to get the better of any bargaining as to measurements than the latter.

² It is very easy to skip a few inches at the end of each rod's length; so that, unless the rod is used carefully and *slowly*, it is far better to use a tape.

A curved "needle," somewhat like a sickle with a hooked end, is passed under the log at the place where the girth is required; the string is then caught on the hook and pulled under the log; and the girth is then found by pulling the string tight to a knot, which should have been previously tied in the string at one end. Then the knotted end is let go of, and the man, taking the girth, pulls the string away from the log without releasing his fingers from the place on the string where the free end met the knot on the other end. The string is then folded into four equal lengths, and then stretched along an ordinary 2-foot rule; and the quarter girth thus read off. Then an allowance for bark is made; and the quarter girth measurement, under bark, is booked next to the length of which it is the quarter girth. The quarter girths are usually measured to the nearest $\frac{1}{2}$ inch.

Occasionally a discussion will arise as to whether a **thick or thin string** should be used in girthing. When a thick string is used there will be a loss of measurement at each bend in the string as it is folded into four.

In practice a piece of whip cord is used; for very thin string would constantly be breaking.

As a matter of fact, there is very little difference between the use of thick and thin string when girthing rough barked trees, as the thin string fits more closely into the crevices in the bark. But when smooth barked trees, such as Beech, are being measured, the use of thick string involves a distinct loss to the vendor.

Fraudulent girthing.—There are two common means whereby a land agent or forester may be deceived, if the girthing is being done by an unscrupulous purchaser or his agent.

1. The string may be unduly stretched in girthing, and the free end of the string not brought right over to the knot.
2. Not including a length of string equal to the full girth when the string is being folded into four.

As regards the first device, it is, of course, perfectly correct to pull the string tight; but there is a great deal of

difference between so doing and absolutely stretching the string to its utmost. A yard of string, especially if wet, will easily stretch 2 inches when a tree is being girthed; but, when folded into four, and the quarter girth is being read off, it cannot be stretched at all and the vendor has thereby lost $\frac{1}{2}$ inch of quarter girth; which is a very substantial loss indeed—the more so, the greater the girth of the tree.

For instance, a butt 25 feet long has a correct quarter girth under bark of $28\frac{1}{2}$ inches, but if the string is unduly stretched the quarter girth as read is 27 inches.

By the correct method the contents are 141 cubic feet; but by the fraudulent method the contents are only $126\frac{1}{2}$ cubic feet; a loss, at 1s. a foot, of 14s. 6d. on a single large butt.

A plea is sometimes put forward to the effect that the custom of the country sanctions the method of stretching the string. Such, however, cannot be the case. For no custom, which is bad on the face of it, will ever be upheld in a court of law. As well might the girth be taken with elastic as for such a proposition to be sanctioned.

No man can set up a prescriptive right to be dishonest.

As regards the second device, that of not including the full girth in the folded string:—Detection here is not so easy. The fraudulent measurer will either shift the position of his finger and thumb, as he holds the free end of the string, nearer to the knot on the other end (which is rather difficult to do); or, he will have two (or more knots) and girth the tree to the knot farthest away, but fold the string into four to a nearer knot.

Hence, in view of possible fraud, the vendor's agent should always girth the trees, even if the purchaser insists on doing it also. But as stated elsewhere,¹ it is always advisable to avoid selling timber at a price per foot, the purchase money to be afterwards ascertained by measurement.

Allowance for Bark.—This is to a great extent governed by the custom of the country.

¹ *Vide Chapter XIV.*

In many parts of the country an allowance of 1 inch for every foot quarter girth is made for bark; and $\frac{1}{2}$ inch for every 6 inches quarter girth. Thus, if a tree girths 12 inches or up to $17\frac{1}{2}$ inches, an allowance of 1 inch is made. If it girths 18 or up to $23\frac{1}{2}$, $1\frac{1}{2}$ inches are deducted; and from 24 up to $29\frac{1}{2}$, 2 inches; and so on. An allowance of 1 inch to 1 foot quarter girth is equal to a deduction of $\frac{1}{6}$ of the contents as computed if measured over bark.

This allowance is about correct for thick barked trees such as Oak, Elm, Ash. But, for thin-barked trees, such as Beech or Sycamore, it is really far too much. However, if no agreement has been made upon the subject, the custom of the country must be observed.

It may be noted that in some parts of the country, as in Buckinghamshire, no allowance whatever is made for Beech bark.

In order to judge what a reasonable allowance for bark would be, it should be remembered that the correct mathematical allowance is .39 of an inch from the quarter girth for every $\frac{1}{4}$ of an inch that the bark is in thickness.

Booking Measurements of Felled Timber.—All measurements are, of course, booked, immediately they have been ascertained, into a note-book. Separate pages should be set apart for each species of tree; and often the various species are divided into two or more classes, according to quality; but this will usually depend upon the conditions of sale.

The number of each tree of each species, or of each class of the same species, is separately entered.

In the majority of cases when measuring felled timber, a different price has been agreed for the same kind of timber, according to its girth; or according to the contents of any particular log. Separate columns should always be left for filling in the various totals which are to be priced differently.

Often, small girthed tops are not measured; but the contents are guessed and booked at once.

The following shows a specimen page, supposing that all timber 12 inches quarter girth and upwards be sold at one

price, and that all timber under 12 inches quarter girth be at another price. (Often half-price).

Note.—(The totals filled in at the office).

OAK.

Page 1.

No. of Tree.	Length.	Quarter Girth.	Total 12 in. and over.	Total under 12 in., and tops.
1	30	17	60	...
	12	15	19	...
	10	10	...	7
	27	7	Tops	9
2	22	18	49½	...
	18	10	...	12½
	20	6	Tops	5

When the vendor's agent and the purchaser are measuring timber together, both parties book the measurements; and, at the end of a day's measuring, the measurements in one book should be read out and checked with the other book, and any discrepancy made good there and then, and each party should sign each other's book.

If the purchaser has felled the timber, all tops and branch wood under 6 inches quarter girth will, in the ordinary course of affairs, belong to him, unless otherwise agreed; and they will not be measured.¹ For in the case of large timber they will about equal the cost of felling; though the allowance would be absurd in the case of long poles. But, if the vendor has felled the timber, such tops and branch wood will belong to the vendor, and are usually sold separately as stacked cordwood. However, the vendor's agent should always endeavour to sell to the merchant any tops, even if they are under 6 inches quarter girth, for any price over about 2d. a cubic foot will usually be more profitable than selling cordwood at 8s. or 10s. a cord. In most cases, however, the merchant has no use whatever for small branch wood.

¹ *Vide Chapter XIV.*

2. Measurement of Standing Timber.

The same general rules hold good as have been described for the measurement of felled timber. But timber is never measured with a purchaser while still standing ; it is merely measured so that the vendor or an intending purchaser may ascertain its value before a sale takes place, etc. Thus, with a little experience, the orthodox method of measuring and booking is often departed from ; but so long as a correct valuation is arrived at, this does not matter.

The **girth**, however, is taken at 4 or 5 feet from the ground ; then an allowance is made for the "taper" of the tree, so as to give the girth at half-way up the first length that is being taken ; and then an allowance is made for bark as already described.

Now, the girth of standing timber is nearly always taken with a leather "timber strap," which is marked so as to directly read the quarter girth measurement (over bark).

This strap should have a fixed iron hook on one end, so that a man can girth a large tree single-handed by throwing the strap round when the hook will catch on the bark. It is very necessary that the strap be well seasoned and stretched before it is marked ; otherwise, with use, it will stretch a great deal and be very inaccurate ; the unmarked strap should be wetted and hung up for several months with a heavy weight attached to the end of it.

The **height or length** of the tree, or any portion of it, is usually guessed at—the scientific height measurers never being used for practical purposes. Sometimes timber poles (marked with paint every 2 or 3 feet) are used, or a long stick can be cut (say 12 or 14 feet long) and the feet notched on, and this, if held up at arm's length by a man, will afford the measurer a good guide as to the height of a tree. This latter method is in common use even with those who have had much experience in measuring standing timber ; but the orthodox timber poles (perhaps 4 or 5 six-feet poles fitting into each other) are only used by those whose experience is very limited. Lengths, not reached by the pole, must be

guessed at, and, so also, must the quarter girths of all lengths except the first. In satisfying oneself as to the correctness of any quarter girth measurement, a good check can often be obtained in cases where long tall trees taper evenly, by adding to the estimated quarter girth measurement at the ground level the estimated quarter girth at the top of the tree at the place where it is (say) 6 inches (quarter girth), and then dividing by 2 in order to arrive at the mean quarter girth. However, in the case of trees with a high form factor, this would give far too small a girth. And in a somewhat similar manner, checks can often be made by working downwards from spots on the tree where the measurer feels very certain that he knows the quarter girth ; for as a rule the eye becomes trained to read certain quarter girths, *e.g.* 12 inches or 15 or 21, etc., more correctly than others.

The booking of measurements may be done in a similar manner to that already described for felled timber. But in order to save time, experienced measurers usually book the contents straight away ; either by reference to a "timber card" or, if in practice, without such aid, though, to refresh one's memory, the multiplying factors for the various quarter girths should be written on the cover of the note-book.

Usually, the tops and small "stuff" are booked separately ; but sometimes all may be conveniently booked together. For instance, if "tops and under 12-inch quarter girth" are to be valued at half-price, it is quite as easy merely to book one-half of the contents of such small timber, and to price it out at the full price, as to separately book the true contents at half-price.

So also, when a defective tree is being measured and valued, a deduction must be made.

But, instead of booking the correct measurements and putting an estimated price against them, it will be preferable, in many cases, to consider the whole as "tops" (if separately booked), or to book reduced contents at full price.

It is, however, impossible to more than indicate a few of the variations that may be made, for, with experience, every measurer will adopt his own particular methods in measuring and valuing standing timber.

Care, however, should be taken not to measure "tops" and big limbs "too hard," for there is always a risk that large limbs will splinter if the tree fall on them; and, if separately cut off, an allowance must be made to cover the extra cost. In all cases, it is best to price out as for felled timber, and to "leave" enough in the tops as cordwood or otherwise, to pay for the cost of felling. And, finally, it is of the greatest importance that a measurer should get in the habit of **always standing the same distance off a tree** when estimating its contents; otherwise the eye will never get properly trained.

The following indicate some methods of booking:—

ASH { 12 inches and over, at 2s. 3d. per cubic foot.
Under 12 inches, at 1s. 3d. per cubic foot. Page 1.

No. of Tree.	12 in. and over.	Under 12 in. q. g.	Remarks.
1	70	18	
2	68	16	
3	...	52	Tree shaky, all booked as tops
4	47	12	
5	30	18	10 ft. of butt omitted as not sound

OAK.

Page 1.

*N.B.—Only half contents under 12 in. q. g. booked ;
but all to be priced out at 1s. 1od.*

No.	Feet.	No.	Cubic feet.
1	50	10	30
2	47	11	27
3	51	12	51
4	56	13	30
5	40	14	47
6	38	15	49
7	30	16	30
8	31	17	25
9	31	18	21

STANDING TIMBER

275

Page I.
OAK.

N.B.—Only half contents under 12 in. q. g. booked ; but all to be priced out at 2s.						Totals. Cubic feet.	Remarks.
30	29	18	23				
31	43	23	31				
38	41	22	39				
41	50	22					
49	30	22					
30	38	24					
27	17	29					
27	19	19					
29	30	17					
27	14	24					

Note.—There are 100 trees booked on each page.

OTHER METHODS OF COMPUTING CONTENTS.

As regards other methods of measuring timber for various purposes, there are **besides the quarter girth method** just described, the following :—

- (1) True Contents Method.
- (2) Calliper Method.
- (3) Die Square Method.
- (4) Board Measure Method.

True Contents.—This is the method almost universally adopted on the Continent when measuring “round” timber. It gives the true mathematical contents. It should be noted that on the Continent the contents of standing crops are nearly always calculated over bark.

To arrive at the contents, the length in feet is multiplied by the superficial area of the mean section in feet.

This mean sectional area is found, when timber is felled, by finding the mean diameter, and then :—

$$\text{or} \quad \begin{aligned} & (1) \text{ by reference to tables;} \\ & (2) \text{ by the formula : area} = r^2\pi \\ & \quad \text{when } r = \text{radius} \\ & \quad \text{and } \pi = 3.14159, \end{aligned}$$

which gives the same result as

$$\frac{d^2 \times \pi}{4}, \text{ when } d = \text{diameter.}$$

The diameter is taken in inches, and must be reduced to feet before being multiplied by the length in feet.

In order to take the diameter, the use of callipers is resorted to; or sometimes a tree compass. In as much as the section of the majority of trees is not circular, but somewhat elliptical, it is advisable to take two diameters at right angles to each other, and then to take the average of the two and calculate as for a circle. By this latter method the error in the true sectional area will only average about 1 or $1\frac{1}{2}$ per cent., whereas if one diameter only be taken, the error may amount to as much as 4 per cent.

By the formula $\frac{d^2 \times \pi}{4}$ the contents of a log are found thus :

$$\frac{(\text{Mean diameter in inches})^2 \times \text{length in feet}}{183}$$

$$\text{For } \frac{\pi}{4} \times 144 \text{ (to reduce to feet)} = 183.$$

Then, again, practically the same result is obtained by the following :—

$$\frac{(\text{Mean quarter girth in inches})^2 \times \text{length in feet}}{113}$$

This is known as the quarter girth measure with 113 divisor, and is often adopted (under bark) by the railway companies.

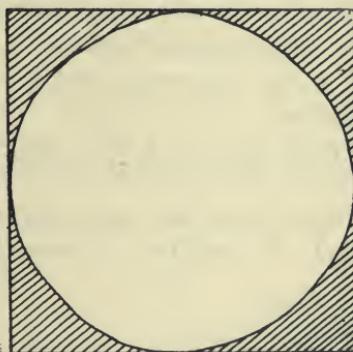
In order to find the mean sectional area of standing timber by the formula $\frac{d^2 \times \pi}{4}$, the sectional area is taken at breast high, and then the mean sectional area is found by multiplying by the form factor,¹ and hence the true contents may be found.

Calliper Measurement.—This is a method used in the royal dockyards and elsewhere for “round” timber. It shows rather the stowage requirements, than the contents. For the contents, as computed by this method, give a result far greater than the true mathematical contents; as it supposes, as it were, that the round timber is square, and that the side of the square is equal to the diameter of the round timber.

To find the contents, the mean diameter is taken with the callipers and the contents are equal to :—

$$\frac{(\text{Mean diameter in inches})^2 \times \text{length in feet}}{144}$$

The following figure illustrates the method :—



Thus the shaded portion is included in the measurements though it does not exist.

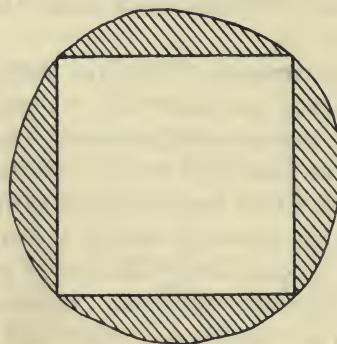
¹ *Vide* Chapter XVII.

Die Square Measurement.—By this method, the contents are computed by multiplying the length of the log by the area of the greatest square that can be obtained out of the section of the log, either at its smallest end or out of its mean section. The contents of the rounded sides are left out of account.

The contents may be found by the following formula :—

$$\frac{(\text{Quarter girth in inches})^2 \times \text{length in feet}}{181}$$

The following figure illustrates the method :—



The shaded portion is not included in the measurement, although it exists.

Board Measure.—This is the method in common use in America. The contents are computed according to the estimated number of superficial feet of 1-inch boards that can be cut from a log, allowance being made for bark, waste from sawdust, etc.

For logs not more than 40 feet in length, the following rule¹ holds good :—

Deduct $1\frac{1}{2}$ inches from the mean diameter in inches at the small end of the log; square the result and multiply by $\frac{\pi}{4}$ ($= .7854$).

This gives the sectional area at the small end.

Then deduct $\frac{3}{11}$ ths and divide by 12 to bring to board measure and multiply by the length of the log in feet.

¹ British Columbia log scale.

The following examples will show the percentage comparison between the foregoing methods.

A log is $28\frac{1}{4}$ ¹ feet long by 20 inches quarter girth (at half its length) over bark. Taper equals 1 inch quarter girth in 7 feet length. Then the

True contents (over bark):—

$$\text{by the 113 divisor} = \frac{20 \times 20 \times 28\frac{1}{4}}{113} \\ = 100 \text{ cub. ft.}$$

or, by the formula $\frac{d^2 \times \pi}{4}$

$$= \frac{80^*}{\pi} \times \frac{80}{\pi} \times \frac{\pi}{4} \times \frac{28\frac{1}{4}}{144} \\ = \frac{1600}{\pi} \times \frac{28\frac{1}{4}}{144} \\ = \frac{45200}{3.14159 \times 144} = \frac{45200}{452.38896} \\ = 100 \text{ cub. ft. (nearly).}$$

* For $d = \frac{\text{circumference}}{\pi} = \frac{80}{\pi}$.

True contents (under bark):—

$$= 100 - \frac{1}{6} \\ = 83\frac{1}{3} \text{ cub. ft.}$$

This shows a deduction of $16\frac{2}{3}$ per cent. as compared with the true contents over bark.

However, usually in practice $1\frac{1}{2}$ inches would be deducted for bark on this particular log, and thus the contents would be:—

$$\frac{18\frac{1}{2} \times 18\frac{1}{2}}{113} \times 28\frac{1}{4} = 85\frac{1}{2} \text{ cub. ft.}$$

By Quarter Girth Measurement (over bark):—

$$\begin{aligned} \text{Contents} &= \frac{20 \times 20}{144} \times 28\frac{1}{4} \\ &= \frac{5650}{72} \\ &= 78\frac{1}{2} \text{ cub. ft. (over bark).} \end{aligned}$$

This shows a deduction of $21\frac{1}{2}$ per cent. as compared with the true contents.

¹ This particular length is taken in order to bring the contents to 100.

By Quarter Girth Measurement (under bark) :—

If an allowance for bark of 1 inch to 1 foot is made, the contents over bark must be reduced by $\frac{1}{6}$ th.

Hence, the contents under bark equals $65\frac{5}{12}$ th cubic feet, i.e., nearly $65\frac{1}{2}$ cubic feet (under bark).

This shows a deduction of $34\frac{1}{2}^1$ per cent. as compared with the true contents (over bark).

By Die Square Measurement out of section at the smallest end :—

$$\begin{aligned}\text{Contents} &= \frac{16\frac{1}{2} \times 16\frac{1}{2}^*}{181} \times 28\frac{1}{4} \\ &= 42\frac{1}{2} \text{ cub. ft.}\end{aligned}$$

* As the taper is 1 in 7, the quarter girth under bark at small end equals $16\frac{1}{2}$.

This shows a deduction of $57\frac{1}{2}$ per cent. as compared with the true contents (over bark).

By Die Square Measurement out of the average section :—

$$\begin{aligned}\text{Contents} &= \frac{18\frac{1}{2} \times 18\frac{1}{2}^*}{181} \times 28\frac{1}{4} \\ &= 53\frac{1}{2}^{\dagger} \text{ cub. ft.}\end{aligned}$$

* $1\frac{1}{2}$ inches deducted for bark, as in practice.

† This is mathematically rather too much, as $1\frac{1}{2}$ inches only had been deducted, instead of $1\frac{1}{3}$, which should be adopted in order to show the correct percentage.

¹ For quickly comparing the true contents over bark as found in continental tables, the deduction may be taken as 35 per cent.; and then the true contents, if divided by 10 and multiplied by $6\frac{1}{2}$, will give the quarter girth contents under bark. This, however, will usually be too great, as continental tables usually include all branchwood, or else down to 3 inches diameter. If it be required to compare the former with quarter girth contents down to 3 inches diameter, no definite rule can be given; so also no definite rule can be given if it be required to compare the true contents of timber down to 3 inches diameter with the quarter girth contents down to 6 inches diameter, for so much will depend upon the size of the trees.

In the latter case, if the trees be large, say 40 cubic feet quarter girth each, another 10 per cent. deduction might suffice, making 45 per cent. in all; so that the true contents down to 3 inches diameter should be divided by 10 and multiplied by $5\frac{1}{2}$ to bring to the quarter girth contents, down to 6 inches quarter girth, under bark. But if the trees are smaller the total deduction would be 55 per cent. or more.

This shows a deduction of $46\frac{1}{2}$ per cent. as compared with the true contents (over bark).

But if $1\frac{2}{3}$ inches, the correct bark allowance of 1 inch to 1 foot is allowed :—

$$\begin{aligned}\text{Contents} &= \frac{18\frac{1}{3} \times 18\frac{1}{3}}{181} \times 28\frac{1}{4} \\ &= 52\frac{1}{2} \text{ cub. ft.}\end{aligned}$$

This shows a correct deduction of $47\frac{1}{2}$ per cent. as compared with the true contents (over bark).

By Calliper Measurement :—

$$\text{By formula } \frac{d^2 \text{ (in inches)}}{144} \times \text{length in feet.}$$

$$\begin{aligned}\text{Contents} &= \frac{\frac{80}{\pi} \times \frac{80}{\pi}}{144} \times 28\frac{1}{4} \\ &= \frac{11300}{\pi \times \pi \times 9} \\ &= \frac{11300}{88.826} \\ &= 127\frac{1}{5} \text{ cub. ft.}\end{aligned}$$

or (say) 127 cub. ft.

This shows an excess of 27 per cent. over the true contents.

By Board Measurement :—

Mean diameter at smallest end equals 23 inches (not quite). $\therefore 23 - 1\frac{1}{2} = 21\frac{1}{2}$ inches.

$$\begin{aligned}\text{Sectional area} &= 21\frac{1}{2} \times 21\frac{1}{2} \times \frac{\pi}{4} \\ &= 363.0511\end{aligned}$$

$$\begin{aligned}\text{Deduct } \frac{3}{11} \text{ ths } (=99.0138) \quad &363.0511 - 99.0138 \\ &= 264.0373 \\ \div \text{ by } 12 &= 22.033 = (\text{say}) 22.\end{aligned}$$

Multiply by length, $28\frac{1}{4} \times 22 = 621.5$

\therefore Contents = $621\frac{1}{2}$ feet (super) board measure.

This is (say) $6\frac{1}{5}$ th times more than the true cubic contents.

Thus, in the previous example, where the bark allowance was 1 inch to 1 foot, and the taper was 1 inch quarter girth

to every 7 feet length, the following percentages hold good when compared to the true contents (over bark) :—

		+ or - per cent.
Cub. ft. True contents , over bark	100	0
" " " under bark	83½	- 16½
" Quarter girth , over bark	78½	- 21½
" " " under bark	65½	- 34½
" Die square , from section at small end	42½	- 57½
" " from average section	52½	- 47½
" Calliper measure	127½	+ 27½
Super. ft. Board measure	62½	{ Say 6½ times greater.

In the same way the following percentages hold good when compared to the contents by quarter girth measurement (under bark) :—

		+ or - per cent.
Cub. ft. Quarter girth , under bark	100	0
" " " over bark	119½	+ 19½
" True contents , over bark	152½	+ 52½
" Die square , from section at small end	64½	- 35½
" " from average section	80	- 20
" Calliper measure	194½	+ 94½
Super. ft. Board measure	948½	{ Say 9½ times greater.

Stack Measure.—This, as its name implies, shows the contents of stacked wood. It is used for cordwood, etc. It gives far more than the actual true contents of timber as the interstices are measured in.

In different parts of the country, cords of wood are made up to various sizes; common sizes being:—

$$8 \times 4 \times 4 \text{ feet} = 128 \text{ cub. ft., stacked measure}$$

$$8 \times 3 \times 4 \text{ " } = 96 \text{ " } "$$

$$12 \times 4 \times 4 \text{ " } = 192 \text{ " } "$$

$$16 \text{ ft. } 4 \text{ in. } \times 2 \text{ ft. } 6 \text{ in. } \times 2 \text{ ft. } 2 \text{ in. } = 88\frac{1}{2} \text{ cub. ft., stacked measure.}$$

If it be desired to know the timber contents of a cord, it may be reckoned that a cord $8 \times 4 \times 4$, containing 128 cubic feet stacked measure, will yield:—

For Poles
and
Split Cordwood.

100 cubic feet down to

or 65 cubic feet ,

For very small
Branches.

60 cubic feet	{	True Contents (over bark).
39 cubic feet		Quarter Girth Measure (under bark).

A standard is a measure for converted timber.

A St Petersburg standard contains 165 cubic feet (true contents.)

CHAPTER XIV.

THE MARKETING, SALE, AND TRANSPORT OF WOODLAND PRODUCE

COPPICE AREAS.

WHEN disposing of coppice, the first steps to take are to mark out the area into portions likely to suit the buyers. These portions are variously known as "lands," "drifts," or "hags." They should all be of a given width, as, for instance, 1 chain wide, and should run parallel right through the compartment from ride to ride. Thus the area of any given length is easy to reckon; for 10 square chains are equal to 1 acre. Along each ride the boundary of each "hag" should be marked by a numbered stake so as thus to avoid confusion amongst the purchasers.

It is very advisable that the coppice be cut by the home staff of woodmen, so that they may be cut close to the ground and with a sloping surface free from jagged edges. When cutting the coppice, the woodmen should throw the coppice, growing along the edge of a "hag," inwards, towards the hag to which it belongs, so as to avoid disputes between the buyers.

Any large area of coppice should be cut early in the season, in order to ensure an early removal of the produce.

However, before the coppice is cut, the approaching sale should be advertised, so that intending purchasers may inspect it and form their estimates of its value.

It is very important that the woodward or forester should render every assistance in showing the lots and in giving all

information possible as to the roads that may be used for removal, date of removal, etc., etc. Where the coppice is growing under standards, all the tellers and saplings, which it is desired to leave, should be marked with a ring of white paint, rather near the ground, so that, when cutting the underwood, no mistake may be made. It is advisable to leave a maximum number, and then, after the underwood is cut, any superfluous ones can be cut out. Generally speaking, there will always be some standards and young trees of all the age classes to be cut out. Sometimes these are sold along with the coppice and felled by the purchasers. But, this is a plan that cannot be recommended. It is far preferable for the home staff to fell them and to sell them separately, as the greatest care is necessary not to injure the standards which are left growing; and also, as a rule, buyers of coppice do not require big timber. When the standards are thus felled by the home staff, a reasonable time should be given to the underwood buyer for clearing his "stuff" up; but, the conditions of sale should contain a clause stating that the standards will be felled on and after (say) 15th March, or later, of course, if there be Oak trees which it is intended to bark; but that no compensation will be paid for any damage or inconvenience occasioned to the underwood buyer by reason of his not having cleared his area.

Standards, thus felled, should also be "knotted," "corded," and "faggoted" by the home staff; and "tushed" out into the rides ready for loading up.

Any poles, which may have been cut, may be placed in heaps in the rides and sold by the "heap" or the "load," etc.

All standards and poles should be pulled out into the rides as soon as trimmed up, as much damage would be done if this were deferred until the stools had flushed their new shoots.

As regards the actual selling of coppice, it is far preferable in nearly all cases, to sell it **by auction**, unless, indeed, it is only a small area when the expenses of advertising and printing would render it inadvisable. Underwood buyers are not so liable to form a "ring" amongst themselves as the

dealers in big timber who fully appreciate these advantages of co-operation, although, at an auction sale, such is illegal. And, it is reasonable, therefore, to anticipate more spirited bidding and better prices through a sale by auction than by any other method, provided always that there be a good local demand for the coppice.

Where there are large areas of coppice in any neighbourhood, it is very advisable to provide a lunch or dinner (by ticket only) for all likely purchasers; and this should be advertised in the sale catalogue. Especially can this be recommended, if other owners of underwood do not offer it. The sale should take place after the dinner. Occasionally, however, the dinner is given after the sale, and is offered, only, to those who have bought one or more lots at the sale.

If coppice be a drug on the market, and buyers be very scarce, it will often be possible to effect a sale by deferring the final payment until after the purchaser has realised; but it will be necessary for the owner to take this risk, and not the auctioneer.

The usual practice is for a deposit of 20 to 25 per cent. to be paid at the sale; the balance to be paid in from 3 to 6 months' time; and a bond or surety, approved by the auctioneer, to be given meanwhile.

A considerable discount of 5 per cent. to $7\frac{1}{2}$ per cent. should, however, be offered for a cash payment of this balance.

As regards the **conditions of sale**, they should be short and concise. They should stipulate, *inter alia*, that:—

- (1) No person advance less than 10s. at a time on any bidding.
- (2) How payment is to be effected.
- (3) A fine of £5 for every tree, teller, or store wrongfully cut.
- (4) No horse suffered to go at large upon any land under a fine of £1 for each offence.
- (5) No dogs¹ to be brought on the land, under a penalty.

¹ Occasionally it is inserted that all dogs brought on will be shot. This is wrong and illegal; a more rational stipulation would provide for the recovery of a heavy fine from the owner of the dog.

- (6) No person shall cut withies except on payment to, and as directed by, the forester.
- (7) All coppice to be made up by 1st April (in many cases a month or two later), otherwise a fine of $2\frac{1}{2}$ per cent. on the purchase money. And if not made up and carried away¹ by 15th April, a further fine of $2\frac{1}{2}$ per cent., making 5 per cent., and so on for every fortnight's delay.
- (8) Only duly authorised roads and drives shall be used for the removal of the produce.
- (9) No responsibility is taken as to the accuracy of the sale catalogue.
- (10) If the purchaser fail to comply with the above terms, he shall forfeit his deposit money; and his lots shall be resold; and he shall be liable to make good any deficiency in respect of the original purchase price, occasioned by the resale, together with the expenses attached thereto.
- (11) Any purchaser found poaching on the land, or possessed of nets and other poaching tackle, shall forfeit his deposit money, and also his lots and the value of any labour he may have bestowed upon them, besides being liable to ordinary legal proceedings.

The following are some of the chief uses to which underwood is put:—

Spanish Chestnut—

- 12 to 16 years old :—Hop poles, split gate hurdles.
- 17 to 20 years old :—Straining posts for hop yards.
- 12 to 18 years old :—The patent split pale and wire fencing.
- 6 to 9 years old :—Best grade barrel hoops.

Ash—

- 12 to 16 years old :—Hop poles, crate wood, split gate hurdles, chair legs, tool handles.

¹ It is convenient to be allowed to stack the produce in the rides up till the 1st of June, so as to await the demand for bean and pea sticks, etc.

Oak—

14 to 18 years old :—Hop poles, rustic fence work, gate hurdles, and (formerly) for its bark.

Hazel—

6 to 8 years old :—Inferior hoops (*e.g.* for cement barrels), Wattle hurdles, Thatchers, “spicks,” and “ledgers.”

Willow—

6 to 8 years old :—For wattle hurdles.

16 to 25 years old :—For gunpowder (must be barked).

Alder—

16 to 25 years old :—For gunpowder (must be barked).

Also broom heads, cigar boxes, clogs, toys, etc.

These are only a few of the special uses. Larger poles can be put to many uses. For instance, 20 to 25 years old poles are saleable near collieries for pit props, Beech poles at the chair factories, Sycamore for turning fancy articles, and so on.

Other general uses, not already mentioned, include clothes props, fencing stakes and bands, walking sticks, bean sticks, and pea sticks. However, the sale of faggots and firewood will often account for the disposal of a large proportion, and this is the final method by which any underwood, not otherwise saleable, is disposed of.

As regards the **General Arrangement of Felling Areas** and the amount to be cut each year :—

There is not the same necessity, so far as damage by wind and insects is concerned, to avoid cutting too large an area at any single time, or consecutive areas year after year, as exists in the case of coniferous high forest. It is, however, advisable to arrange that the cutting areas for each year are intermittent; but, usually, the whole area, to be cut in any one year, should, if convenient, be in one block, as this facilitates supervision and entails least expense in repairs to roads, gates, etc., and, as a matter of principle the fellings should proceed in a direction opposite to that of the prevailing winds.

As far as possible, an equal area, under the same rotation, should be cut annually. Thus, if the rotation is 20 years, the whole area may be divided by 20, and that will give the area to be cut annually.

And, instead of cutting each year's fall in one long sequence, it is preferable to divide the area up into about 4 blocks and enter each block every 4th year; and thus each annual fall will vary from its neighbour by four years.

HIGH FOREST AREAS.

(i) The Marketing of Thinnings.

High Forest.—The marketing of thinnings is, when remote from a good centre, usually somewhat difficult. Any trees to be cut out should be marked by the forester¹ either with a handbill or a scribe; this marking should never be left to the discretion of the ordinary woodmen. The trees should be cut as near the ground as possible, and then trimmed up, and the small "stuff" tied up into faggots. If there be big branches, there will also be some cordwood to make up.

After the poles have been trimmed up, the best plan is to pull them out into the rides, and, unless they be very large, to sort them into heaps of 20 or 25 each, and then sell them, either by auction or privately, at so much a heap. An auction sale would only be admissible if there were large quantities.

The larger trees, cut towards the end of a rotation, may, usually, be conveniently sold in little lots of 4 or 5 to each; the trees of each lot being left in the rides close to each other.

The trees should be pulled out by the home staff, so as to insure the least possible damage being done to the trees left standing.

¹ This marking of thinnings may advisably be done in the summer when the leaf is on and when the forester has most spare time on his hands.

However, generally speaking, it is not easy to sell thinnings, and in most cases they must be used for estate purposes —fencing, etc. ; though near collieries they will sell for pitwood, and near large towns a considerable quantity, especially of Larch poles, can be disposed of for rustic garden work, fences, pergolas, etc. But the whole question of the profitable disposal of thinnings will depend upon the distance from the market.

(ii) The Marketing of Mature Timber.

Whenever arranging for the felling of mature timber, it is a matter of the greatest importance that all fellings proceed, from year to year, **in a direction opposite to that of the prevailing winds**; and thus the danger from windfall, in the crops left standing, is minimised.

And, also, the fellings on coniferous areas should always be **intermittent**; that is to say, neighbouring areas should not be felled consecutively ; and an interval of from 5 to 7 years should elapse after a felling, before an adjoining area is felled ; for this will minimise the danger to be apprehended from the Pine weevil and other insects.

Then again, where there is a large area under timber, an attempt should always be made to produce an equal yearly income from the woods ; and, therefore, to effect this purpose, an equally productive area should be felled annually.

The Sale of Timber.

There are three ways of effecting the sale of timber :—

- (1) By Auction (or Roup).
- (2) By Tender.
- (3) By Private Contract.

In all three cases it may be sold in any of the following ways :—

- (a) **Standing** ; for a **Lump Sum**.
- (b) **Standing** ; at a **Price per Foot** ; the contents to be ascertained after it is felled.
- (c) **Felled** (by home staff) ; for a **Lump Sum**.

(d) **Felled** (by home staff); at a **Price per Foot**; the contents to be ascertained after the contract to purchase.

In cases (*a*) and (*b*) it is usual for the purchaser to fell the trees; but this should be clearly stated in the Conditions of Sale. And, in cases (*b*) and (*d*) it should be clearly stated who is to measure the timber, and what is to be measured as timber; and an arbitrator should be appointed in cases of dispute.

Now, before discussing the advantages and disadvantages of sales by auction, tender, or private contract, it will be advisable to discuss the merits and demerits of selling timber:—

(i) **Standing or Felled.**

(ii) **For a Lump Sum; or at a Price per Foot.**

As regards the former, in a general way it may be stated that mature timber (especially if large) should, usually, be sold after it has been felled. There are, however, exceptions to this rule. Now, if a timber merchant buy timber standing, he cannot be quite certain, even if he knows the locality well, how the trees will "come down." And, therefore, it would be decidedly indiscreet of him if he were to offer a "top" price, and allow himself no factor for safety. So that, if the trees be all sound, the owner will probably lose considerably. And then again, if a merchant, who perhaps does not know the locality, be once deceived by the timber, he is not likely to be a keen buyer on that estate in the future; and, through his influence, the estate may get a bad name.

If, on the other hand, the trees be felled by the home staff, he can gauge the quality easily, and a maximum price may be offered.

However, when once the trees be felled, the owner has to sell; and, to some extent, he is in the hands of the timber merchant, unless indeed, he converts, or partially converts, the timber himself. It should be remembered that, if timber be left unmeasured for any length of time, after it is felled, it shrinks considerably, and an appreciable loss will thereby be incurred by the owner. But, on large

estates, where a considerable amount of timber of good quality is annually put on the market, this chance of a failure to obtain a fair price is not much to be feared ; for, it would not be a sound policy on the part of the merchants to attempt to "squeeze" the owner of the timber. Such a policy might be described as an attempt to "kill the goose that lays the golden egg." However, the owner of an estate where timber is put on the market intermittently, is not in such a favourable position ; and, it will generally be best for him to sell the timber standing ; and, if he cannot obtain his price, he can wait for another year ; for, in as much as he will not have any methodical plan of fellings, this will not matter, unless indeed he requires the money.

So also, hedgerow timber may often, with advantage, be sold standing, as it will seldom form part of any methodical plan of fellings, and will not therefore interfere with any general plan of management ; but, as already stated, a maximum price must not necessarily be expected.

Then again, those timber trees which must be quickly removed from the woods after being felled, may, with advantage, be sold standing. Such trees include Ash, Beech, and Sycamore, whose colour deteriorates if left lying in the woods. The sale of timber while standing may also be practised in the case of crops which are clear cut when young ; as, for instance, 40-year-old coniferous crops fit for pit props. In such a case, there is not the same likelihood of the timber of young crops deceiving a purchaser as is the case with more mature timber.

In all cases, however, when timber is sold standing, a few sample trees should always be felled by the home staff so that the timber merchants may have a criterion upon which to base their estimates.

Such a method will eliminate much of the uncertainty that attends the purchase of standing timber, and will often render it advisable to sell standing when otherwise such a method would not be admissible. It is often urged that timber should be sold standing, as the buyer then fells it ; and that the men whom he employs are more used to felling

timber than the home staff; and that it will be more economically and efficiently done; and that the stools will be cut closer to the ground.

This, however, cannot, generally speaking, be considered a sound argument.

On very small estates, where the sale of timber is not frequent, it may be the case; but, on large estates most of the woodmen should be good timber fellers, and the work should always be done by piece-work. The workmen should always be instructed to cut the trees as low as possible; and, if it is done by piece-work, it will not usually be to their advantage to leave high stools, any more than it is for those who are working for the timber merchants. If the timber merchant buys for a lump sum, it is immaterial to the owner of the estate, whether the trees are cut low down or not. If, however, a price per foot has been agreed upon, the owner will often lose through the manner in which the trees have been cut by the timber merchant. Often big stools will be left; large boughs which are worth 10s. to 15s. each, and which, at a cost of an extra 1s. or 2s., should have been lopped before the tree was felled, are splintered by the fall of the tree; and, therefore, not measured. And, then again, much small timber, of 7 inches, 8 inches, 9 inches, and even of 10 inches quarter girth, is severed at these girths (instead of being severed at 6 inches quarter girth), and, if the tops are long, the mean quarter girth will perhaps be 5 inches, and the whole is claimed as tops, under timber size, and will not therefore be paid for, whereas, all over 6 inches quarter girth should properly be paid for (or according to the arrangement.)

It is, therefore, always advisable for all timber to be felled by the home staff, unless it is sold standing for a lump sum.

As regards whether timber should be sold for a **lump sum** or at a **price per foot**, there can be no doubt whatever that, in nearly all cases, it should be sold for a lump sum.

In some cases, locally, prejudice exists against this

method. It is claimed that every timber merchant, who desires to make an offer, has to measure the timber, and that, as only one can have the timber or any particular lot, the time spent by the others in measuring that timber is entirely wasted. This, however, is more in the nature of an excuse to avoid a little trouble, than a valid reason against the method ; for in all trades and businesses there is always a certain amount of unremunerative labour. Measurements and a valuation must always be made by the agent or forester ; and, in many cases, the estate measurements are given, and, often, when the estate is known, relied upon by the buyers (but at their own risk).

When a lump sum has been offered and accepted, there is usually no more trouble between buyer and seller, except, perhaps, as to unnecessary damage done to roads, gates, and fences.

But, if a price per foot has been agreed upon, and the contents have to be measured up, differences often arise, and there is usually cause for some dissatisfaction. It is only natural.

If the timber is going to be sold by auction, it is often inserted that the auctioneer shall measure, and that his measurements shall be taken ; but, as he will not usually have had much experience in this business when compared to that of land agents, timber merchants, and foresters, it will not usually be satisfactory to either party.

Then again, if the land agent or forester measure with the timber merchant, such questions arise as :—Who shall girth the trees? Is thick or thin string to be used? Is it right to stretch the string to its utmost, provided it does not break? Can the use of the tape be refused for measuring the length? What is the allowance for bark? What allowance is to be made for inferior timber, frost shakes, and so on? What is to be measured as timber? etc., etc. And thus unpleasantness and friction arise, which could easily be avoided, if only the timber were sold for a lump sum.

**The Choice as between Sales by Auction, Tender,
and Private Contract.**

There is always much difference of opinion as to the best method to adopt in order to obtain a price for timber. In a general way, it may be said that **sales by tender are infinitely preferable** to any other method. However, the merits and demerits of each of the three methods may be briefly considered, along with a short description of each.

Sale by Auction.—It is a *sine quâ non* that the auctioneer employed be well up in this particular line of business. He must know the "Trade," and the "Trade" must know him; otherwise, success cannot be anticipated.

The success of the sale depends largely upon the auctioneer. He alone is responsible for the advertising, and the preparation of the catalogue. If he be a good judge of timber and if he know the demands of the trade, the lotting may be left to him, but not otherwise; and the conditions of sale must always be submitted to the agent of the estate for approval.

A sale by auction encourages spirited bidding, and thus a better price may be obtained for the timber than if there be no competition. But auction sales render facilities for buyers to form a "ring," and thus defeat the desired competition.

When a ring is formed, those in the ring do not bid against each other, but, after the sale, they usually meet together and have a "knock out" sale amongst themselves; and divide the spoils of their ill-gotten gains.

If the lots be large, there is always more likelihood of a successful ring being formed, than if the lots be small. For, in the latter case, the "big men" will not deign to admit the "small fry" into their confidence, and initiate them into the advantages of co-operation.

It must be distinctly understood that the formation of a ring at an auction sale is quite illegal. But its existence is very difficult to prove.

It is, however, a consolation to reflect that there are many buyers who will never, under any circumstances, enter, or join a ring.

It is said that a "Dutch" auction prevents a ring being successful. To some extent this may be so; because, if there be a single buyer outside the ring, a bid from him will secure the timber, and he cannot be "squeezed" out of that particular lot. Another disadvantage of an auction sale is that the expenses are very great; so that, if only a small quantity of timber is for sale, it is quite out of the question, for the cost of advertising alone would be prohibitive. And then again, the timber must be sold to the highest bidder, even though his presence on the estate may be undesirable. The auctioneer is bound to accept the offer of the highest bidder, unless, indeed, the owner reserves the right to bid, and buys the timber in. But such a course is usually disastrous. Another disadvantage is the fact that there is often considerable delay in getting the timber removed; for the auctioneer, who is responsible for the money, will not, very properly, take the least risk; and thus, in the case of buyers whose financial position is somewhat doubtful, there is often much delay; whereas, had the timber been sold by tender or private contract, the offer of such a buyer would not have been accepted.

Sale by Tender.—By this method, the almost universal plan is to sell the timber for a lump sum, either standing or felled. The sale may be made quite public by advertising, etc.; or tenders may be invited from (say) 6 or 10 likely purchasers.

The timber is sold either as a single lot, or it is divided into several lots. Any considerable quantity should always be divided up, as explained hereafter. It is the usual practice to prepare a printed form of tender, in which are given all particulars as to the number of trees and lots, and also the conditions of sale; and a day should be specified by which the tenders are to be delivered.

In some parts of the country, a room is hired in the nearest town and the tenders are handed in by the merchants themselves, to the agent, and opened by the latter in their presence.

This method, however, is to be deprecated as it renders the formation of a ring an easier matter than it is even at

an auction; for the buyers can arrange matters amongst themselves half an hour before the appointed time.

The better plan is to stipulate that all the tenders be sent by post to the land agent's office; this will make it very difficult for a ring to be formed, as the buyers may not have discovered all those who are tendering. Other advantages are, that the method is not expensive; the agent can refrain from accepting the tender of any person who is undesirable; and the advantages of competition which may exist at an auction are also obtained.

Sale by Private Contract.—This method is often advisable, especially for small quantities of timber. It is the least expensive of any method, but, on the other hand, there is no competition. However, a local builder or wheelwright will often give a better price for a small quantity of timber than a merchant who resides at a distance. So also, it will often be advisable to sell privately to a local timber merchant, provided that he offer a fair price. But large quantities should be sold by tender, and, in many cases, the local merchant will be able to tender the highest, owing to the small cost of the haulage of the timber to his yard.

Now, in all sales of timber every assistance should be given to possible purchasers in showing them the timber. If the railway station is far off, arrangements should be made with some liveryman to meet any train, on receiving notice to do so, and this fact should be advertised. Then again, when merchants come to inspect and measure timber, which is to be sold for a lump sum, a woodman should be put at their disposal to assist in girthing the trees, etc., for this may save the merchant another day's visit, or at anyrate avoid the necessity of sending a foreman down to measure.

In all cases instructions should be given to any woodman thus deputed to assist, and to others who come in contact with those who come to inspect the timber, not to be too loquacious and not to repeat the names of all those who have come to inspect and measure the timber. And thus, in cases of sales by tender, it will not be so easy for the buyers to form a ring if so minded.

Conditions of Sale of Timber.

The following is an abstract of suitable conditions of sale of timber, by tender. Many of them are also applicable to conditions of sale by auction or by private contract.

(1) All tenders **must be upon the printed form annexed hereto**, and must be signed by those tendering, who must also append their addresses.

(2) All tenders marked outside "tenders for timber" are to be sent by post to "A.B." (here insert address of land agent), and are to be received not later than twelve o'clock on the day of , at which time the tenders will be opened and notice sent by post to each person whose tender is accepted.

(3) The vendor does not bind himself to accept the highest or any tender.

(4) If more than one lot is tendered for, a separate sum must be set against each lot so tendered for. And each of such sums shall be considered as a separate tender.

(5) Each purchaser shall immediately upon the acceptance of his tender (or tenders) pay to the said "A.B., " a deposit of £25 per cent. on the amount of the purchase money, and shall, within 14 days from the date of the acceptance of the tender (or tenders), deliver, at his own expense, to the said "A.B., " bills or promissory notes, endorsed by a responsible surety, approved by the said "A.B., " for the remainder of the purchase money, payable to the said "A.B." or his order, 4 months after the date upon which his tender (or tenders) was accepted. Until such security is given and accepted, no purchaser shall enter upon the land and fell or remove any part of the said timber or trees.

If default is made in giving such bills or notes as aforesaid the deposit money shall be forfeited, and the property in the timber and trees, purchased by any person thus making default, shall revert to the vendor. Any purchaser may pay cash in lieu of giving the bills or notes, for the remainder of the purchase money, and he will thereupon be allowed discount at the rate of 4 per cent. per annum on any amount of such latter sum as he pays for in cash.

(6) (If sold standing).—All the trees are to be felled in a proper and workmanlike manner ; and these, together with all lop and top, cordwood faggots (and bark), are to be removed and cleared off the estate by the day of

; and any trees, or the lop and top, or cordwood, or faggots, or bark remaining on the estate after that date shall be forfeited to and become the property of the vendor without compensation to the purchaser.

(6a) (If sold when already felled).—Only those butts, limbs, and tops, which are marked with one or more bands of paint are included in the sale, and these are to be removed and cleared off the estate by the , etc.

(7) The purchasers shall use all possible caution to prevent damage to lands, timber, fences, gates, or growing crops, in the felling and removal of the timber. All unnecessary damage occasioned to property, or damage caused by the negligence of any purchaser or those deriving authority under him, shall be compensated for and made good by such purchaser to the satisfaction of the said "A.B."

And in the case of Hedgerow Timber, Park Timber, and the like :—

(a) (If sold standing).—All those trees growing in any field, or on any meadow land—and such trees are marked with a white cross—shall be "grub" felled, and all large surface roots shall be extracted and the soil evenly filled in.

(b) All timber felled on to any grass land or on to any arable field shall be removed along with all lop and top, etc., by the 1st day of April 19¹ etc., as per sect. (6). Any damage occasioned to be made good as per sect. (7); and any claim that a tenant may make upon the vendor for damage sustained shall be satisfied by the purchaser occasioning such damage.

¹ A later date must be allowed if Oak trees are to be barked ; those on grass land should be left until after hay harvest, unless removed immediately.

(8) (If sold standing).—Any purchaser wrongfully cutting down any tree, teller, or sapling, shall pay to the vendor treble the value of such tree, teller, or sapling.

(9) No saw pits shall be made on the estate, nor engines or steam tackle used in the extraction of the timber without the written permission of the said "A.B.," and upon such terms as he may decide if his permission be given.

(10) No horses shall be allowed to wander at large on any part of the estate; and no dogs shall be brought on to the estate by any purchaser or those authorised by him. The purchaser shall pay to the vendor a penalty of 20s. for every offence so committed.

(11) The said "A.B." shall have full power to dismiss, from off the estate, any employee of any purchaser who shall be guilty of any gross negligence, or of drunkenness, or other act of gross misbehaviour, or of poaching, or if nets or other poaching tackle be found in his possession; and such person shall not be again employed.

(12) Only such private roads as are pointed out shall be used for the removal of any timber or other produce.

(13) If any purchaser shall fail or neglect to pay the purchase money, or if he shall become bankrupt before the purchase money is paid, the vendor or his agents shall be at liberty to take and secure all timber and trees and other produce arising therefrom, purchased by such purchaser, and still remaining on the estate. The vendor shall be at liberty to sell and dispose of the same, and to retain so much of the proceeds of such sale as shall pay off the purchase money, together with all expenses connected with such seizure and sale, rendering the over-plus, if any, to such purchaser or those claiming under him. But such seizure and sale shall not discharge such purchaser or his surety or sureties from their respective liability upon any bill or note then unpaid, any further or otherwise than to the extent of the net proceeds arising from such sale.

(14) Any matter of dispute, as between vendor and purchaser, arising out of this sale, or referable to these conditions of sale, shall be referred to "X.Z." Esquire, of

(address), who shall act as arbitrator in this matter. But no mistake whatsoever in the particulars of sale shall invalidate the sale of the several lots or any of them; and no compensation shall be paid or allowed by the vendor in respect of any such mistake or mis-statement.

The following form of tender should be annexed:—

FORM OF TENDER.

.....the undersigned.....
of.....
hereby offer to purchase (fell) and carry away the lots mentioned in the Schedule annexed hereto, at the sums placed opposite to such lots, in accordance with the foregoing particulars and conditions of sale, to which.....hereby agree in all respects, as witness.....
signature(s) hereunder.

Dated this.....day of.....19....

SCHEDULE.

No. of Lots mentioned in the foregoing particulars.	Price to be paid for each Lot.		
Lot	Number.	£	s.
Lot			
Lot			
Lot			
Lot			
Lot			
Lot			
Lot			
Lot			
Lot			
Lot			
Total			

Signed.....

The Marking and Lotting of Timber.

The separate marking of timber, previous to the felling thereof, will often be unnecessary, as, for instance, where a whole area is to be clear felled. But, wherever there can be any doubt as to what is to be felled, marking must take place; either the trees to be cut must be marked, or those that are to be left must be marked. In the former case, as, for instance, hedgerow timber or trees to be cut under the selection system, or thinnings to be removed, the trees may be simply blazed with a handbill. And in the latter case, when the marked trees are to be left, they should be marked by a ring of white paint, etc., since no harm must be done to the tree. It is very important that trees should be marked on both sides, as otherwise mistakes are often made.

Where trees are to be sold standing, each tree to be felled should be marked with a ring of white paint, and should be separately numbered, unless the whole of a given area is to be felled and sold in one lot, or unless the excepted trees are marked and the remaining trees on the area are comprised in one lot.

The Lotting of Timber is a matter that requires very great experience. It will almost always be necessary, and the folly of selling large lots of mixed timber cannot be too strongly condemned. The different species of trees should almost invariably be sold separately; and, in many cases, separate lots should be formed for different qualities of the same species.

For merchants continually get orders for some particular class of timber; and, on the other hand, they often have much difficulty in disposing of certain classes of timber; so that if they have a full stock of all kinds except the particular class for which they have a special order, they cannot possibly give a full price for a mixed lot in order to obtain some trees of the particular species they require. Then again, the lots should never be too large. Their actual size will depend upon the amount of timber to be sold and upon the local market.

Small local buyers should always be catered for; and if there is a probability that 8 or 10 lots of £10 to £15 a-piece would find a ready sale, such small lots should be made up; but most of the lots in a big sale may conveniently range in value from £100 to £200.

When lotting **standing** timber, the trees comprising any one lot should be fairly close together; and, except as previously stated, each tree should be marked in paint with the number of the lot to which it belongs, and, in many cases, the consecutive number of each tree in a lot is also added in paint, or it may be stamped on with a numbering hammer, a blaze having first been made on the bark.

For example:—

Lot 3	Lot 3	Lot 4
71	72	I

Sometimes neighbouring lots may be marked with different coloured paints so as to assist in identification and avoid confusion. In cases where most of the trees consist of two or three species and there are a few trees of various other species here and there, it will often be convenient to assign the few odd species to one lot, as it would not be worth while to make separate lots for each of the miscellaneous species. Occasionally, lotting may be effected by area in the same manner that coppice is lotted by area. Such a procedure would be advisable in cases where young coniferous crops are sold standing for pit wood; or where mature pure crops are being cleared and there is much uniformity in the quality of the timber.

When lotting **felled** timber, the first question to decide is whether the timber or poles are to be left lying as they are felled or are to be drawn out to the rides and more or less assorted. A great deal of money is often wasted in unnecessary lotting, or rather, in attempting to arrange the lots in a neat order.

Trees cut under the selection system, or thinnings made in high forest, or standards cut when growing over coppice

should almost always be pulled out on to the rides by the home staff, as great care is required not to injure the trees left growing. They can then to some extent be sorted and arranged in lots. Quite small poles may be placed in heaps; but it would not pay to drag bigger trees into neat heaps, as it were. Where an area is clear cut, or where, if not clear cut, the trees left standing are all big trees and not easily damaged, it will be best to leave the felled trees as they fall and not to pull them out to the rides, for, although they must ultimately be pulled out before being loaded up, the cost of so pulling them out is seldom recouped by the owner by any extra price obtained from the buyer.

When lotting the timber, the trees should be marked at the butt end; the number of the lot should generally be in paint, and the number of the tree may be stamped with a numbering hammer. The number of the lot should also be painted on the trunks, or some mark put so as to readily distinguish it from any neighbouring lot; as by the use of different coloured paints, or one or more parallel bands across the trunks, etc.

It must be distinctly understood that no pole or limb or top is included in any lot unless it be marked with paint; for the vendor, who fells the timber, retains all cordwood and faggots.

Occasionally, as described in some cases of standing timber, the lotting can be done by area; when this is so, the trees on the boundary of any lot should be thrown inwards, towards the lot to which they belong, so as to avoid confusion on the boundary line.

THE FELLING OF TIMBER.

It has already been stated that trees should be felled as close to the ground as possible.

Small trees up to about 6 inches quarter girth are felled with the axe only; but larger trees are felled with the axe and saw. The axe is first "laid in" all the way round, as low down as possible, and then the rest of the butt is sawn

through. As the sawing proceeds metal wedges are driven in behind the saw so as to prevent the saw becoming jammed, and, finally, to tilt the tree over. Usually the tree must be felled in the direction of its natural inclination; but, occasionally for special reasons, it is thrown in another direction; in such cases it must be pulled over with ropes, previously attached to the top of the tree, and assisted by driving in wedges.

Wherever there are large valuable limbs or perhaps a double leader on the side on which the tree is going to be thrown, these should be first severed before the tree is thrown. For otherwise such limbs will be splintered; and, for the sake of an extra 2s. or 3s., about 15s. or £1's worth of timber is often thrown away.¹

These limbs are cut by a hand-saw by a man who ascends the tree. This man, sometimes called the "jack," will usually put on climbing irons to assist him to get up.

When felling on steep hillsides, the trees should, if possible, be thrown uphill as less damage will be done in the fall; and, during gales, felling should usually be suspended, as it is decidedly dangerous.

When small trees are being sawn through, 2 men can easily work the saw; but, with large trees, 3 men are necessary and can well do the work with a good saw. However, in some parts of the country a cord is attached to the saw at either end and it is worked by 5 men, but though this method be slightly quicker, the cost of sawing will be more expensive per cubic foot. Strong, hard working men will, when on piece-work, usually work with 3 men on the saw.

Three men should be able to lay in with the axe, and saw through an oak tree 2 feet 6 inches to 3 feet diameter in about 2 hours.

¹ When felling is by piece-work an extra 1s. besides the rate per foot paid for felling, should be paid for each limb thus severed, as it involves greater labour. The woodward or forester should previously indicate each three where he requires a branch or limb to be thus separately severed.

It is very essential, however, to have a good sharp saw made of the best steel.

A good saw should have:—

(1) The cutting edge slightly convex; more so for soft woods than for hard woods.

(2) The teeth should be more or less triangular, and should provide ample space for removing the sawdust.

(3) The teeth should be well "set" to alternate sides; and more so for soft woods than hard woods.

(4) The back of the blade should be thinner than the front, so as to minimise jamming.

After the trees are felled, they are "trimmed-up" or "squared-up" or "knotted" or "rounded-up." This consists in cutting off with the axe all the side branches flush with the trunks and trimming up the trees. The trees should not, as a rule, be cross cut, as this should be left to the purchasers, who may require particular lengths, etc.

After rounding-up, all unsaleable timber, generally under 6 inches quarter girth, is made up into **cordwood** and **faggots**—the larger "stuff" into cordwood and the small "stuff," or "browse," into faggots. The size of a cord varies in different parts of the country.

Common sizes are:— $8 \times 4 \times 4$ (feet)

$12 \times 4 \times 4$ "

$12 \times 4 \times 3$ "

16 ft. 2 in. \times 2 ft. 6 in. \times 2 ft. 2 in.

When the vendor fells the timber himself, he retains or sells separately the cordwood and faggots; but if the timber merchant fell the timber, he is entitled to the cordwood and faggots, unless otherwise agreed. As a general rule, it may be taken that the profit on the cordwood and faggots will about pay for the cost of felling.

The amount of cordwood obtained from trees must vary greatly; but, in the case of well-grown tall Oak, it will average about 1 cord ($12 \times 4 \times 4$) to every 110 to 130 cubic feet, and in the case of inferior Oak, it will average about 1 cord to 65 to 75 feet, or even less.

Prices for Felling, etc.—These are subject to great variation, but the following is perhaps a fair average :—

Felling and rounding-up broad-leaved trees	5s. to 7s. per 100 ft.
" conifers . . .	3s. 6d. to 5s. per 100 ft.
Cording (8 x 4 x 4)	3s. 6d. a cord.
,, (16 ft. 4 in. x 2 ft. 6 in. x 2 ft. 2 in.)	2s. 6d. a cord.
Faggotting (including withies)	3s. 6d. to 4s. 6d. per 100.

The best Season for Felling.—Generally speaking, felling should be done in late autumn and winter; for the less sap in the wood, the better for most purposes. Winter felled timber is always stronger and more durable, and shrinks less. However, where timber is sold by weight, as, for instance, pit wood, it should be felled when the sap is in it, provided that the same price per ton can be obtained for it.

Then again, timber felled in the summer is usually easier to split; and timber that it is required to steam and bend can be more easily treated when felled with the sap in it.¹

If timber has to be barked, the felling must, of course, be delayed until the bark will "run."

In forests of Spruce and Scots Pine, if the Pine weevil (*Hylobius abietis*) be very much to be feared, it is sometimes advisable to fell the trees in the summer, and bark them immediately, but small rings of bark should be left on the stems, so as to minimise the danger of splitting and cracking.

Barking Trees.

The barking of timber is now almost confined to Oak trees, the bark of which is used for tanning hides. The bark of most other trees contains tannin; but it is seldom that any bark except Oak is used for tanning in this country.

Other trees are sometimes barked for special purposes, as, for instance, Alder and Willow, which are going to be

¹ It is very probable that green wood can be more easily impregnated with preservatives than seasoned wood or winter felled wood. But in all such cases where green wood is used, it must be treated *immediately* after being felled.

made into gunpowder ; and, as regards Alder, some of the bark at any rate should always be chipped off, soon after it is felled, so as to hasten the drying, and preserve the timber.

As soon as the bark will "run"—about the end of April and beginning of May¹—the trees are felled and barked. Before being felled, each tree is tested to see if the bark will "run," and a strip of bark, about 3 feet long, is removed from all the way round the base of the tree ; then the tree is felled and the bark ripped off.

At the time of barking, only such branches are trimmed off the trees as is necessary to enable the men to remove the bark. The trimming-up or rounding-up of the timber must wait until after barking operations are over ; for no time must be lost, as the bark will only run for a few weeks.²

The bark is cross cut with a handbill (one edge of which is straight, the other curved) all the way round the stem or branch at short intervals of about 3 feet if on the butts, and perhaps 18 inches on the smaller branches ; and then one longitudinal cut is made along each section. Then a barking iron or chisel is inserted along the longitudinal cuts, and the bark ripped off. If the bark will not come away, it should be gently tapped with the "flat" of an axe or a wooden mallet. But the small profit in barking renders it impossible to spend much labour on bark that will not easily run. The less tapping the better, as it injures the bark. The bark always runs better during warm, damp, muggy weather ; and better in the morning and evening than during the daytime.

Occasionally, as in the Forest of Dean, the trees are barked when still standing. In this case the men ascend by means of ladders, strip the bark and throw it down.

The only advantage of this method is that the trees can be felled in the following winter, and so escape being felled when the sap is in them. But the extra expense involved, and also

¹ This is in the South of England. In the North it will be much later. The sessile Oak is often a little later than the pedunculate.

² There is, however, a second and third flow of sap at later periods ; but it is very rare for trees to be barked at these dates.

the risk of injury to the men, is hardly warranted; and if standards growing over coppice were thus felled, considerable harm would be done to the coppice, which would have made a year's growth by the time the trees were felled.

After the bark is stripped, it is stacked up. Occasionally, a regular staging is made of small poles supported by forked stakes, but unless the land is very wet, all that is necessary is to support a single long pole, at about 2 feet from the ground, by means of two or three forked stakes and then to pile the bark against this.

Medium-sized pieces are placed face inwards against either side of this pole—their ends on the ground, and their tops resting against the pole—these two sides thus form an equilateral triangle with the ground. On the apex, as it were, of this triangle, the smallest pieces of bark are placed; and then, above this row of small pieces, the largest slabs of bark from the trunk are placed, face downwards, so as to form a capping and keep the wet out.

The bark is then left like this for about 3 weeks¹ or until it be dry, when it is sent off to the tannery. **Good bark, when dry, should be a pinky colour, and should snap easily** when broken, and not bend or be pliant. The small thin bark of coppice shoots and young trees is more valuable than the coarse bark of older trees. And the bark of trees growing on hot southern aspects is more valuable than the bark of trees growing on cool northern aspects. The more quickly it has seasoned, the more valuable will it be. In drying, bark will lose about one-third of its weight when green.

The amount of Bark obtained from Timber.—This will vary very greatly, but, on an average, it may be taken that :—

One ton of bark will be yielded from :

110 to 130 cub. ft. (q. g.)	of large hedgerow timber,
150 „ 175 „ „	of mature high forest trees,
380 „ 500 „ „	of coppice shoots, down to 1 in. diameter, the rotation being 12 to 15 years.

It must be remembered that bark is usually sold by the ton of 21 cwt.

¹ Sometimes the bark will season in about 10 days.

The Price of Bark is now very low indeed, compared to that which prevailed a few years ago. It fluctuates from year to year, but usually in a downward direction. This is largely due to imported tanning substitutes from foreign countries. The most important, perhaps, are preparations from Quebracho wood from Argentina; and from the *Quercus Aegilops* from the Mediterranean. An average price for Oak bark delivered at a tannery is at present¹ about £2, 5s. to £3 a ton.

The Cost of Barking.—The usual custom is to pay a certain sum to include felling and barking and stacking-up the bark, and to pay a separate sum for rounding-up the timber afterwards.

Large Oak trees are usually felled and barked for about £1, 5s. to £1, 7s. a ton of bark. And the cost of rounding-up such trees will be about 1s. 6d. per 100 cubic feet; but the barking of coppice poles would cost from £2, 5s. to £2, 15s. a ton of bark, for the bark is thin and the labour much greater.

Three men should, if the bark "runs" easily, peel and stack up about $\frac{1}{2}$ a ton of bark from a large tree in about 3 hours. A small gang of 6 or 7 men can very conveniently work together when felling and barking. If 4 men are barking, they can just about keep pace, in the case of large timber, with the 3 men who are felling the trees. Now in fine weather, if on piece-work, very good wages can be earned; but on the other hand, the men may often be stopped for rain.

The Advantages or otherwise of Barking.—There is, usually, still a small margin of profit on barking, and even if there were no direct profit, it must be remembered that the timber will often, as it were, be felled for nothing; and, if the timber has to be sent by rail, there will be an additional saving in the cost of transportation.

But, on the other hand, winter felled oak is better than that felled in the spring; and if a better price can be obtained for the former, it will in many cases be the better policy to fell the oak in the winter.

¹ 1908.

No general rule can be laid down, as so much depends upon the distance away at which the tannery is situated.

The following instance will show an advantage in barking :—

If winter felled :—

150 cub. ft. of timber at 1s. 6d.	. . . . .	£11 5 0
<i>Less</i> , cost of felling and knotting, at 6s. 6d. per 100 cub. ft.	. . . . .	0 9 9
		<hr/>
		£10 15 3

If spring felled :—

150 cub. ft. of timber, at 1s. 6d.	. . . . .	£11 5 0
1 ton bark, at £2, 11s. at tannery	. . . . .	2 11 0
		<hr/>
<i>Less</i> , cost of felling and barking, at £1, 6s.		£13 16 0
per ton	. . . . .	£1 6 0
Delivery	. . . . .	0 11 9
Knotting, 150 cub. ft. at 1s. 6d. per 100 ft.	. . . . .	0 2 3
		<hr/>
		2 0 0
		<hr/>
		£11 16 0

This shows a gain of £1, os. 9d. on 150 cubic feet of timber, which equals a gain of 1½d. per foot by barking.

But, as the winter felled Oak will often be worth an additional 1d. per foot, the gain will only be ½d. per foot.

EXTRACTION AND TRANSPORTATION OF TIMBER.

As already stated, the timber must almost always be dragged out from where it is growing on to the rides, where it can be loaded up. There is often a great waste of horse power in doing this. Quite small logs may be pulled out without any particular device being resorted to; but, for large poles, a dragging shoe or sledge should be put under the forward end of each tree, and thus it will easily ride over the ground. For large trees, where the ground is always more open, a pair of "tushing" wheels, sometimes known as a timber "bob" or "janker," may be used. By this means the heavy end of the log is raised up off the ground, and

thus the draught is much lessened. Occasionally the trees can be loaded up, where they are felled, on to the timber waggons, but this will not be very often.

When loading a timber waggon, a couple of "skids" or "leaders" are placed at an angle from the ground to the top of the waggon, and the logs are then pulled or rolled up by means of one or more horses pulling (on the other side of the waggon), on to chains which pass over the waggon and round each end of the log.

As regards the Cost of Haulage by Horses.—If the timber is near a good hard road, and if the gradients are not very steep, a fair average is to allow 1d. to 1½d. per foot quarter girth measurement for the first mile, and then ½d. a foot up to 5 miles, and beyond this distance ¾d. per foot per mile (*i.e.*, 3 miles for 1d.).

If, however, the trees lie in an inaccessible place, or the woodland rides be very wet and gradients bad, it may easily cost 2d. to 3d. a foot to haul for the first mile on to, perhaps, a good road. For it may require double the number of horses or more to do this first length of hauling, and sometimes the trees have to be "tushed" a long way before they can be loaded up. Then again, even if there be a good hard metalled road, the cost will be greatly increased if the gradients be bad, for extra horses must be used. But if there be only a bad gradient here and there, two waggon loads may proceed together, and when the bad gradient is reached, they must stop, and put all horses on to one waggon; haul this up; and then come back for the other waggon. This, of course, all means delay and extra expense. An extra 1d. a foot spent in hauling means something like £10 to £20 per acre; and hence the advantage of having good roads and rides on woodland areas cannot be too strongly insisted upon; for timber merchants are not slow to accurately gauge the cost of extracting timber.

The Cost of Steam Traction on roads is considerably less; though, in many cases, the timber will have to be "tushed" out for a much greater distance, on account of the engine and trucks not being allowed in the woods, or not

being able to approach so near to the felled area as the timber waggons.

It must be remembered that heavy engines and loaded trucks will often do a great deal of damage to grass rides; and, especially, to any culverts which may cross a ride.

But when once on truck the cost of steam haulage by road may be put at $\frac{1}{10}$ d. per mile per cubic foot (*i.e.*, 10 miles for 1d.).¹

If traction engines are used, they should only be allowed in the woods during the summer season.

Forest Roads.—The necessity for having good roads leading from the area upon which the timber is growing has already been noticed; and it has been stated, that in large forest areas, it will generally be necessary to convert some of the main rides into hard roads, unless such areas be intersected by hard roads, either public or private.

The making of metalled roads is, however, very expensive; even if stone can be quarried close by and can be had for the labour of quarrying it. At 6s. a yard run, the cost per mile would be £528. It will seldom be possible to make a road at a less cost, and in many cases the cost will be very much more. To what extent such an outlay is advisable, is a matter requiring much consideration, and cannot be decided with mathematical precision. However, a calculation after the following manner will assist in arriving at a correct conclusion.

Thus, supposing that there be 1500 acres of forest; that it be normally stocked with all age classes; that 20 acres a year of mature timber, averaging 60,000 cubic feet, can be cut; that the average hauling distance from the centre of the area to the nearest metalled road be 1 mile; that at present there be an indifferent grass track for this distance; and that it be estimated that a saving in haulage of $\frac{1}{2}$ d. per foot for this mile could be effected if the track were made into a good metal road.

Then the saving in haulage per annum would be £125 if

¹ A somewhat smaller charge for very long distances,—about $\frac{1}{15}$ d. per foot per mile.

the road were metalled. But from this it would be necessary to deduct interest on the cost of making the road :—

5 per cent. on £528 equals (say) . . .	£26 0 0
and the annual upkeep of road (say) . . .	44 0 0
= total debit of . . .	£70 0 0 per annum.

Therefore, it would appear that the making of the 1 mile of road for the benefit of 1500 acres would result in a gain of £55 per annum ; or a gain of nearly 9d. per acre per annum, on a normally stocked area.

In the above case, if the whole area were more mature and were to be all cleared in the next ten years, the whole cost of the road would be far more than paid for by the saving effected on the haulage during the first year.

However, a decision, as to whether the money saved in the cost of haulage would find its way into the pocket of the owner of the estate, or the timber merchant, or the timber hauler, can only be arrived at in theory.

Then again, it will often be possible and advantageous to make a private road connecting up two main roads, and thus, perhaps, effecting a saving of 3 or 4 miles haulage by making a short length of new road. But in this case the saving will not be at the same rate per foot, as the comparison is different. It may be that $\frac{1}{2}$ d. to $\frac{1}{4}$ d. per foot per mile will be saved if only horse traction be considered ; but, in the case of steam traction, the saving will perhaps be only $\frac{1}{10}$ d. per mile.

Forest Tramway.—Instead of making a hard road, the making of a forest tramway will sometimes be preferable. There is not a great difference in the actual cost, or in the upkeep, if depreciation on the rails and rolling stock be taken into account.

If there be no levelling of gradients, etc., a good horse tramway, including 4 sets of two bogies each, will cost, laid complete, about £300 to £400 per mile. The haulage, usually, will cost about $\frac{2}{5}$ ths of that of ordinary road haulage by horses ; but in cases where there is a long decline, the haulage will be very much less.

However, unless the tramway leads to the place where the timber is to be converted, it will generally be preferable to make a hard road and rely upon ordinary haulage, unless the length of tramway is very long—at least over 1 mile. For, at the end of the tramway, the timber would have to be unloaded, and then reloaded on to waggons; so that, unless the length of tramway be sufficient to more than pay for the cost of reloading, out of the saving effected by the cheaper cost of tramway haulage over ordinary road haulage, there will not be much advantage in having the tramway instead of a metalled road.

The advantages of a tramway over a road are briefly:—

- (1) Haulage is very cheap.
- (2) The tramlines can be moved, and spurs are easily made right up to the nearest ride where the timber is growing.

And the disadvantages are:—

- (1) That unloading and reloading on to waggons is usually necessary.
- (2) That the tramway lines are not serviceable for other vehicles of commerce (if so desired).

In laying tramways, a gradient up to 1 in 13 is admissible, and curves with a radius of from 70 to 80 feet; though, if only short lengths of timber are being removed, the radius of a curve may be much less. The rails should weigh about 5 lbs. per foot, and there should be sleepers about every 3 feet 6 inches apart. Lighter metal will suffice if the sleepers be closer together.

The most serviceable sleepers (or ties) are, for portability, those made of corrugated steel; though creosoted wooden sleepers may be used. The usual gauge is 24 inches. Near dangerous places, as where a steep gradient must terminate in a curve, a short length of "run away lines" should be provided, if possible. These should lead up hill, so as to stop the bogies or trollies, and switch points will have to be provided, so as to turn the trollies off. This, however, would involve having a man stationed at these points.

The following specification has been given for a tramway 1300 yards long.¹

1300 yards light railway material, 24 in. guage, consisting of:—

- (1) 520 flat-bottom steel rails, 14 lbs. per yard, in 15-feet sections, complete, with fish-plates, bolts, and nuts.
- (2) 1300 single corrugated steel sleepers, 30 in. long, 3½ in. wide, by ½ in. thick, complete, with their necessary bolts and nuts for laying 3 feet apart, with riveted clips for 14 lb. flat-bottom steel rails, with clutch bolts, 4¾ in. by ½ in., and with nuts and washers.

The above at 2s. 9d. per yard of line	£178 15 0
Two sets of points at £3	6 0 0
Four sets each of two bogies, with double screw brakes, swivel bolsters, chains, jacks, and all necessary fittings, complete	54 16 0
1300 creosoted Scots Pine intermediate sleepers, 3 ft. by 5 in. by 1½ in.	11 14 0
Labour on laying track and tarring rails	35 0 0
Total	£286 5 0

This equals 4s. 5d. per yard run.

Timber Slides.—Occasionally in this country the use of timber slides may be advantageous in extracting timber. As, for instance, when timber is grown on a high plateau and the descent down is very awkward. A slide is made of poles of timber; it is trough shape in section; and its surface must be free from projections. They are, however, very expensive, and do not last many years.

The use of timber slides can never be of such common occurrence in this country as in many places abroad. Nor can the **drifting or rafting of timber** in streams and rivers often be resorted to in this country, although it is, where practicable, the cheapest means of transporting timber, and has the additional advantage of helping to season it.

So, again, the **sledging of timber** on frozen tracks is out of the question.

Transportation by canals in barges costs about 1d. per foot per 15 miles. The cost, however, is very variable, and is largely governed by local competition.

¹ "A Forest Tramway," by F. Moon: *Transactions of Royal Scottish Arboricultural Society*, January 1908.

Railway Carriage of Timber.—This is a matter of great importance to all who are interested in the production and utilisation of timber. For the cheaper the freight, the less local should be the market for timber; and, consequently, better prices might be anticipated in any sale of timber. The cost of transporting timber, whether by road or rail, to a consuming centre, is one of the chief factors in determining its price.

The cost of carriage by rail is, roughly, 1d. per foot (q. g.) per 16 miles including the cost of loading, but not of unloading. It is, however, subject to very great variations governed by competition with other lines, facilities for loading, etc., etc.

Within recent years much has been heard about the difference in railway rates on home-grown and imported timber; and the railway companies are constantly accused of attempting to penalise the trade in home-grown timber, whilst fostering the trade with foreign countries.

However, the case against the railway companies is not really so bad as some over-zealous champions of the cause for the home producer would lead one to believe. For the rates per measured "ton" in round timber and converted or squared timber are not directly comparable. But, that discrepancies per actual ton weight do arise, and often very considerable discrepancies, cannot be denied. Though to what extent they can be justified, on the ground of "through rates," or of having a large constant quantity to handle, or of being more easily handled, or of a given weight requiring less stowage room,¹ (as is the case when converted timber is carried instead of "round" timber) is a very difficult question to decide, impartially.

In order that this question may be more fully understood, it is necessary to consider, in some detail, the methods adopted by the railway companies in arriving at the weights of timber, and to contrast some actual rates per measured "ton" with the proportional rates per actual ton of foreign and home-grown timber.

¹ There may, however, not be much difference if the round timber is green and the converted timber is seasoned.

Briefly, the conditions of the railway companies are as follow :—

- (1) For squared timber the 144 divisor¹ is used.
- (2) For round timber—string under bark and 113 divisor (or if measured over bark, an allowance for bark to be made). Includes loading.

But on (1) Scotch railways, (2) or from Scotch railways to England or Wales, (3) or from North-Eastern Railway stations—

Tape over bark, and 144 divisor, and loading² is not included.

- (3) The companies reserve the right to charge separately for bark when measuring with string under bark and 113 divisor.
- (4) Timber, in pieces over 6 tons, is charged 25 per cent. over usual rates.
- (5) The weights of timber are ascertained from the measurements on the assumption that :—

Acacia		}	40 cub. ft. (as measured) equal 1 ton.
Ash			
Beech			
Hornbeam			
Oak			
Elm (if string under bark, and 113 divisor)			

And that :—

Alder		}	50 cub. ft. (as measured) equal 1 ton.
Birch			
Spanish Chestnut			
Elm (tape over bark, and 144 divisor)			
Fir			
Hemlock			
Larch			
Pine			
Spruce			
Maple			

¹ *Vide* Chapter XIII.

² Tape over bark rates are not the same as string under bark rates. In nearly all cases, tape over bark rates may be agreed upon by the sender.

- (6) Rates for round timber do not include unloading.
- (7) When round timber is consigned, the number of cubic feet must be declared by the sender; or else an extra charge will be made.
- (8) For pieces of timber, of less than four tons weight, which, owing to their length, require more than 1 truck, a minimum charge of 1 ton per truck is made for each truck so used, whether carrying part of the load or used as a safety waggon only.
- (9) **Pitwood** for mining purposes is charged at measurement weight and tape over bark with 144 divisor.
- (10) Except between stations on Scotch railways, the following special conditions hold good, and special rates per ton are quoted for 2 tons and upwards:—

(a) Fir and Pine deals, battens, and boards	66 cub. ft. (as measured)
(unprepared, and not exceeding 4 in. in thickness, post and rails, Fir cut square for fencing (and not exceeding 4 in. in thickness).	
(b) Planks, sawn or hewn square, or waney-edged logs of Alder	40 or 50 ft. per ton
Ash	(vide sect. (5)), but special rates.
Beech	
Birch	
Chestnut	
Elm	
Fir	
Larch	
Pine	
Spruce	
Hornbeam	
Plane	
Poplar	
Sycamore	
(c) Pitwood and telegraph poles (consigned direct to a mine), ordinary measurement weight, but special rate, viz., 20 per cent. over rate for deals, battens, and boards.	

With reference to the above, it may be stated, by way of a summary, that

- (1) **Battens, deals, and boards** of Fir and Pine are carried

at a special rate, and 66 cubic feet (actual or true contents) are reckoned to 1 ton.

(2) **Planks or square baulks** of all timbers are carried at the same special rate, and 40 or 50 cubic feet (actual or true contents) are reckoned to one ton.

(3) **Round Timber** at ordinary rates and

40 or 50 cub. ft. $\left\{ \begin{array}{l} \text{Quarter girth measurement over bark,} \\ \text{144 divisor; }^1 \\ \text{Or true contents under bark, }^1 \text{ 113} \\ \text{divisor.} \end{array} \right.$

are reckoned to 1 ton.

Thus, it is evident that Fir or Pine (only), battens, deals, and boards are given a preference over planks or square baulks of Fir or Pine ; for 66 cubic feet (true contents) are carried to the ton instead of 50 cubic feet (true contents). This preference for the battens, deals, and boards is equivalent to an import duty on the planks or baulks ; hence, merchants are not likely to employ home labour to saw planks, etc., into scantlings, when they have the extra railway freight to pay.²

Now, before comparing any rates between square timber (whether imported or not) and round timber, it is necessary to note the difference between the two forms of measuring timber in the round ; and to compare their measurements with the true contents.

With a bark allowance of 1 inch to 1 foot, a log containing $78\frac{1}{2}$ cubic feet over bark with 144 divisor, will give nearly $83\frac{1}{3}$ cubic feet under bark with the 113 divisor. So that the latter gives just over 6 per cent. more contents.

But in the above case the true contents, measured over bark, would be 100 cubic feet.

Thus, by the tape over bark method, each measured

¹ The rates per measured ton are not necessarily identical for the two forms of measurement ; and loading is only included in the 113 divisor case.

² But probably they could not saw up so cheaply as is done abroad, even if all timber, good and bad, were imported in baulks.

"ton" contains rather more cubic contents than $1\frac{1}{4}$ "tons" of square timber.

So that, *cæteris paribus*, a rate of 14s. a ton for timber in the **plank** would be equal to a rate of 17s. 10d. a ton for timber in the "**round**";¹ therefore, an increase of 27½ per cent. on the rate for square timber should be made for round timber. But, in order to make a perfectly impartial comparison between rates on imported planks or baulks and home-grown timber in the round, it is necessary to make some allowance for the difference in the weight per foot of the same kind of timber, owing to the home-grown timber being consigned in a green state and the imported timber being more or less seasoned.

This cannot be determined with mathematical accuracy, as every individual case differs; but, in a general way, there is a striking difference in the weight per foot (true contents).

Without entering into too much detail, the following may be taken as a rough average of the weights per foot (true contents) of the heavy timbers and of the conifers, both in the green state and when seasoned:—

	Weight per foot (true contents) in green state.	Weight per foot when seasoned.
Oak		
Beech		
Hornbeam	63 lbs.	
Acacia		46 lbs.
Elm		
Ash	55 lbs.	
Conifers	47 lbs.	31 lbs.

But, as the home-grown timber may not be absolutely green, and as the imported timber will not be absolutely

¹ This presumes that the weight of wood and bark is equal (per volume), and that the timber is not barked.

seasoned, the following average weights may be taken, in order to effect the comparison :—

	Weight per foot (true contents) in more or less green state.	Weight per foot in more or less seasoned state.
Oak		
Beech		
Hornbeam	59 lbs.	50 lbs.
Acacia		
Elm		
Ash	53 lbs.	
Conifers	45 lbs.	34 lbs.

Thus, in the case of Oak or the other heavy woods, except Ash, there is an actual increase in weight, owing to carrying green timber, instead of more or less seasoned timber, of 18 per cent.

And in the case of conifers, the increase amounts to $32\frac{1}{3}$ per cent.

So that it would seem that the railway companies are justified, when carrying home-grown timber in the "round," in adding to their rate per ton for square timber.

In the case of the heavy woods,* $27.4\% + 18\% =$ (say) 45%

" " conifers, $27.4\% + 32.3\% =$ " 59%

* Except Ash, when it should be 27.4 per cent. plus 6 per cent., equals (say) 33 per cent.

Thus, for given rates per ton in the plank, the rates for timber in the round, tape over bark, **should be** as follow :—

Heavy Hardwoods.		Conifers.
Rate in round should be	If rate per ton in plank equals	Rate in round should be
£ s. d.	£ s. d.	£ s. d.
I 0 4	0 14 0	I 2 3
I 9 0	I 0 0	I 11 9
I 1 9	0 15 0	I 3 10
0 11 7	0 8 0	0 12 9
		and so on.

And then again, in fairness to the companies, it must be admitted that the timber in the round occupies a great deal more space per actual cubic foot than square timber.

It is urged by some that the bark should be carried free of charge, but there seems no justification for such an assertion.

Having regard to the foregoing facts, it would seem that, speaking generally, the railway companies' charges are perfectly fair, except in the preference given to foreign boards, battens, and deals, and also the preference on pitwood (consigned direct to a mine), and on telegraph poles, scaffold poles, etc. (in many cases).

THE USES AND THE PRICES OF TIMBER.

In dealing with the prices obtained for timber in the wholesale market, it is impossible to give more than an approximate estimate of the value; for so much depends upon the local markets, the distance from a converting and manufacturing centre, the accessibility of the timber, the quality of the timber, and so on. Then again, it is of great importance to have a good knowledge of the various uses to which timber is put; for this will often reveal the demand, or otherwise, of any particular timber in any particular locality.

In all cases the cost of haulage and extraction must be carefully considered.

With reference to the prices quoted hereafter for timber, for which the general market has no special demand, such, for instance, as Oak burrs, Walnut, Box, Lime, Cherry, it will invariably be the better plan for the vendor's agent to endeavour to place such timber in its special market, and so to obtain a better price. It involves much extra trouble, but such extra trouble will be amply repaid.

Occasionally, also, it will pay to place some of the more common timbers in the hands of the converters. For instance, good Beech might be "slabbed" and sent to the chair-making districts, and so on.

The following list will show some of the chief uses to which timber is put, and also the prices that may be expected,

if there be a reasonable market within a reasonable distance. In all cases the higher prices indicate the best quality timber, and usually that of large dimensions; whereas, the lower prices are for small or inferior timber:—

OAK (Pedunculate or Sessile) :—

Uses.—High-class building work, window- and door-sills, coffins, panelling, church fittings, ship-building, cask staves, furniture, railway and other wagon building, spokes, parquet flooring, ladder rungs, railway “keys,” posts, piles, groynes, gates, and fencing, and, in fact, wherever great strength and durability are required.

Note.—The pedunculate is the stronger and harder wood of the two.

“Brown” Oak.—In some cases, when Oak are felled, they are seen to be “Brown,” though apparently healthy, and the timber is quite sound. Such Brown Oak have a great value, though not now so highly prized as formerly. The timber is cut into veneers, and used for ornamental furniture, picture frames, cabinets, fancy boxes, etc.

Oak “burrs,”¹ and Pollard Oak.—Often large “burrs,” or cushion-like excrescences, from which a mass of small twigs are growing, are found on the trunks of Oak trees (and other trees), and after the same manner, large cushions are found at the top of the trunks of Pollard Oaks, where they have been periodically pollarded. These burrs or cushions are of great value. They are very ornamental, and are cut into veneers, which present an appearance somewhat like “Bird’s eye” Maple, owing to the partial development of a mass of latent buds.

The veneers are used for ornamental furniture, etc.

¹ The primary cause of these “burrs” must generally be ascribed to various errors in sylvicultural management, which result in the flushing of latent buds; whereas the secondary cause, which prevents normal development, is most usually due to spring and autumn frosts; though there are other causes, such as repeated damage by deer or cattle; fungous disease of the young twigs (*? Myxoderma*), etc., etc.

OAK—*continued.*

Prices.—Good quality Oak (pedunculate or sessile) is worth 1s. 6d. to 2s. per foot for butts over 12 inches¹ quarter girth; one-half that price, *i.e.*, 9d. to 1s. per foot, for trees under 12 inches quarter girth, or for tops. Or, sometimes different prices are paid, according to the total number of feet in a tree, *e.g.*:

- For trees containing 10 cub. ft. or under, 9d. to 1s. per foot.
- For trees containing over 10 cub. ft. and under 20 cub. ft., 1s. 3d. to 1s. 6d. per foot.
- For trees containing over 20 cub. ft. and under 30 cub. ft., 1s. 6d. to 1s. 9d. per foot.
- For trees containing over 30 cub. ft., 1s. 9d. to 2s. per foot.

Brown Oak is worth from 7s. to 14s. a cubic foot according to quality and demand.

Oak “Burrs” or “Pollards” are worth from 2s. 6d. to 10s. per foot super. for every 1 inch in thickness.

TURKEY OAK—

Uses.—This timber is very inferior to the pedunculate or sessile Oak. It is a quick-growing tree, and has not the same strength; nor has it such a well-marked “grain.”

It may be used for panelling or any interior work, where great strength is not required, furniture, etc. It might be used extensively in place of much of the imported oak from Austria and elsewhere.

Price.—5d. to 9d. per cubic foot.

RED OAK (Q. rubra)—

This timber is superior to that of the Turkey Oak. There is, however, no home-grown timber on the market. It would be reasonable to anticipate a price of 10d. to 1s. 2d. per cubic foot.

¹ When timber is bought or valued on this plan, the average quarter girth of the butt, or of any length from stop to stop, is taken as determining whether full price or half shall be paid. No artificial stops are made; as, for instance, by measuring a length up to the exact spot where the tree or bole ceases to be 12 inches quarter girth.

ASH :—

Uses.—Wheelwrights' work, coach building, agricultural implements, shafts, furniture, chair legs, tool handles, oars, and wherever elasticity is of importance. The timber should not be more than about 70 years old when cut. English grown Ash is superior to imported Ash for nearly all purposes.

Prices.—Large sound butts, 1s. 6d. to 2s. 6d. a cubic foot. Small trees, if sound, 1s. to 1s. 6d.

SPANISH CHESTNUT :—

Uses.—It is an excellent substitute for Oak in many cases. It is quite as durable as Oak, but not so strong. It is used for gate posts, fencing, furniture. Good sound Chestnut free from shakes, as for instance, that grown in the South-West of England, can be substituted for Oak in most house-building work; and for the outside timber work of old "half-timbered" houses and cottages. The timber should usually be cut before it is more than 65 years old, though in the South-West of England slightly longer rotations are admissible.

Prices.—10d. to 1s. 6d. for butts 12 inches quarter girth and over; 6d. to 1s. for tops, or trees under 12 inches quarter girth.

ELM (English) :—

Uses.—Coffins, tin plate boxes, seats of wooden chairs, weather boarding, wheelbarrows, cart bottoms, pulley blocks, keels of ships, boarding for stall partitions in farm buildings, naves for wheels, etc.

Prices.—For sound butts 12 inches quarter girth and over, 8d. to 1s.; under 12 inches quarter girth and tops, 4d. to 6d.

ELM (Wych) :—

This wood is tougher than English Elm.

Uses.—It is used for the same purposes as English Elm; but for many purposes it is a more valuable wood. Young Wych Elm poles are often used for shafts instead of Ash, though they are heavier.

ELM (Wych)—*continued.*

Prices.—About the same as for English Elm. But in some parts of the country 2d. or 3d. a foot extra can be obtained, especially for young Wych Elm.

BEECH:—

Uses.—Furniture, and especially the legs and backs of wooden chairs, piano making, backs of hair brushes, boot and shoe trees, plane boxes, and other carpenters' tools. Keels of ships (sometimes). Frames of butter churns, cider presses. It lasts well under water and is used for planking (under water).

Prices.—These are very variable. Usually 10d. to 1s. 4d. for butts 21 inches quarter girth and over; and 5d. to 7d. for trees under 12 inches quarter girth and tops. But if near a chair factory or other manufacturing centre, up to 2s. a foot may be expected for large good butts, and 1s. to 1s. 6d. for smaller trees.

NORWAY MAPLE AND SYCAMORE:—

Uses.—Furniture, dairy utensils, bread-platters, and generally, for turning toys, reels, etc.

Large girthed clean butts have a special value as rollers in calico mills; but they must be over 18 inches quarter girth.

Prices.—10d. to 1s. 4d. a foot for fairly large timber, 5d. to 10d. for small timber. If large enough for mill rollers, 3s. to 5s. a foot.

POPLARS (Black and Black Italian and White):—

Uses.—Packing cases, bottoms and sides of carts, brake blocks for railway and other carriages, floor boards. It is the least inflammable of any wood. It makes excellent pulp wood.

Black and Black Italian Poplar have a special use for butter boxes or cases, as their timber is the least odorous of any timber.

POPLARS—*continued.*

Prices.—If near a good market, 8d. to 1s. 3d. But ordinarily, 6d. to 9d. In London large butts fetch from 1s. 3d. to 1s. 6d. As a rule the Black Poplars are worth 1d. to 2d. a foot more than the White Poplar.

The Lombardy Poplar is of little value, and is usually a drug on the market at 3d. a foot.

TREE WILLOWS :—

Uses.—Packing cases, bottoms and sides of carts, floor boards, charcoal for gunpowder, toy making. There is a special market for cricket bats, for which purpose the “close-barked” trees¹ are the best.

Prices.—6d. to 10d. a foot.

But if suitable for cricket bats, up to 7s. a foot may be obtained.

HORNBEAM :—

Uses.—Cog-wheels and other woodwork in machinery, pulley blocks, wooden screws and nails, turnery, and various minor purposes. The wood is very hard.

Prices.—10d. to 1s. 3d.

LIME :—

Uses.—Piano sounding boards, cabinet work, turnery, packing cases, leather cutting boards.

Prices.—9d. to 1s. 3d.

Occasionally a big price is obtained for special butts in a special market.

WALNUT :—

Uses.—Furniture, carving, gun stocks.

Note.—Most of the walnut used is of foreign origin ; and English-grown timber is not easily saleable at a good price. Gun stocks are imported roughly shaped, and home-grown timber cannot compete with them ; but home-grown timber should sell readily for furniture.

Walnut “Burrs,” are very valuable, and are cut into veneers. This trade, however, is almost entirely confined to France.

Vide Chapter XV.

WALNUT—*continued.*

Prices.—Walnut Timber (*Juglans regia*), 1s. 3d. to 2s. 6d. (or more) a cubic foot.

The **Black Walnut** should be worth considerably more—(say), 2s. to 3s. a cubic foot.

Walnut “Burrs” are bought by weight in the “trade,” at from £25 to £40 per ton.

BIRCH :—

Uses.—Furniture and cabinet making. Bobbins, staves for cheap barrels, clogs, turning, padlocks, charcoal for gunpowder.

Note.—Many of the padlocks used in London scaffolding consist of imported Birch. In America, thin layers of wood are skinned off round the circumference of a log and used as seats for tramcars, railway station seats, garden seats, etc.

Prices.—4d. to 8d. a cubic foot.

ALDER :—

Uses.—Clogs, cigar boxes, broom heads, toys. The timber will last well when entirely underground or when always under water, and is occasionally used for wooden drains. It is one of the best woods for charcoal for gunpowder.

Prices.—5d. to 9d. a cubic foot.

HORSE CHESTNUT :—

Uses.—Rollers for cotton mills (if large), pattern making (for castings), bottoms of carts, packing cases, turning.

Prices.—6d. to 8d. a cubic foot.

ACACIA (False Acacia) :—

Uses.—Gate and fence posts—(it is very durable),—tree nails, and by cabinetmakers, for it is a very handsome wood. On the Continent it is used for cart shafts and for spokes of wheels. It is a very elastic wood.

Prices.—Probably 1s. to 1s. 6d.; but the timber is seldom on the market.

PLANE :—

Uses.—Furniture, turning.

Prices.—About 1s. a foot; but it is rarely on the market.

BOX:—

Uses.—Mathematical instruments and foot-rules, turning, wood-engraving blocks.

Prices.—Probably 2s. to 6s. a cubic foot; but home-grown timber is seldom on the market.

It is generally bought by weight—say, £4 to £12 a ton.

HOLLY:—

Uses.—Much the same as for Box; it is also stained in imitation of Ebony.

Prices.—Probably 2s. to 5s. a cubic foot, if over 4 inches quarter girth; or say £4 to £10 a ton.

CHERRY:—

Uses.—Furniture, cabinet making, interior decorative work in houses, wooden block flooring, turning, musical instruments.

Prices.—6d. to 1s. 3d. a cubic foot.

LARCH:—

Uses.—Sleepers, pit props, for strutting and shoring tunnel work, etc., gates, fencing, straining poles in hop gardens, bridge building, and for general estate work. The timber is very durable, but has a tendency to warp and twist, and is not very suitable for ordinary building construction.

Prices.—If large and sound, 10d. to 1s. 5d. Small trees and poles, 6d. to 10d.

SCOTS PINE:—

Uses.—The timber, if well grown and free from side branches, can be used for all the purposes for which the "Red" Deal of commerce is used. For instance, general building purposes—joists, rafters, trusses, doors, and door frames, window frames, etc., pit timber, telegraph and telephone poles, scaffolding, etc.

Note.—Unless, however, it be grown in very close canopy when young, the preference will always be given to imported timber.

Prices.—4d. to 8d. a foot for large clean timber; 2d. to 4d. for small or badly grown trees.

CORSICAN PINE is used for the same purposes, and worth the same price. But **Austrian Pine** is much inferior in quality and value, and is always coarse and knotty.

WEYMOUTH PINE:—

Uses.—This is the “Yellow Pine” of commerce, and is used for high-class joinery, shelves, door panels, cupboards, etc., packing cases.

Prices.—6d. to 8d. a foot for clean grown trees.

DOUGLAS FIR:—

Uses.—This is the “Oregon” Pine of commerce. The **heart wood** is very strong and durable, and may be used wherever strength is necessary. In constructive building work—joists, rafters, trusses, quarter partitions, bridge building, sleepers, pit props, masts and spars of ships.

The **sap wood** may be kiln dried, by which means the “figure” of the wood is brought out, and it can be used for all interior house decorative work:—e.g., panelling, skirting, window boards, match lining, stair treads and risers, newels, handrails, shelves, etc.

Prices.—There is no home-grown timber on the market at present; but it is quite reasonable to expect 9d. to 1s. 3d. a cubic foot for closely grown timber, since home-grown timber is of excellent quality in all respects.

NORWAY SPRUCE:—

Uses.—This is the “White Deal” of commerce. The white Christiana flooring boards are cut from this tree.

It may be used for the same purposes as the imported timber, though it will seldom be of the same quality, except that grown in Scotland. Its uses embrace:—floor boards, inferior joinery, skirting, mouldings, packing cases, scaffold poles, pit props.

It makes excellent pulp wood.

Prices.—4d. to 7d. a cubic foot.

SILVER FIR :—

Uses.—It can be used for the same purposes as Spruce. The imported timber is often known as "White" Pine.

Prices.—4d. to 7d. a cubic foot.

THUYA GIGANTEA :—

Uses.—The timber is very durable and, in its native habitat, the timber is very valuable, and is used for gate posts, "shingles," outside weather boarding, and also largely in house construction and interior work, though it is not so suitable as the Douglas Fir for this purpose. The timber could be used as a substitute for Larch in many cases.

Prices.—It seems reasonable to anticipate a price of 6d. to 10d. a cubic foot.

PIT TIMBER FOR PROPS, ETC. :—

Almost any kind of timber can be used for such purposes ; though coniferous timber is more frequently used than the timber of broad-leaved trees.

Almost any tops or poles down to $2\frac{1}{2}$ to 3 inches diameter at the small end can be used, if they are straight. They are used in various lengths from 2 feet 2 inches and upwards.

Prices.—Poles suitable for pitwood are usually sold by the ton weight, or by the load, etc. The actual price in the forest will chiefly depend upon the distance from a colliery. About £1, 2s. a ton is paid by some collieries for suitable poles delivered at the colliery ; so that, the price in the forest would be about £1, 2s. a ton, less the cost of haulage, say 1s. a ton per mile (for road haulage) if there were no middleman's profit to be allowed for.

RAILWAY SLEEPERS :—

Within recent years foreign timber has been almost exclusively used for this purpose, but formerly home-grown Larch was chiefly used, and sometimes Oak.

RAILWAY SLEEPERS—*continued.*

Fairly large timber is necessary for cutting into railway sleepers, which are 9 feet long by 10 inches by 5 inches. If two sleepers are to be cut out of one length, the small end of the log must be 12 inches quarter girth under bark. But if only one sleeper is to be cut, the small end need only be $8\frac{1}{2}$ inches quarter girth under bark.

Prices.—The timber will be bought at so much a foot, in the ordinary way.

CORDWOOD is used chiefly for firewood, though some kinds are burnt for charcoal, and there are other minor uses.

Prices.—This will depend upon the size of the cord and the vicinity to a good market, etc.

In well-wooded districts a cord 8 by 4 by 4 feet is worth from 8s. to 10s.; a cord 16 feet 4 inches by 2 feet 6 inches by 2 feet 2 inches is worth from 4s. 6d. to 6s. 6d.; though if near large towns another 25 per cent. or 50 per cent. may be added to these prices.

These prices are equal to about 5s. per ton weight, and as the heating power of wood is about half of that of good coal, the price compares very favourably with that of coal, in spite of the more or less unavoidable waste in burning more wood than is required.

FAGGOTS :—

Prices.—These vary largely, according to the size of the faggots and the demand, etc.

Small faggots of “browse”—*i.e.*, tops of coniferous trees—(about 5 feet long) are worth about 5s. to 6s. 6d. a 100.

Small faggots (about 5 feet long) of coppice or hardwood trees, 8s. to 10s. 6d. a 100.

Large faggots of coppice or hardwood trees, 13s. to 18s. a 100.

CHAPTER XV.

SYLVICULTURAL NOTES ON TIMBER TREES— BROAD-LEAVED TREES.

ACACIA (False Acacia).

Robinia pseudo-Acacia = **The Acacia (False) or Locust Tree.**

It is not a native tree to this country.

As to Seed.—The seed ripens in early autumn in England, but it rarely ripens in Scotland.

Home-grown seed should generally be avoided.

Spring sowing is to be recommended, but the seed should be kept in the pod until the season for sowing arrives, otherwise its germinative capacity rapidly deteriorates.

The germinative capacity is about 55 per cent.

One pound of seed contains about 22,000 seeds.

The timber is very hard and durable and elastic. It is the most durable (when felled young) of any timber that can be grown in this country.

It is an easy timber to work, but often causes sores to those engaged in working it; apparently, on account of some poisonous properties inherent to it.

It is largely used for making long wooden pegs or nails for use in shipbuilding.

Soil and Situation.—A light, deep, dry soil is the most suitable for it. It will not thrive on wet soils or stiff clays.

On poor, deep, dry soils, it grows quite well, where other broad-leaved trees, except Birch or White Alder, would absolutely fail. It requires considerable summer warmth, and is very tender as to spring and autumn frosts.

Southern aspects suit it best, provided frosts are avoided.

Cultivation, etc.—It is a very light-demanding, thinly foliated tree. Its roots are stoloniferous and extend over a large area, and it throws up innumerable suckers.

It is a very rapid-growing tree, but generally becomes rotten at the heart when more than 40 to 60 years of age, at which period it should be felled.

Occasionally it may be planted as standards over coppice; but there is at present very little market for its timber, and its chief use should be for estate fences, gate posts, etc., for which purpose, however, it will not pay to grow it separately.

It is valuable for planting as a fire belt on dry sandy Pine soils, in the same way that White Alder and Birch may be planted; but, otherwise, it is of little sylvicultural interest, until a greater price can be obtained for its timber in the open market.

It shoots very well from the stool, when coppiced.

It is the only large leguminous tree that has been planted for timber in this country; and on poor soil the nodules on its roots are instrumental in rendering the free nitrogen of the air available for the use of the tree.

ALDER.

Alnus glutinosa = Common Alder.

Alnus incana = The White Alder.

The Common Alder is a native tree to this country.

As to Seed.—The seed ripens at the end of September, and the germinative capacity is about 25 per cent. One pound of seed contains about 320,000 seeds.

Trees 25 years old give good crops of seed, and good seed years occur every 2 or 3 years.

The timber is soft and splits easily, and is of a reddish-brown colour. It lasts for a long time under water, but otherwise soon decays.

If logs are not converted at once, they must be barked, or strips of bark must be taken off, so as to help it to dry; otherwise, it very quickly deteriorates.

Soil and Situation.—A moist soil is essential. It will grow in the wettest of soils, provided there be no stagnant water. It is very sensitive to drought. A moderately deep soil is necessary. It is fairly hardy as to late frosts.

Cultivation, etc.—It is a light-demanding tree; but will bear considerable shade when young or when coppiced, provided the soil be sufficiently moist. It is an excellent tree for coppice on very wet soils. It grows very rapidly from the stool and lends itself to a long rotation as underwood, coppice poles 25 years old often being 40 feet high, and very straight and clean. The stools are long-lived.

Short rotations are harmful to it.

It is not a very profitable tree to grow by itself; and the market for its timber is not very good in most localities. It is most useful as coppice under Poplars, Willow, Ash, or Oak.

The White Alder grows well on the same kind of soil as the Common Alder. But it will also thrive on very dry soil; and it can bear a considerable amount of shade. It is very quick growing when young. It has stoloniferous roots, and throws out innumerable suckers.

It has been used successfully to bind together spoil heaps, consisting of the waste from stone quarries.

Planted at considerable distances apart, the ground soon gets completely covered ; and the barren spoil heap, formerly an eyesore, presents a pleasing spectacle.

It is also most useful for forming fire belts of coppice on dry barren sands, where most other hardwoods would fail.

Of Insects.—A saw-fly, *Cræsus septentrionalis*, often does considerable damage by defoliating the trees.

ASH.

- Fraxinus excelsior* = The Common Ash or European Ash.
- Fraxinus Americana* = The White Ash or American Ash.
- Fraxinus Oregonia* = The Oregon Ash.
- Fraxinus viridis* = The Green Ash.

The Common Ash is a native tree to this country, and is one of the most valuable trees that can be grown.

It produces seed freely and constantly from about the 30th year onwards ; or earlier if grown in the open.

As to Seed.—The seed ripens in October, but does not germinate until the second spring. The seed should be kept, meantime, in pies of moist sand, and finally sown in drills in April of the 2nd year.

An average germinative capacity of the seed is about 60 to 65 per cent. ; and 1 lb. of seed contains about 6800 seeds.

The timber quickly deteriorates if left in the forest ; it loses less weight in seasoning than any other hardwood timber.

The timber is very valuable ; and is usually worth as much per foot, or more, than the best English Oak. It is the most elastic of any British-grown timber, and is far superior to all imported European Ash.

Soil and Situation.—A deep marl (if not too stiff) or a good loam with some lime in it, is the most suitable soil for Ash ; and a constant, plentiful supply of moisture is essential ; but wet soils should generally be avoided, as spring frosts are far more common on such soils. Shallow soils, or stiff soils, or light dry soils are quite unsuited to it.¹ A thick humus soil covering is of great advantage.

The tree is very susceptible to late spring and early autumn frosts, and the greatest caution is necessary when planting it. Fortunately, it is usually rather late in coming into leaf. It likes moist air; and succeeds far better on northern than on southern aspects. Where late frosts are

¹ However, Ash poles, up to 20 or 30 years old, can be grown on stiff clays and on other soils which are quite unsuitable for mature timber.

feared, the young crop should be raised under a light shelter wood.

Cultivation, etc.—The Ash is a very thinly foliaged tree, and pure crops of Ash are quite unable to keep the soil clean or preserve soil moisture for more than a few years.

The trees are very light-demanding after they are about 20 to 30 years of age ; but, up to that period, they will bear slight shade ; so also will young coppice poles. Young self-sown Ash will bear far more shade than planted trees.

The trees grow very rapidly when young ; and are not usually checked very much by being transplanted, as is the case with Oak and Beech and Spanish Chestnut.

Any newly planted trees which do not grow rapidly should be cut over at the ground level, and the best shoot only allowed to grow.

Ash is peculiarly suited to being cut over in this manner, and the resulting growth is generally very clean and straight, and possesses less tendency to forked growth. The cutting over may be done at the time of planting, but it is best to wait one, two, or more years.¹ The forked growth is often caused by the young leading shoot being nipped by frost and the subsequent development of two opposite buds lower down.²

Ash make excellent standards over coppice.

In high forest they may, advisably, be grown pure and underplanted, with seedling shade-bearing trees, before the land has got in a foul state. Again, Ash can often be easily regenerated, naturally ; and the shelter of the mother trees affords beneficial protection to the young crop from frost. This natural regeneration will not usually be possible on very moist soils, as the young crop will get choked by weeds.

¹ An instance occurred where some Ash, which had been planted 14 years and were not thriving, were thus cut over, and then grew 11 feet in one season.

² All the lower buds open later than the bud of the leading shoot ; hence the leader is more likely to suffer. In Germany a forked growth is often caused by the larva of the Ash bud moth attacking the bud of the leading shoot.

But on fairly moist soils, it is often very easy and very profitable.

Ash naturally regenerated may be perpetually grown as a **two-storied high forest**, the upper storey being removed when necessary.

Larch and Ash grow well as a mixture for about 30 years; after that, one or other of the species should usually be cut out (as the Larch will surpass the Ash), and underplanting should take place.

Ash and Spanish Chestnut is another very good mixture; though the Chestnut, thus grown, will be rather coarse; but they can advisably be coppiced.

Ash is peculiarly suitable for the system of high forest with coppice. And for being partially cleared from the 35th year onwards.

Usually, when Ash is grown in a mixture, in high forest, it should be planted in small pure groups or patches; for its side branches will have little pruning effect on any other trees except Larch, with which it may be mixed by single trees.

The thinnings of Ash and small poles are most valuable.

Young Ash standards in coppice should, if the rotation be a long one, be freed from time to time of any growth of coppice which threatens them, otherwise they will be unduly drawn up, and will be unable to support their own weight when the coppice is cut.

Rotation.—This must be short—from 65 to 75 years.¹

Average Returns from pure crops in high forest should be per acre:—

Thinnings	1380	cub. ft. to 2 in. q. g.
-------------------	------	-------------------------

Final yield (at 70 years) .	1900	" 6 "
-----------------------------	------	-------

Total production . . .	3780	" 2 "
------------------------	------	-------

Average annual increment, 54 cub. ft.

Equivalent net rental ² for land only { at 3% = 17s.
(from date of planting) { at 4% = 9s. 3d.

¹ Thus, seldom can any undercrop be felled at the same time.

² After deducting interest on £8, the cost of planting and establishing the crop

Of Fungi.—The **Canker Fungus** (*Nectria ditissima*) causes cankerous spots on the bark, and the timber becomes blackened, and acquires a most unpleasant smell.

Various species of **Polyporus** (or Bracket fungi) attack the stems and branches. *Fomes igniarius* causes white rot.

Of Insects.—The Ash Bark Beetle (*Hylesinus fraxini*) attacks the upper branches of healthy trees, and often kills them. This beetle, together with *H. crenatus*, is very common on sickly trees.

The Ash Branch Bark Beetle (*H. oleiperda*) also occasionally does damage. Cockchafer grubs gnaw the roots of young trees.

Of other Pests.—Rabbits are, perhaps, more fond of eating the bark of Ash than of any other tree.

The American Ash, or White Ash, and the Oregon Ash have probably a great future in this country. Though, until their success be proved by time, any planting of them must be regarded somewhat in the light of an experiment. There is, however, every probability that the Oregon Ash will prove a most valuable tree in this country; and may, possibly, rival the Common Ash.

Both grow very quickly, and they are peculiar in that their seed germinates during the first year. They are usually rather later in coming into leaf than the Common Ash, and so often escape a spring frost when the common variety suffers.

The White Ash will grow on **rather dry, sandy soils**, such soils being far too dry for the Common Ash. It is therefore worth an extensive trial on such soils. It is the quickest growing of any variety of Ash.

The Green Ash is not likely to be of much value, as it does not usually grow to a large size.

BEECH.

Fagus sylvatica = The Common Beech.

This tree is a **native** tree to England, but not, apparently, to Scotland.

As to Seed.—The seed ripens in the autumn.

From the 60th year onwards the Beech produces good crops of seed. But seed years are very intermittent; a really good year occurring about once in every 5 to 12 years.

An average **germinative capacity** of the seed is about 50 per cent.

And 1 lb. of seed contains about 2000 seeds.

The **timber** is not very strong, nor is it durable when exposed to inimical influences; though it will last well under water. It lends itself to being steamed, and then bent; and it takes creosote very well. It is very liable to be worm eaten. It must be quickly removed from the forest, as it soon deteriorates if left, and loses its colour. If felled when the sap has risen, the timber invariably becomes inferior in colour, and streaked with black markings.

Soil and Situation.—Beech will thrive on a very great variety of soils, but, generally speaking, a fairly deep soil is necessary. It delights in a calcareous soil, and will thrive on shallow soils resting on chalk, or on shallow clay soils resting on disintegrated limestone rock. It is not suited to very stiff clays; but, on moderate clays, if the situation be not too wet, it will succeed admirably. Any prolonged flooding of the land is usually fatal to it. Very dry soils are not suited to it; but, on deep light land of fair quality it usually succeeds well. It should not be planted on land that has long been covered with heather, as such land is nearly always too acid, even if well drained, for the growth of Beech, or any broad-leaved trees, except Birch or Alder. Beech are very susceptible to late spring and early autumn frosts, and the former danger is intensified, inasmuch as the trees usually break out early into leaf. Young Beech are very susceptible to hot sun; and, for the first few years of their existence, overhead shade and

shelter is very beneficial to them. Northern aspects are far more suitable for their growth than southern aspects.

Cultivation, etc.—The Beech is a very densely foliated tree, and can bear a very great amount of shade. Its side branches are not easily pruned off by other trees. It is of slow growth when young; but, ultimately, grows to a great height provided it be crowded, and provided its strong tendency to form a crown be delayed. It receives a considerable check on being transplanted; and it is very impatient of pruning until it has become well established. If any plants be cut over, at ground level, at the time of planting, as may be done with Ash, Norway Maple, or Sycamore, they are almost sure to be killed. Even when well established, the tree will not usually stand being coppiced for more than a few times; and, after about the second cutting, its vigour is lessened each time it is coppiced.

Beech makes an excellent hedge, and will stand trimming well; and, when thus treated, the leaves, though dead, are retained all through the winter.

Its dense foliage and thick fall of leaves enables it to protect and improve the soil in an extraordinary manner. For this reason it is a very desirable tree in most mixtures. It may be grown pure, as even-aged high forest, or under the group or selection systems. It is most valuable for mixing with other broad-leaved trees, or with Larch. It is, however, far preferable to use it in uneven-aged mixtures than in even-aged mixtures; for, in the latter case, it will ultimately outgrow and overtop most broad-leaved trees, and, owing to its slow growth when young, it will fail to prune any other trees unless they, also, are slow growing. And then again, if planted on open land, the young trees suffer from late frosts and hot sun. However, if attempted, even-aged mixtures should nearly always be by patches, though Beech and Larch may be otherwise mixed; but unless the Beech form the greater proportion of the crop, they will be very coarse. The Beech is admirably suited for underplanting; and, if the land be clean enough, 1 year seedlings can be dibbled in at a very small cost. However, none but

thinly foliaged trees should be underplanted, except under rare circumstances.

Natural regeneration is very easy, provided the land be clean and be not at all acid or sour,¹ and also that rabbits be kept down. But the "seed" felling must be delayed until a good seed year comes.

Thinnings are usually necessary from about the 25th year onwards.

Rotation.—90 to 130 years for even-aged high forest. But on poor land or under the selection system a rotation of 85 to 100 years will usually give the best result.

Average Returns from pure crops in close-canopied high forest should be per acre :—

Thinnings 1660 cub. ft. to 2 in. q. g.

Final yield (at 120 years) 4800 " 6 "

Total production . . . 7060 " 2 "

Average annual increment, 58 $\frac{3}{4}$ cub. ft.

Equivalent net rental² for land only } at 3% = 1s. 1d.

(from date of planting) } at 4% = minus 4s. 8d.

Of Fungi.—**Phytophthora omnivora** often destroys beds of seedlings in the nursery, causing the well-known "damping off." It is somewhat similar to the potatoe disease.

Nectria ditissima causes a canker on the stem. Beech is also attacked by various species of **Polyporus** and **Fomes** or Bracket fungi, e.g., *Fomes fomentarius*, *Fomes igniarius*, *Polyporus sulphureus*. *Agaricus melleus* is a very common saprophyte on the decaying stumps of old Beech trees.

Of Insects.—The **Felted Beech Scale**—**Cryptococcus fagi**—is very common, and often does great damage to trees. It is recognised as a white felt-like substance on the bark of the trees.

The weevil (*Orchestes fagi*) attacks the leaves of trees.

¹ For this reason natural regeneration is far more common and far easier to effect in cases where the soil contains much lime, than where there is little or no lime in the soil.

² After deducting interest on £8, the cost of planting and establishing the crop.

The Aphid (*Philaphis fagi*) attacks the leaves, and causes the so-called blight.

Cockchafer Grubs gnaw through the roots of seedlings and young trees; and often do great damage.

The foliage is eaten by the larvæ of the Hop Dog Moth (*Bombyx pudibunda*).

BIRCH.

Betula alba = The Common Birch.

Betula papyracea = The Paper Birch.

Betula lutea = The Yellow Birch.

There are two distinct varieties of the Common Birch:—

(i) The smooth bark variety = *Betula alba pubescens*.

(ii) The rough bark variety = *Betula alba verrucosa*.

The **Common Birch** is a **native** tree, but not the others.

As to Seed.—It produces much seed when about 25 years of age; and good seed years are very frequent.

The **germinative capacity** of the seed is only about 20 per cent.

One pound of seed contains about 800,000 seeds. The seed ripens about the end of August.

The **timber** is moderately hard, and does not split well. It is a very handsome wood.

Occasionally large “*burrs*” are met with which are very valuable for cutting into veneers.

Soil and Situation.—Birch will grow on almost any soil, but it seems to avoid chalky soils. It springs up naturally on water-logged land and on dry barren sands. It is quite immune to late spring and early autumn frosts.

Cultivation, etc.—It is a very light-demanding tree. As a timber producer it is of little value in this country; but it is the best “*nurse*” which exists.

Where it is desired to plant a frost tender species in a locality subject to late spring and early autumn frosts, the growth of Birch affords a ready means of effecting this purpose. Two year seedling Birch may be dibbled in, and the tender species planted in about 10 years’ time. Such tender species must be able to withstand some shade; but the canopy of Birch is very light and thin.

After the same manner, a few Birch growing over young crops of Silver Fir or Beech, will afford welcome protection, not only from frosts but also from hot summer sun.

Birch may also be planted as fire lines on very dry sands,

but it is not so efficient as White Alder, as it is not so dense, nor will it submit to much coppicing; for most of its reserve nutriments go to form seed.

The Paper Birch may possibly prove superior to the Common Birch in many cases. It grows quicker and taller, and endures more shade than the Common Birch; but it appears to be much more exacting.

The Yellow Birch grows up to 100 feet in its native country, and is much used for furniture.

CHERRY.

Prunus avium = The Common wild Cherry or Gean or Mazzard.

Prunus padus = The Bird or Black Cherry.

As to Seed.—The seed or “stone” should be sown as soon as it is ripe, about the beginning of July; otherwise, its germinative power is quickly lost.

The timber is hard and not very heavy; and the heart-wood is of a beautiful brownish-pink or brownish-yellow colour, and takes a very fine polish. It is valuable to furniture- and cabinet-makers, and is used for parquet flooring, and for ornamental wooden block floors. It is also sometimes used for the heads of wooden golf clubs.

Soil and Situation.—The trees grow on almost any soils, though a fairly deep soil is necessary for their proper development. They will grow on thin soils if the subsoil rock be disintegrated. They delight in calcareous soils and prefer a fairly dry soil. Stiff wet soils are not suited to them.

Cultivation, etc.—The trees are quick growing, thinly foliated, and light-demanding; though the *Prunus padus* will bear very slight shade. Both species will coppice well. The *Prunus avium* (or Gean) makes the taller and better tree, and its timber is rather darker than the Bird Cherry.

The Gean is only suitable for a short rotation of 60 to 70 years, as it is apt to become rotten at the heart, though apparently sound when standing. It will probably pay to plant on many rather poor soils; and it might be grown as standards over coppice. The present market for its timber is small and unremunerative; but if the timber became better known, it should find a ready market. For there is an increasing tendency for furniture- and cabinet-makers to work up some of the less common kinds of timber; and, with a little patience and trouble, a good market might be created.

ELM.

Ulmus campestris = The Common or English Elm.

Ulmus montana = The Wych or Scots Elm.

Ulmus Americana = The American Elm or The White Elm.

The Scots Elm is native to this country, but the other two varieties have been introduced.

As to Seed.—The seed of the English Elm never ripens in this country; but the Scots Elm seeds freely and frequently. The seed is ripe in about the first week in June, and should be sown immediately. The **germinative capacity** of the seed is about 25 per cent., and 1 lb. of seed contains about 60,000 seeds. Good seed years are very frequent. The English Elm is propagated by root-suckers.

The timber is not very strong as regards resistance to weight, tension, and shearing. But it is very difficult to split; and it is very durable. The timber of the Scots Elm is stronger and more elastic than the Common Elm; and, when young, is often used in the place of Ash. In many parts of the country, it is worth about 3d. a foot more than the Common Elm, provided it be cut when quite young. The heartwood of the English Elm is reddish-brown in colour, but that of the Scots Elm is not conspicuous in this manner.

Soil and Situation.—Elm require a considerable amount of moisture. They will grow in a great variety of soils; but, dry sandy soils, or thin chalky soils, or very stiff clays, are quite unsuited to them.

Clays that suit the Sessile Oak will also generally grow good Elm; and Elm will grow on soils which are far too stiff for Ash.

Generally speaking, Elm require a deep soil, but they will thrive very well on quite thin clay soils, provided that the subsoil rock be disintegrated. Stoney subsoils seem to suit them, as is the case with Larch.

The Elm are fairly hardy as regards late and early frosts; and they are one of the few trees which seem to grow equally

well on southern aspects. The Wych Elm does not require so much warmth as the English Elm, and will grow well in the North of England and Scotland, whereas the English Elm thrives best in the South of England.

Cultivation, etc.—Both trees are very light-demanding. The Scots Elm, unless grown in close canopy, tends to form a large crown in early life, whereas the English Elm is a straighter growing tree. Both trees ultimately develop very large boughs, which often break off and split down the trunk. The Wych Elm is more storm-proof and deeper rooted than the English Elm; and it grows faster than the latter. The English Elm is one of the least storm-proof trees there are. Both trees coppice very well and grow vigorous stool shoots even if the trees are 40 or 50 years old. Both trees also produce an abundance of suckers.

They may be grown in even-aged high forest, or as hedgerow timber.

The English Elm may, possibly, be grown as standards over coppice. It makes the better hedgerow tree of the two, as it forms a taller and straighter bole, though its roots are very spreading.

It will, however, seldom be advisable to plant Elm in the South of England, for there is an abundance of it in the hedgerows; and the supply is quite equal to the demand; and, furthermore, after severe gales enormous quantities are often, of necessity, thrown upon the market with a corresponding diminution in price.

In the North of England and Scotland, the Wych Elm will often prove more profitable than most trees, when grown upon suitable soil.

On a long rotation of 25 years, Wych Elm forms very valuable coppice; and the stools last a long time.

Of Fungi.—Various species of **Polyporus** and **Fomes** attack the tree through wounded surfaces.

Of Insects.—The **Elm Bark Beetle**—*Scolytus destructor*—is often very destructive. It, generally, first attacks the ends of branches and tops, and works down the tree, separating the bark from the wood.

The American Elm.—May prove very valuable in this country; but it is too early at present to form an opinion. When young it is very quick growing, transplants well, and seems decidedly hardy as to late frosts. Also, it appears to bear rather more shade than the English or Scots Elms.

HAWTHORN.

Crataegus oxyacantha = The Common Hawthorn or "Quick."

This is of interest as being the most common species to plant for hedgerows; and it forms the best fence against stock that can be grown.

As to Seed.—The seed or "haws" are ripe in November.

They should be immediately mixed with dry sand, and stored for about 16 months in a heap or pie out in the open. By this means the outside pulp is rotted off, and the seed is then fit for sowing, which should take place in the beginning of March.

Soil and Situation.—It will grow almost anywhere; except on very wet soils or on very dry soils, where its growth is unsatisfactory. It delights in deep marly soils. It is extremely hardy as to spring and autumn frosts.

HAZEL.

Corylus avellana = The Hazel.

This is more a shrub than a tree, and is found largely in coppice.

It is native to this country.

As to Seed.—One pound of seed contains about 420 nuts.

Soil and Situation.—It will grow on almost any soil, but not on swampy ground. It is little injured by spring and autumn frosts.

Cultivation, etc.—It is invariably treated as coppice ; the stool shoots are vigorous and the stools last a long time.

It will bear considerable shade.

Hazel coppice has now very little value, and should seldom, if ever, be planted. Where it predominates, it should be grown on a short rotation of 6 or 7 years, when the produce is more easily sold than if left until older.

HORNBEAM.

Carpinus Betulus = Common Hornbeam.

It is native to England, and possibly to parts of Scotland.

As to Seed.—It produces seed freely when about 40 years of age; and seed years are very frequent.

The germinative capacity of the seed is about 65 to 70 per cent., and 1 lb. of seed contains about 14,000 seeds. The seed does not germinate until the second spring, and must be kept in sand, as is done in the case of Ash seed.

The timber is very hard, heavy, and tough, but not very durable when exposed to inimical influences. It is very liable to be cross-grained.

Soil and Situation.—Hornbeam is found naturally on rather stiff clay lands, but it will grow on almost all soils, provided they be deep. It is distinctly hardy as regards spring and autumn frosts, and will, therefore, often succeed where Beech must fail.

It will grow on much heavier clay soils than Beech could possibly succeed upon.

Cultivation, etc.—Hornbeam is densely foliated, and will bear a great amount of shade, but not so much as Beech. Like the Beech, it is a great soil improver. It grows quicker than Beech when young, but later on it is surpassed by Beech. It never grows into very tall trees, like Beech; but has a strong tendency to form a branched crown.

The Hornbeam may be grown and cultivated in a similar manner to the Beech; but its smaller out-turn usually renders the latter preferable wherever it can be grown.

However, in cases where underplanting has been decided upon, and only a short rotation is desired for the undercrop, it will often be preferable to underplant with Hornbeam instead of Beech; as the former more quickly grow into saleable timber.

Hornbeam makes excellent coppice, and the stools last for centuries. It is quite probable that, in view of the low price of coppice produce, the Hornbeam will prove one of

the best trees to grow for coppice; for it will bear great shade, and there will not be the same expense in keeping the ground fully stocked.

Hornbeam is admirably suited for the coppice in the system of high forest with coppice.

The Hornbeam may be cut over at ground level the year it is planted; but it is best to wait for another year. The tree is not much checked by being transplanted, and grows rapidly when young.

Of Fungi.—*Nectria ditissima* causes a canker on the stems.

Of Insects.—Cockchafer grubs do much damage to seedlings and young plants.

The larvæ of the Winter Moth (*Geometra brumata*) sometimes devour the foliage.

HORSE CHESTNUT.

Aesculus hippocastanum = The Common Horse Chestnut.

It is not a native tree; and is said to have been introduced about 1629.

The Timber is soft and not durable, and is of small market value.

Soil and Situation.—A fairly deep soil is necessary, but the tree is not very particular, though it will not thrive on very stiff wet clays. It appears to like calcareous soils. It is fairly frost hardy, even though it breaks out very early into leaf.

Cultivation, etc.—The tree is quick growing, but of little sylvicultural value, and the market for its timber is bad. It is able to bear a fair amount of shade.

When sown in the nursery, the nuts should be placed with the scar downwards; a very vigorous growth is made the first year; seedlings 1 year old being often over 12 inches high.

Of Fungi.—*Nectria cinnabarina* often does great damage to the crowns of the trees.

LIME OR LINDEN TREES.

Tilia Europea = The Common Lime, or Linden, Tree.

There are several varieties of the European Lime, but none of them are native to this country; though the tree is said to have been introduced by the Romans.

Of these varieties may be mentioned:—

Tilia grandifolia = The large or broad-leaved Lime.

Tilia parvifolia = The small-leaved Lime.

Tilia rubra.

Tilia intermedia.

As to Seed.—The seed ripens in this country in October; and the best trees can only be grown from seed; though, usually, the trees are propagated by layers.

One pound of seed of the broad-leaved variety contains about 5000 seeds; and 1 lb. of the small-leaved variety about 15,000 seeds.

The germinative capacity of both varieties is about 55 per cent.

The seed should usually be sown as soon as ripe, and the beds protected from frosts as the seed germinates. If sown in the spring, the seed should be stored in rather damp sand (but not wet sand); for, if stored in the dry, much of the seed will not germinate until the second spring.

The timber is white, soft, and close-grained, and is lighter in weight than that of any other common broad-leaved species. Like all white-wooded trees, it should be quickly removed from the forest after being felled.

Bast is obtained from the bark.

Soil and Situation.—The Lime will grow upon almost any soil provided that it be fairly deep and not too dry; and, on the other hand, not too wet.

It is often found growing upon thin dry soils overlying disintegrated limestone rock.

It usually requires a fairly sheltered situation.

The trees are tender as to spring and autumn frosts, and also as to drought.

The broad-leaved species is rather more exacting than the other species.

When grown for ornament in towns, or when the atmosphere is impure, a smooth-leaved variety (*e.g.*, *T. intermedia*) should be planted, as its leaves are washed clean by each heavy shower of rain.

Cultivation, etc.—The trees grow fast, especially the broad-leaved variety; and on good soil they are capable of withstanding considerable shade. They suffer little from being transplanted, and get established almost at once. They stand pruning very well; but, as is the case with all soft-wooded trees, only small branches should be pruned, on account of the danger from fungous attacks. The trees coppice well, and the stools are long-lived.

Lime may be used for underplanting thinly canopied crops, and may often be useful where other species, except Hornbeam, might outgrow the overwood before the latter were ready to be felled. The trees are thickly foliaged, and their fall of leaves can well protect the soil.

Trees raised by layering appear to have a greater tendency to throw out side branches and to develop a mass of latent buds along the stem and at the base of the tree than is the case with those trees raised from seed.

Owing to the limited market for the timber, the planting of lime can hardly be recommended. A limited number of trees can often be sold well if the retail market be sought out; but, otherwise, there is only a poor market for the timber.

If, however, the timber could be sold for about 1s. 6d. a cubic foot, it would probably pay to plant it, especially the broad-leaved variety.

Of Fungi.—*Nectria ditissima* sometimes causes a canker on the bark of the stems and branches.

Nectria cinnabarinus, the **Coral Spot Fungus**, causes a canker on the branches.

Of Insects.—The larvæ of the Winter Moth (*Cheimatobia brumata*) devour the foliage.

OAK.

- Quercus pedunculata* = The Pedunculate Oak.
Quercus sessiliflora = The Sessile Oak.
Quercus cerris = The Turkey Oak.
Quercus rubra = The Red Oak.
Quercus ilex = The Evergreen or Holm Oak.

Of these varieties the **Pedunculate and Sessile Oak** are of the greatest sylvicultural importance in this country. They are both **native** trees.

As to Seed.—Seed is produced freely from about the 60th year onwards, and good seed years occur about every 3 to 6 years. The seed ripens in October. It is of the greatest importance that only the best seed should ever be used. Seed should be collected from strong, vigorous trees, and also from such as show a predisposition in youth to form a long leading shoot, and to grow a clean stem free from side branches.¹ Such trees should be specially marked as “seed” trees.

The **germinative capacity** of the seed is about 60 to 65 per cent.; and 1 lb. of acorns of the pedunculate variety contains about 130 acorns, whereas 1 lb. of the sessile variety contains about 155 acorns.

The **timber** is very strong and durable, and most valuable. The timber of both species has the same market value; though the pedunculate is rather the better.

Soil and Situation.—Both these Oak prefer a deep, moist, stiffish loam for their best development. However, they will both grow on stiff clays. The pedunculate Oak will grow on very stiff wet clay soils if not sour; but, on such land, the growth is very slow indeed.

The sessile Oak is not suited to very stiff clays; but it will thrive well, and is found naturally on rather dry soils, provided they be fairly deep, such soils being far too dry for

¹ The absence of side branches is not always entirely dependent upon the adoption of correct sylvicultural methods; for, occasionally, trees growing in the open show a pronounced tendency to grow with a clean stem free from side branches.

the pedunculate Oak. The sessile Oak will also thrive at higher elevations than the pedunculate Oak.

Both trees are susceptible to late spring frosts; but, as they are amongst the latest trees to break into leaf, they often escape damage, when other trees suffer.

In this connection it should be remembered that the sessile Oak is sometimes rather later in breaking into leaf than the pedunculate Oak.

Severe winter frost is harmful to these Oaks; and much damage is often done to the timber by frost cracks, a bole often splitting all the way down. These trees will succeed better on southern aspects than most other species; they have a deep root system, and are very storm-proof trees.

Cultivation, etc.—Both trees are very **light-demanding**, and both have a strong tendency to form large crowns, and to develop and retain side branches. In this respect the sessile variety is rather more tolerant of slight shade, and does not possess such a strong tendency to form large crowns, and it will usually grow with a longer bole than the pedunculate variety.

The foliage of the trees is not dense; and pure crops, when about 40-60 years of age, will fail to keep the surface-soil clean, and the supply of moisture will be lessened.

Only a very small proportion of the trees planted on any area will ever develop into clean, quickly-growing trees, as compared to crops of other species. Therefore, when grown in high forest, it will usually be preferable to plant pure Oak, at a distance of 3 feet apart each way, and then to **under-plant** the crop when the canopy is getting broken at (say) 50 to 60 years of age. By this means, there will be a large number of trees to choose from, as the whole crop left at (say) 50 years, should consist of only strong, healthy, vigorous trees. After about the 70th year, the crop should be partially cleared at intervals. Close-canopied mature crops of Oak are never profitable, with the timber selling at its present price. The thinnings may usually be left to nature, till the trees are about 20 feet high. The thinnings and partial

clearances should be made very gradually in close-canopied crops, otherwise epicormic branches will be thrown out, and the trees may become stag-headed. The undercrop, if suitable, may be periodically coppiced, thus constituting high forest with coppice.

Even-aged mixtures with Oak are usually not very satisfactory, as the Oak will generally be outgrown, unless indeed the other trees be coppiced. Where, however, mixtures are attempted, the oak should be planted (pure) in patches, unless indeed the mixture consist of Oak and Hornbeam. In this case, however, it will often be necessary to give the Oak artificial aid during the first 30 or 40 years. One of the best uses for Oak is as standards over coppice. They should be planted close together in little groups of about 5 or 7, so as to insure having 1 good tree in each group. The young standards must be pruned of side-branches at each cutting over of the coppice. Five-year-old plants (*i.e.*, 1 year 2 year 2 year) should usually be planted as standards; but for ordinary planting 3-year-old plants should generally be used.

Some of the best crops of oak have been raised by sowing acorns *in situ*. On arable land the acorns may be sown broadcast, and ploughed in with a light furrow.

When crops are raised by artificial sowing, another good plan is to sow in lines about 5 to 6 feet apart, and to have about 3 rows of acorns in each line. By this means a saving is effected in the labour cost of cleaning; and the close sowing in the rows ensures having some clean grown plants to choose from when thinnings are made.

Any young crops that do not show vigorous growth during the 2nd and 3rd summer after being planted out, should be coppiced over at the actual ground level, and, finally, the best shoot selected to grow into a tree. The best time to cut such trees over is in May.

Oak may sometimes be naturally regenerated under a very light canopy of mother trees. About 20 tall, well-grown trees are enough to leave per acre, and most of these must be removed in about 2 years' time, and the remainder by the

4th or 5th year, operations being governed by good seed years.

Rotation.—This should be from 90 to 130 years on good soil.

Average Returns from pure crops in close-canopied high forest should be per acre :—

Thinnings	1840	cub. ft. down to 2 in. q. g.
Final yield (at 120 years)	3000	" " 6 "
Total production . . .	5390	" " 2 "
Average annual increment, 45 cub. ft.		
Equivalent net rental ¹ for land only ² } at 3% = 3s. 3d. (from date of planting) } at 4% = minus 3s.		

Of Fungi.—*Rosellinia quercina* causes root rot in seedlings and young nursery plants, and often causes great damage. *Nectria ditissima* causes a canker on the bark of the stems and branches. Various species of **Polyporus** and **Fomes** (Bracket Fungi) attack the stems through wounded surfaces—e.g., *F. igniarius* and *Fomes fomentarius*, both producing white rot. White rot is also produced by *Hydnus diversidens* and by *Stereum hirsutuu*. *P. sulphureus* produces a red rot.

Of Insects.—The larvæ of the *Tortrix viridana* often defoliate the trees; and the larvæ of the Cockchafer grub (*Melolontha vulgaris*) do considerable damage to the roots of trees—often killing them—in nurseries and young plantations. Wherever Cockchafer grubs cause trouble in a nursery, it is an excellent plan to grow a few broad-leaved trees near the boundaries of the nursery, and to keep these trees cut back to a height of about 12 feet. When the beetles emerge, they will fly to these trees to feed upon the foliage. They can then be shaken down, collected, and destroyed. The larvæ of the Oak Boring Bark Beetle (*Bostrychus dispar*) often kill young trees.

The larvæ of the Small Black Weevil (*Orchestes querci*),

¹ *Vide* Chapter XII.

² After deducting interest on £8, the cost of planting and establishing the crop.

and of the Winter Moth (*Cheimatobia brumata*), and of the Brown tail Moth (*Bombyx chrysorrhœa*), and of the Lackey Moth (*Bombyx neustria*), attack the foliage. Various species of Gall Wasps (*Cynips*) cause galls of various kinds. *C. querci* produces the "Oak Apple Galls." *C. kollari* produces the Oak Marble Galls, etc.

The Turkey Oak.—This is a tree of little value sylviculturally, unless it should increase considerably in market value. Its timber is not durable, nor is it so strong or tough as the common Oak. However, for internal decorative house-work and for furniture, it might be largely used, as it is a handsome wood when properly converted. It shrinks much on seasoning, and has a great tendency to crack and split.

The tree is hardier, less exacting, and of quicker growth than the common Oak.

The acorns, with their moss-covered cups, do not ripen until the second autumn.

The Red Oak or American Oak.—This is an extremely fast-growing tree, and should be given an extensive trial in this country.

The tree thrives on somewhat light dry soil, provided it be deep; it is not so successful on stiff clays.

The timber is not likely to prove very durable or of great value. But the rapidity of its growth will compensate for its low price per foot. The timber will probably prove very suitable for all internal house construction, for furniture, barrel staves, etc.

The trees coppice very well. They might with advantage be grown as standards over coppice. The acorns take 2 years to ripen.

The Evergreen or Holm Oak.—This must be regarded only as an ornamental tree, as it is a very slow-growing tree indeed. It is less injured by salt spray and sea breezes than probably any other broad-leaved tree, and can be strongly recommended for seaside planting if the soil be sufficiently deep. It prefers a little lime in the soil. It is a difficult tree to transplant, since it makes a long naked tap-root.

The timber is very heavy and hard, and very durable,

364 SYLVICULTURAL NOTES ON TIMBER TREES

and is marked with a most beautiful grain, and takes a very high polish. It shrinks much on seasoning, and takes a long time to season.

For high-class furniture and interior decorative work, it is of the greatest value, though usually un procurable. The acorns take 2 years to ripen.

PLANE TREES.

Platinus orientalis = The Eastern Plane Tree.

Platinus occidentalis = The Western Plane Tree.

The **Eastern Plane** is little grown in this country; though a variety of it, the **London Plane** = *P. orientalis acerifolia*, is very common, and may be treated in the same way as the Western Plane.

The Western Plane:—

As to Seed.—One pound of seed contains about 93,000 seeds.

When grown from seed, it is always preferable to use foreign seed. It is, however, very easily grown from cuttings or "slips," and may also be propagated by layers.

The Timber is fairly hard, yellowish-white in colour, handsome, and ornamental; the best of it is often cut into veneers. There is little on the market in this country, but there is every reason to anticipate a ready sale at remunerative prices if any constant supply were available.

Soil and Situation.—A deep, rather moist, loamy soil is necessary; but the tree also grows, when once established, on rather stiff clay soils, if well drained.

Dry soils, or very stiff clays, or soils containing an excess of lime, are quite unsuited to it.

It requires rather a sheltered locality, and is tender as to spring and autumn frosts. Owing to the habit it has of shedding its bark, it is admirably suited for planting in or near towns, or wherever the atmosphere is smoky or impure.

Cultivation, etc.—The tree is light-demanding, and the foliage usually not quite so dense as that of Sycamore. It is a fairly quick-growing tree, and should prove profitable to plant, if the timber could be sold for 1s. 6d. a cubic foot. Owing to its demands for shelter, it may be grown as standards over coppice, though as an ideal standard its foliage is much too dense; but, considering the usual low price for coppice, this is a minor consideration.

The Western Plane is usually of more rapid growth than the Oriental Plane, and also, generally forms a taller and straighter bole.

Of Fungi.—The **Plane-Leaf Fungus** attacks the foliage, and causes the premature fall of the leaves.

POPLARS.

Populus nigra = The Black Poplar.

Populus Canadensis = The Canadian Poplar, or Black Italian Poplar.

Populus alba = The White, or Abele, Poplar.

Populus canescens = The Grey Poplar.

Populus tremula = The Aspen Poplar.

Populus pyramidalis = The Lombardy Poplar.

THE BLACK AND THE BLACK ITALIAN POPLARS.

These are very much alike in all respects, and demand much the same conditions, and may be considered together.

Neither of these two trees are native to this country. The latter is said to have been introduced in 1769, but the former was probably introduced by the Romans.

As to Seed.—The seed of both ripens at about the end of May or beginning of June, and it must be sown at once, as its germinative capacity is very quickly lost. The seed is collected along with the downy mass surrounding it.

Both trees are, however, best raised from cuttings.

The timber is white, soft, and tough, and does not easily fracture. It is more nearly fire-proof than any other timber ; and, for this reason, should be often used for floor boards. It is used for the battens in hop oasts on account of its fire-resisting qualities. The timber is also nearly free from smell ; and is, for this reason, used for butter boxes. By some, the timber of *P. Canadensis* is considered superior to that of all other varieties.

Soil and Situation.—Good deep moist loams are the best kind of soil for the growth of the Black Poplars. But they will also thrive on stiff clays, but not on the very stiffest. Sour soils, or water-logged soils, are quite unsuited to them ; and they should never be planted on very dry soils. They are slightly sensitive to late and early frosts—*P. Canadensis* being harder than *P. nigra* in this respect.

Cultivation, etc.—The trees grow very rapidly when

young, averaging about 2 feet 6 inches or rather more each year. The trees sometimes take a year or two before they get established, as the roots are not very fibrous, but they have great recuperative power, and, in many cases, grow quickly from the actual date of transplanting.

It will often be advisable to cut the trees over close to the ground 1 or 2 years after planting out; this should always take place if the trees do not seem to be growing well, or if they have been injured by frost.

The trees should not usually be pruned, except as to quite small branches, since fungous attacks may supervene.

All Poplars are very light-demanding, and their foliage is thin; and, *per se*, they will never protect the soil.

The Black Poplars are very profitable trees to plant, and good butts always sell well in the London market.

Poplars may be grown as standards over coppice, or as the standards in high forest with coppice, or they may be grown in ordinary high forest.

It is almost impossible, unless artificially pruned, to mix them by single trees or alternate rows with any other species except the tree willows, as their growth is so fast that neither the Poplars, nor their neighbouring trees, will ever be properly pruned.

On estates, where there is a creosoting plant, Poplars might be grown pure, planted 4 feet 6 inches to 5 feet apart each way; and the thinnings can then be creosoted, and used for estate fencing, etc.; but, unless creosoted, small Poplar poles have practically no value at all.

Small willows are much more saleable, as they can be used for split gate hurdles; and, when barked, can be sold, where there is a market, for the best quality charcoal.

Now, in order to provide valuable thinnings, Larch may be mixed with Poplars, the latter planted sporadically over the area. The Japanese Larch is preferable to the European Larch for this purpose, owing to its more rapid growth when young. The Japanese Larch is, however, rather expensive.

In all these cases the Poplars must be artificially pruned

if necessary, in spite of the risk of disease; the Larch will exercise no pruning effect on the Poplars.

Poplars and Spanish Chestnut form an excellent mixture in the proportion of about 1 to 10, though the Poplars will have to be artificially pruned.

In many cases it will be advisable to coppice the Chestnut about every 25 years; though on good Chestnut soils the two should be able to grow to maturity.

There is a good deal of simple coppice on clay soil consisting chiefly of Chestnut, which should most certainly be planted up with Poplars, as standards in high forest with coppice.

Then again, over simple Alder coppice, Poplars should be planted largely in many cases, and the quick-growing Alder coppice shoots will naturally prune the Poplars.

So also, Poplars over Ash coppice should be grown as high forest with coppice on many soils, which are too stiff for mature Ash.

It should be noted that the necessity for artificial pruning is largely avoided when Poplars are planted over existing copice areas, owing to the very rapid growth of the coppice shoots.

Rotation.—This should be short—about 50 to 60 years.

An average annual increment at the rate of 100 cubic feet (q. g.) per acre is often grown.

THE WHITE POPLAR OR ABELE.

This is a native tree to this country.

As to Seed.—The seed ripens about the end of May; but the trees are, however, best raised from suckers, dug up in the forest.

Layering may also be adopted, but the best trees are grown from suckers.

Cuttings are not to be recommended.

The timber is white and light, but not quite as good as that of the Black Poplars just described. It is rather liable to have "ring" shakes.

Soil and Situation.—The tree will grow on similar soils to those described for the Black Poplars.

But it will also grow on the very stiffest of clay soils; and, on such soils, it is probably the most profitable tree to plant.

The tree appears quite immune to spring and autumn frosts, and hence is of the utmost value in many cases.

Cultivation, etc., is similar to that described for the Black Poplars.

The tree throws out innumerable root suckers, and spreads naturally by such means.

Rotation.—This should be from 50 to 60 years.

THE GREY POPLAR.

This is not a native tree.

It is probably an hybrid between *P. alba* and *P. tremula*.

It is very similar in all respects to the White Poplar; and thrives under the same conditions.

It is raised from suckers, which are developed in great profusion.

It will grow in rather drier localities than the Black Poplars or the White Poplar; and like the White Poplar, it is very frost-hardy.

THE ASPEN POPLAR.

This is a **native** tree to this country.

As to Seed.—The seed ripens about the end of May, and, like all Poplar seed, must be sown at once.

It is generally raised from root suckers, and sometimes by layering. Cuttings are not very successful.

The **timber** is white and brittle, and is inferior to that of the White Poplar, being worth from $\frac{1}{2}$ to $\frac{2}{3}$ as much.

Soil and Situation.—It will grow on any soils suited to the other Poplars just described. But it will also grow on drier soils than the other Poplars will grow upon; and also on more shallow soils. It can exist on very dry soils, but its growth is then poor.

It is very frost-hardy.

Cultivation, etc.—The Aspen must usually be regarded as a weed. It may be used in the place of Birch, as a pro-

tecting species in frost localities on dry soils; but, on moist soils, the White Poplar is much more valuable.

The Aspen is often very difficult to get rid of, and its quick-growing root suckers often interfere with more valuable trees.

THE LOMBARDY POPLAR.

This is not a native tree.

The timber is of less value than all the other Poplars described, and the stem is usually somewhat corrugated, and there is much waste in conversion.

It should never be planted from a sylvicultural point of view.

Of Fungi.—*Melampsora pinitorqua* produces a rust on the leaves of Aspen Poplars, and sometimes on the leaves of the White and Grey Poplars.

Little harm is directly occasioned thereby, but this *Melampsora* is an alternate generation of the *Cæoma Pine-torquum*, which injures the leading shoots of Scots Pine.

Other species of *Melampsora* produce a rust on various Poplars: e.g., *M. larici tremulæ* (on Aspens), or *M. larici populina* (on Black Poplars), which is the alternate generation of *Cæoma laricis*.

Polyporus sulphureus causes Red Rot in the timber of Poplars.

Of Insects.—The larvæ of the *Cossus Ligniperda*, or Goat Moth (so named on account of its vile odour), damages the timber.

The timber is also much damaged by the larvæ of the Large Longicorn Beetle (*Cerambyx carcharias*).

The larvæ of the Small Poplar Longicorn Beetle—(*C. populnea*)—attacks the branches.

The larvæ of the Satin Moth (*Bombyx salicis*) and the beetles and larvæ of the Red Poplar Leaf Beetle (*Lina populi*) and of the Aspen Leaf Beetle (*L. tremulæ*) feed upon the foliage.

Mistletoe is very frequently found on Poplars.

SPANISH CHESTNUT.

Castanea vulgaris = Spanish Chestnut.

The Spanish Chestnut is not a native tree to this country.

As to Seed.—The seed rarely ripens properly in this country; and home-grown seed should not be used.

The **germinative capacity** of the seed is about 60 per cent.; and 1 lb. of seed contains about 112 nuts.

The **timber** is of excellent quality, fairly hard, strong, and very durable. It also splits very well.

The timber is, however, very liable to "cup" or "ring" shakes; though, if grown on a deep loam with sufficient moisture it is usually quite sound. There is only a small proportion of sapwood; and the sapwood quickly changes to heartwood.

Soil and Situation.—A deep soil is necessary with a fair amount of moisture. Soils with more than a small amount of lime in them are quite unsuited to its growth; so also are very wet soils. The tree will grow on dry sandy soils, but the timber is invariably shaky. Very stiff clays are not suitable for growing mature timber; but, Chestnut coppice often succeeds well on such land. The tree suffers from severe winter frosts; and is very susceptible to late spring and early autumn frosts; and thus, it is very difficult to establish on cold clays or on land subject to late frosts, unless indeed it be used for underplanting.

A considerable amount of summer heat is necessary, in order that the wood may be properly ripened; and thus it succeeds far best in the south-west of England, where, on northern aspects, its growth is all that can be desired.

Elsewhere in this country it often succeeds better on southern aspects, where it obtains the necessary warmth.

Cultivation, etc.—The Spanish Chestnut will bear considerable shade until about 25 years of age; afterwards, as maturity is approached, it must be considered as a light-demanding tree. It is usually somewhat slow-growing until

it has been planted out 3 or 4 years, for transplanting checks it; but, after then, its growth is very rapid in suitable localities. The tree has a great power of reproduction from stools, and the stools are very long-lived. It also throws out suckers to a considerable extent. The side branches are rather persistent; and a close canopy is necessary, in order to effect natural pruning, and to prevent the development of side branches. The tree, even when well grown, has a very considerable taper; more so than any other tree grown under similar conditions.

The foliage is fairly dense, and the leaves form good humus, and improve the soil; and pure forest is usually quite admissible. It is one of the most profitable broad-leaved trees that can be largely planted, coming next to Black Poplar and Ash.

Permanent even-aged mixtures by single trees will not usually give satisfactory results for the whole mixture.

Chestnut and Ash, or Chestnut and Larch, makes a very good mixture, however mixed; though the Chestnut will be coarse, and should, in most cases, be periodically coppiced. By this means (under the system of high forest with coppice), the soil will be kept very clean, and the best Ash or Larch will be grown, if only the locality be suitable.

Spanish Chestnut coppice is, along with Ash, the most valuable.

Spanish Chestnut is very suitable for underplanting Oak, or Ash, or Larch.

The thinnings may usually be left to natural agencies, until the trees are 25 feet high.

The thinnings are amongst the most saleable and valuable of any species, and should therefore be included in many mixtures by single trees, even if they are not required for the final crop.

They will prune all their broad-leaved neighbours (except Poplars) very well. They are, however, an expensive tree to plant.

Rotation.—In high forest 70 years. Though, in moist climates and on good soils the rotation may be somewhat

374 SYLVICULTURAL NOTES ON TIMBER TREES

longer, as, under the best conditions, the timber is quite sound.

The **average annual increment** is about 65 cubic feet.

The tree is remarkably free from fungoid and insect attacks. However, a Bark Beetle sometimes kills the trees.



SYCAMORE AND NORWAY MAPLE.

Acer pseudo-platanus = Sycamore.

Acer platanoides = Norway Maple.

Acer campestris = The Field Maple.

Neither of these trees are native to this country.

As to Seed.—They both produce abundant crops of seed from about the 35th year onwards; and good seed years are very frequent.

The germinative capacity of both Sycamore and Norway Maple is about 55 per cent.; and 1 lb. of seed of either Sycamore or Norway Maple contains about 5500 seeds.

The timber of both species is fairly hard and whitish; but not very durable in the open. Large clean butts are in great demand; otherwise, the market is not usually good. The timber should be quickly removed from the forest, as, like all white timbers, it deteriorates if left.

Soil and Situation.—Both trees will grow on almost any soil, except very dry sandy soils, provided they be fairly deep, or that the subsoil be disintegrated.

The Norway Maple is even more accommodating than the Sycamore. Both trees are very storm-proof and grow fairly well by the seaside, especially the Norway Maple.

They are somewhat susceptible to late spring frosts.

Cultivation, etc.—On moist deep soils the trees will bear a fair amount of shade when they are young. The foliage is fairly dense, but pure crops will seldom be advisable. Generally, they should be planted, sporadically, in even-aged high forest, or in little groups of 3 or 5, when they should be allowed to grow to maturity, which is reached at about 100 years.

As coppice, the stools do not last very long, but the stool shoots are vigorous; those of the Norway Maple more so than the Sycamore.

Both trees grow very rapidly when quite young, averaging 18 inches to 2 feet 6 inches a year; and very little shock is experienced in being transplanted. In fact, these two trees,

Alder, Birch, Ash, and Hornbeam suffer less from transplanting than almost any other valuable timber trees, and grow more rapidly from the start.

If desired, Sycamore and Norway Maple may be cut over at the ground level, at the time of planting ; though it would be better to wait for one year. But usually there is no need to cut the trees over, as their natural growth is vigorous and straight.

Rotation.—This should be about 90 to 100 years.

Of Fungi.—*Rhytisma acerinum* causes the familiar black blotches on the leaves, but little harm is done thereby.

Phytophthora omnivora sometimes causes "damping off" in the young seedlings.

Nectria cinnabarina (showing reddish pustules on the bark of fairly young wood, when dead) often causes great damage to the living trees.

Various species of *Polyporus* (the **Bracket Fungi**) attack the stems through wounded surfaces.

Of Insects.—**Cockchafer grubs** gnaw through the roots of seedlings and young trees.

The Field Maple is of little sylvicultural importance. It is a **native tree**, and grows wild amongst coppice and in hedgerows.

It never grows to any great size, and, except as inferior coppice growth, should be regarded as a weed.

TULIP TREE.

Liriodendron tulipifera = The Tulip Tree.

This tree, known variously as "Canary Wood," "Yellow Poplar," and "White Wood," is native to Canada and the United States of America.

As to Seed.—It flowers profusely in this country, but home-grown seed is generally useless.

One pound of seed contains about 10,000 seeds.

Seed sown in spring will often take a year before it appears; hence autumn sowing is to be recommended, but the seedlings must be protected with screens, etc.

The timber is soft, and, when recently felled, is usually a crimson red colour, but afterwards it becomes a greeny-white colour. It is an easily worked wood, and is used by furniture- and cabinet-makers. It is largely used for the "backing" or "blind" wood upon which veneers are set.

Soil and Situation.—Deep soils, with plenty of moisture, are essential. It will thrive on clay lands if not excessively stiff. It avoids calcareous soils, and very dry soils.

It is very tender as to late spring and early autumn frosts, and hence many clay soils are too cold for its growth.

Southern aspects suit it best, if spring and autumn frosts can be avoided.

Cultivation, etc.—It is a thinly foliaged, light-demanding tree. It requires considerable summer warmth, in order to ripen its wood before autumn frosts set in.

It should be grown as standards over coppice, or as standards in high forest with coppice; for, under such circumstances, the danger from late and early frosts is minimised.

It should, generally, be avoided in even-aged high forest, as the risks are too great.

The Tulip tree is rather slow-growing when young, and makes a long tap-root; it must therefore be transplanted frequently, so long as it remains in the nursery.

It is not a very good tree to transplant; and hence transplanting should be done very late in the spring.

The tree begins to grow fairly rapidly when about 10 years old; and, when grown closely, will form a clean, straight bole free from branches for about 50 feet in height.

On account of its demands for summer heat, it should only be grown in the south of England.

There is, however, a risk that the home-grown timber will not sell well, though it be of excellent quality.

The expensive "Tulip" wood, used for veneers, is not the timber of this tree.

WALNUT.

Juglans regia—The Common Walnut.

Juglans nigra—The Black or American Walnut.

Neither of these trees are native to this country. Imported seed of Black Walnut should always be used.

The timber of both species is valuable, and of a dark brown colour, the sapwood being white. The Black Walnut, however, grows the finest timber, and, for timber production, should be grown in preference to the Common Walnut. The timber of the common variety is very liable to "heart" shakes, and is not of such a fine colour as that of the black variety. The sapwood is very liable to be worm-eaten. Any burrs on the trunks are very valuable indeed, if of any considerable size.

Soil and Situation.—A deep, light, rather dry loam is the best soil for Walnuts, especially if it rest on a chalky or marly subsoil. Cold, stiff, clay soils or subsoils are quite unsuited to it. Any excess of moisture is very harmful to its growth. Both species, and especially the American variety, are very susceptible to late spring and early autumn frosts. A considerable amount of summer heat is necessary, in order to ripen the wood; especially is this the case with the American variety.

The American variety should only be planted in the south of England.

Southern aspects suit it best, if spring and autumn frosts can be avoided.

Cultivation, etc., of the Black Walnut.—The tree is very light-demanding and thinly foliaged. It forms a very long tap-root, but will transplant readily if properly schooled in the nursery. Wherever possible, however, it should be sown *in situ*. In order to effect this, the best method is to germinate the seed in a heap, and then to dibble the already sprouted nuts into the land. It is a very fast-growing tree.

On account of the great damage done by frosts, it should

only be planted over existing coppice areas; either as standards over coppice, or as standards in high forest with coppice.

It is usually too risky to plant it in even-aged mixtures.

Rotation.—This should be 80 to 100 years.

The financial return from planting it should be good, even if only 1s. 6d. a cubic foot were realised for its timber. If, however, the timber were to realise 5s. to 7s. a cubic foot—the price obtained for the best imported timber—the tree will prove to be one of the most profitable that can be planted.

However, time alone can prove the market value of any considerable quantity of home-grown Black Walnut.

And, though extensive planting can be recommended on suitable land in the south of England, it must be looked upon in the nature of an experiment.

WILLOWS.

<i>Salix alba</i>	=The White Willow. ¹
<i>Salix alba cærulea.</i>	
<i>Salix viridis.</i> ²	
<i>Salix fragilis</i>	=The Crack Willow.
<i>Salix viminalis</i>	=The Osier.
<i>Salix caprea</i>	=The Goat Willow or Sallow.

Of the above mentioned trees, the first four are tree Willows of considerable importance. *Salix viminalis* is the Osier which is cultivated for the production of basket material;³ but *S. caprea*—a small broad-leaved tree—is of little sylvicultural value, and practically worthless. *Salix caprea* is a native tree to this country; so also, in all probability, is *Salix alba* and its varieties; but *S. fragilis* and *S. viminalis* have been introduced from foreign countries.

The propagation of Willows is effected by means of "cuttings" or "sets," which should be obtained from stool shoots or from the young branches of pollarded trees. Such cuttings will produce a far more vigorous growth than cuttings taken from the young wood, at the ends of the old branches, on ordinary standard trees. The cuttings should be taken when the sap is rising in the spring, and, if not immediately planted out, they should be left with their ends in water.

The Timber of the tree Willows is light in weight, soft, and very tough, and, as a general rule, can be used for any of the purposes for which Poplar timber is used.

The economic value of the cultivation of tree Willows lies chiefly in the use of the timber for the manufacture of

¹ *S. alba* is also sometimes known as the Huntingdon Willow.

² *S. viridis* has also been known as *S. Russelliana* or the Bedford Willow; but, locally, these names are also applied to *S. fragilis*. Therefore, in order to avoid confusion, local names should be abandoned.

³ For further information about Osiers and their cultivation, *vide Board of Agriculture Leaflet, No. 36.*

cricket bats. Except for such purposes, the cultivation of tree Willows will not prove nearly so remunerative as the cultivation of Black Poplars.

The Planting of Willows for the Production of Timber for Cricket Bats.¹

Whenever it is desired to grow Willow timber for the manufacture of cricket bats, the greatest care is necessary, in order to obtain the right kind of stock.

The best timber is produced by *Salix alba cærulea* and that of *Salix viridis* ;² and *Salix alba* ranks next. On the other hand, the timber of *Salix fragilis* or its varieties is quite unsuited for any except the cheapest kinds of bats, and is usually difficult to sell.

The trade requirements demand a "close bark," or fairly smooth bark, with branches somewhat erect or fastigiate; whereas trees of *Salix fragilis* and its varieties which have a coarse open bark and a spreading crown, are always avoided by trade buyers.

In this connection it has been noticed that the female trees are more erect and fastigiate than the male trees; and, therefore, until the contrary may be proved, cuttings obtained from female trees of the proper varieties should alone be planted; and, furthermore, these cuttings should be taken from a stock obtained from trees growing in the counties of Essex, Herts, or Suffolk, where alone the best bat Willow is at present to be found.

The timber of *S. alba*, *S. alba cærulea*, and *S. viridis* is white, soft, tough, not easily split, and light in weight. The timber of *S. alba cærulea* is the lightest of all, and hence is

¹ For further information on this subject, *vide* "Bulletin No. 8, 1907, The Royal Botanic Gardens, Kew;" also an article by A. E. Pratt in the *Quarterly Journal of Forestry*, October 1907.

² *Salix viridis* is an hybrid between *S. alba* and *S. fragilis*. It is very variable in its habit; sometimes it resembles very nearly the habit of *S. alba* or *S. alba cærulea*; but at other times it resembles the *S. fragilis*. It is, however, only when it approaches the *S. alba* or its varieties in its habits, that it produces a good timber for the manufacture of bats.

the most valuable of all the bat Willows. The quicker the trees are grown and the wider the annual rings, the more valuable is the timber for bat making. So again, the greater the amount of sapwood, the more valuable the timber ; for, any heartwood is darker in colour, heavier, and more apt to split.

The timber of *Salix fragilis* and its varieties is darker in colour than that of the trees just mentioned ; and it is also heavier and more readily split. Hence, therefore, its inferiority for the manufacture of cricket bats.

Soil and Situation.—Willows require a deep, moist soil. They should never be planted on dry soils, or on shallow soils, or on soils where there is stagnant water. They are found naturally on the deep; rich, silty soils near the banks of streams. But they may be planted with every chance of success in nearly all deep, moist soils, provided there be no stagnant moisture. Very stiff clay soils are, however, not suitable ; though they usually succeed well on fairly stiff clay soils.

The trees are tender as to spring and autumn frosts ; and a fairly sheltered position is preferable.

Cultivation, etc.—The trees are very light-demanding. They should usually be grown pure, when the young trees or the "sets" may be placed 5 to 6 feet apart from each other. Sometimes Larch may be mixed with them, so as to afford more valuable thinnings. In such cases the Larch and Willow can be mixed in almost equal proportions, the trees being planted 4 feet to 4 feet 6 inches apart from each other. In most instances the Willow trees will grow very much faster than the Larch, but the latter should generally attain a fair size before being suppressed, and will then be readily saleable in most districts.

Before, however, the Willows are planted, a choice must be made between planting large "sets" (or cuttings)—about 10 to 15 feet long—and between planting young trees raised from small "sets," and schooled for a year in a nursery.

If the "sets" have to be bought, the latter method will generally be preferable, since the long "sets" are very expensive to buy. But in cases where the "sets" can be

taken without payment, the use of long "sets," planted out directly, can nearly always be recommended, provided enough long "sets" can be taken. The advantages of using long "sets" are that:—

- (1) A mature tree is obtained in the shortest possible time; and the labour cost of planting the "sets" is only about 12s. per 1000.
- (2) The expense of schooling in a nursery is avoided.
- (3) The expense of planting out¹ young trees in pits at a cost of say £1, 8s. per 1000 is avoided; so, also, is the cost of cutting out any rank grass from amongst the young trees.
- (4) The large "sets" will often be above the frost line; whereas small trees might be cut over by frosts.
- (5) Hedgerow Willows can thus be easily grown without any fear of being choked.

The young trees must be carefully tended; all double leaders must be cut away; and the boles kept free of side branches for three-fifths of their length.

As soon as a clean bole, 20 feet in length, has been attained, the trees should be given ample growing space so that a maximum girth expansion may take place.

It must be remembered that heartwood is not required, and that the broader the annual rings, the more valuable is the timber for bat making.

Timber under 11 or 12 inches quarter girth is of no value for bat making, as it is not large enough to be split up into pieces from which bats can be made; for the face of a bat is a longitudinal radial section, and does not contain any of the "core" of the log.

Any length of timber 2 feet 3 inches² long, or some

¹ These large "sets" should be inserted about 2 feet in the ground, so that they may not be swayed by the wind. A hole should be made with a crowbar, the "set" inserted, and earth then filled into the hole and firmly trodden in. On no account must these long "sets" be pushed in, or the bark will become injured.

² Bat lengths are 2 feet 2 inches long; 2 feet 3 inches is taken to allow a margin for safety.

multiple of 2 feet 3 inches, would be saleable if it were of good enough quality, and 11 or 12 inches quarter girth at its smaller end.

Rotation.—As a general rule, it will be found that the trees should be cut when from 30 to 35 years of age.

Financial Returns.—In cases where most of the timber can be sold for bat making, at the current price of 5s. to 6s. 6d. per cubic foot, the growth of tree Willows is by far the most profitable sylvicultural undertaking that can be embarked upon.

Of Fungi.—Various species of **Melampsora** having a change of generation in a **Cæoma** form (probably often on conifers) produce a rust on the leaves.

Polyporus sulphureus produces red rot in the wood.

Fomes igniarius produces white rot.

Of Insects.—The larvæ of various **Longicorn Beetles**, especially *Cerambyx carcharias*, bore into the sapwood. The larvæ of the **Goat Moth**—*Cossus ligniperda*—bore into the timber. So also do the larvæ of the **Willow Wood Wasp**—*Sirex dromedarius*.

The foliage is attacked by the larvæ of various **Spinner Moths**—e.g., *Bombyx antiqua* and *Bombyx salicis*, and also by the beetles and larvæ of the leaf beetles *Lina populi* and *Lina tremulæ*.

The bark is attacked by a scale insect, *Coccus salicis*, which appears as a felted white scale.

A weevil, *Cryptorhynchus lapathi*, gnaws the bark of the young shoots of trees, whilst its larvæ burrow into the wood and form small galleries.

CHAPTER XVI.

SYLVICULTURAL NOTES ON TIMBER TREES—*continued*

CONIFEROUS TREES.

CUPRESSUS.

Cupressus macrocarpa.

Cupressus Sitchensis—The Sitka Cypress.

CUPRESSUS MACROCARPA.

THIS is native to California, and is said to have been introduced in 1838.

As to Seed.—It ripens seed in this country, but home-grown seed should never be used except experimentally. One pound of seed contains about 73,500 seeds, and the **germinative capacity** is about 15 to 20 per cent. The tree can be raised from cuttings, but such trees are inadmissible from a sylvicultural point of view.

The timber is somewhat soft, but of good quality; and should be equal in value to that of Norway Spruce.

Soil and Situation.—Moist, deep soils are essential for its maximum development. On dry soils, or on shallow soils, it will not thrive.

It succeeds on stiff clay soils if it escapes spring and autumn frosts, to which it is rather susceptible. It is a very storm-proof tree, and withstands salt sea breezes and gales. It prefers a moist atmosphere, and is often much injured by cold, dry east winds.

On light, deep, moist, humous soils resting on clay, it succeeds admirably, if only the atmosphere be moist enough.

Cultivation, etc.—It is a very rapid-growing tree when young; and trees which have been planted out 10 years are often 20 to 30 feet high.

Seedlings grow rapidly, and are often 2 feet 6 inches to 3 feet high at the end of the second summer.

The tree will bear a great amount of shade; and a close canopy is necessary, in order to suppress and kill off the side branches. The foliage is very dense.

It is admirably suited for underplanting or undersowing.

It may be grown as even-aged high forest, either as a pure crop, or else mixed by patches.

Mixtures by alternate trees or rows of trees would, however, succeed in the case of:—

Cupressus and Douglas Fir.

Cupressus and Sitka Spruce.

Cupressus and *Thuya gigantea*.

On suitable localities the tree could also be grown under the selection or group systems.

Any planting of this tree must be looked upon as an experiment; but if its timber were saleable at 6d. to 8d. a cubic foot, it would be one of the most profitable trees that could be grown, coming near to Douglas Fir and Black Poplars.

CUPRESSUS SITCHENSIS.

This is sometimes called the *C. Nootkatensis*, or the Sitka Cypress or the Alaska Cypress. It is a native to the west coast of North America. It is said to have been introduced in 1850.

As to Seed.—One pound of seed contains about 128,000 seeds, and the germinative capacity is about 15 to 20 per cent. Home-grown seed should prove quite satisfactory. Plants raised from cuttings should never be used, if the production of timber be desired.

Cultivation, etc.—This tree may be experimented with and grown in the same manner as *C. macrocarpa*. Its timber is of excellent quality, but it will not prove so remunerative as *C. macrocarpa*, as its growth is not nearly so rapid.

It is, however, a hardier tree than the *C. macrocarpa*; and is, usually, not much injured by spring or autumn frosts. It prefers deep, moist, humous soils, but will also grow fairly well on thin clay soils resting on broken calcareous rock; it will succeed on drier soils than the *C. macrocarpa*.

The Sitka Cypress is expensive to raise, and it is hardly likely to prove a remunerative tree to plant in this country, unless there be a substantial rise in the prices of timber.

DOUGLAS FIR.

Pseudotsuga Douglasii = The Douglas Fir or Oregon Pine.

There are several varieties of this tree, the two chief varieties being those known as :—

- (1) The Vancouver or Oregon variety.
- (2) The Colorado or glaucous variety.

Only the Vancouver variety will be considered, as there is nothing to recommend the glaucous variety, which is very much slower growing ; and any assertion that it is hardier or stands a colder climate, is quite unfounded, for the Vancouver variety thrives high up in the Rocky Mountains as well as at the sea coast.

The **Vancouver Douglas Fir** is native to the west coast of North America, and grows to perfection on the coast regions of British Columbia. It is said to have been introduced in 1828.

As to Seed.—Good crops of seed are produced from about the thirtieth year onwards, and there is every probability that home-grown seed will prove quite as good as any imported seed, provided that it be collected from trees raised from seed grown upon the coast regions of British Columbia.

One pound of seed contains about 40,000 seeds, and the **germinative capacity** is about 30 per cent.

The **timber** is fairly hard and resinous, and very strong, provided it be grown in close canopy. It forms heartwood earlier in youth than most other trees.

It is a handsome timber, especially the sapwood, if the latter has been kiln-dried.

It makes most excellent timber for all interior carpenters' and joiners' work ; but it is not very durable for outdoor work, unless painted or preserved in some way.

Soil and Situation.—A deep, rather moist, though well-drained soil is necessary. It succeeds admirably on a deep, porous soil with a cool bottom. It will grow on stiff clay soils, but its development is not very good under such

circumstances, and a short rotation of about forty to fifty years will usually then be indicated.

Chalky soils or those containing an excess of lime, seem very inimical to it in most cases. It should never be planted on such soils unless there be abundant proof that it is likely to succeed. It should be avoided on very dry soils.

It prefers a damp atmosphere, and will succeed better in the west than in the east of England.

It is tender as to spring and autumn frosts, and on exposed localities the trees are apt to lose their leaders; though, in crowded pure plantations, this latter danger is minimised to the greatest extent.

Cultivation, etc.—The tree is thickly foliaged, and a moderate shade bearer, and its side branches require a close canopy in order to prevent their development. It bears pruning very well indeed.

It is a very rapid-growing tree, and soon surpasses practically all other trees which may happen to be planted with it. In its native country it often attains the enormous height of 300 feet and over.

It may be used for underplanting thin-foliaged trees, provided the canopy be not thick. In this respect it is necessary to take into consideration its rapid height growth, as the over crop would have to be cut directly it is caught up.

It may well be grown in even-aged high forest, but must, usually, be grown quite pure, or else mixed by patches, on account of its very rapid growth.

Possibly an even-aged mixture of **Douglas Fir** and **Corsican Pine**, planted 3 feet 6 inches apart, would give good results; but the pines should all be removed as thinnings.

Douglas Fir and *Thuya gigantea* occur naturally together, but the Douglas Fir usually soon outgrow the *Thuya*.

Japanese Larch will sometimes keep pace for a time with Douglas Fir, but finally they will have to be removed; and they will not have exerted any pruning effect on the Douglas Firs.

Douglas Fir and Sitka Spruce is a very good mixture.

Douglas Fir can also be grown upon the selection

system or the group system, provided that home-grown seed prove satisfactory in every respect.

Rotation.—This, in even-aged high forest, is about 55 to 75 years.

Average Returns from pure crops in even-aged high forest should, on Quality I. soil, amount per acre to :—

Thinnings	9,620	cub. ft. to 2 in. q. g.
---------------------	-------	-------------------------

Final yield (at 75 years).	11,200	" 6 "
------------------------------------	--------	-------

Total production	21,190	" 2 "
----------------------------	--------	-------

Average annual increment, $282\frac{1}{2}$ cub. ft.

Equivalent net rental¹ for land only at 3% = £3, 3s. od.

(from date of planting)	£ at 4%	= £2, 1s. 7d.
-----------------------------------	---------	---------------

Of Fungi.—Many of those enumerated as attacking other conifers will also attack Douglas Firs; but up to the present there is not sufficient evidence to detail any complete list of fungi which can be considered very frequent in this country.

The tree is by no means free from fungous attacks, and it should on that account be planted only in localities suitable to its growth.

The **Honey Fungus** and **Trametes radiciperda** (= *Fomes annosus*) attack it.

Phoma pithya causes a canker on the twigs, branches, and small stems.

Botrytis cinerea (= *B. Douglasi*) attacks the foliage and young shoots of the current year's growth.

Pestalozzia Hartigii causes a bark canker on the twigs and stems of seedlings and young plants.

Of Insects.—Many of those attacking other conifers will, in all probability, also attack the Douglas Fir.

The **Pine Weevil** (= *Hylobius abietis*), and **Cockchafer grubs** attack young plants.

¹ After deducting interest on £8, the cost of planting and establishing the crop.

LARCH.

- Larix Europea* = The European Larch.
Larix leptolepis = The Japanese Larch.
Larix occidentalis = The Western Larch.
Larix Kurilensis = The Kurile Larch.
Larix Siberica = The Siberian Larch.

None of these trees are native to this country.

EUROPEAN LARCH.

This is a native to the mountains of Central Europe, the Bavarian Alps, and the Tyrol.

As to Seed.—It ripens seed in this country, but home-grown seed should never be used.

One pound of seed contains about 70,000 seeds, and the germinative capacity of the seed is about 35 per cent.

The timber is hard, tough, and durable, but it is liable to twist and warp, and, therefore, should not be used in house construction. But it is a most valuable timber, and makes the best railway sleepers, and is largely used for general estate purposes. It makes excellent fencing material, and the wood, even when quite young, is hard and durable; hence, thinnings from young Larch plantations are nearly always saleable.

The wood splits fairly well.

Soil and Situation.—For its successful growth Larch is very particular; a deep, well-drained loam with a fair amount of moisture, is quite suitable to it. Dry, sandy, or gravelly soils are quite unsuited to it; so, also, are thin soils resting on chalk, or stiff clay soils, or any badly-drained soil. On stiff clay soils it often grows well, but the trees, even if they look healthy, are usually hollow or “pumped.”

On dry soils the timber is always brittle, and very often decayed, such timber being termed “foxy” in the incipient

stages of the disease. Trees grown on thin, chalky soils or dry soils are also often quite hollow or "pumped."

This hollow condition can be detected by tapping the trees with a stick, when, if hollow, the sound emitted will disclose the fact.

Larch succeeds admirably on shallow clay soils overlying disintegrated limestone rock. It appears to delight in very stony soils; and, in all probability, its failure on certain soils is due to a lack of air to the roots. A free circulation of air is very necessary for its success; hence, on flat sheltered localities it will often prove a failure. Northern aspects are almost always preferable to southern aspects, for its well-being.

The trees suffer a good deal from late frosts, but this largely depends upon the extent to which the leaves have developed. If the leaves have been unfolded about a week, little damage is usually done, but if a frost occur just previous to this, irreparable damage will often be done.

Cultivation, etc.—Larch is a very thinly foliaged, light-demanding tree, and pure crops are quite unable to protect the soil. It is quick growing until the principal height growth has been attained; but it often suffers a considerable check on being transplanted, unless, indeed, quite small plants are used. The side branches easily drop off, and are readily pruned by all other trees whose rate of height growth is similar. But the side branches of Larch have practically no pruning effect on the side branches of other trees.

On account of the ease with which Larch cleans itself, pure crops may be planted from 4 feet to 4 feet 6 inches apart, and the thinnings may at all times be more severe (provided there has been no previous overcrowding), than would be judicious with any other species of tree.

It is, however, a very risky proceeding to plant Larch pure, on account of the extraordinary damage wrought by the Larch disease. When forming plantations the probability of ravages from this disease should always be very carefully considered.

Pure plantations of European Larch should certainly

seldom be made on any but the very best localities, where, if fortunate, the disease will not make its appearance. Sometimes, however, an owner is willing to take the risk of loss from Larch disease; and, if at the end of 20 to 25 years there be 200 sound trees per acre, these can be underplanted and should give most profitable returns; and the small diseased poles, which have been cut out, can be used for rustic work, fencing, etc.

On northern aspects, at a somewhat relatively high altitude, Larch will often remain free from disease if the soil be really suitable for its growth.

But the disease is almost certain to occasion immense damage wherever the conditions are unsuited to its growth; as, for instance, on unsuitable soil, on southern aspects, on flat land, or on land liable to spring or autumn frosts. In many cases the disease is noticed on trees planted on maiden land, whereas it may be absent on similar localities from which a crop of timber has been removed, where the soil is left well aerated and covered with a good layer of humus.

Then again, the disease is always more prevalent in crowded plantations which need thinning, and where the free circulation of air is impeded.

However, in cases where it is particularly desired to grow pure Larch to start with, as in places where the thinnings are very saleable, a mixture of European and Japanese Larch should be planted, for the latter have so far proved to be more or less free from disease. By this means the risk is lessened.

In as much as pure crops of Larch are unable to protect the soil, they must be underplanted before the land gets foul. But it will almost always be preferable if they be first partially cleared from about the 30th to 40th year, and often much earlier; for the trees cannot have too much light and air as they approach maturity.

Beech, Spanish Chestnut, Douglas Fir, *Thuya gigantea* and Silver Fir may be used for this underplanting. But Beech or Spanish Chestnut are particularly suitable, as the soil improves so much under their thick fall of leaves; and

much finer Larch can be grown than if no underplanting had taken place, unless, indeed, the soil be very rich and deep. The Spanish Chestnut will prove more remunerative than the Beech.

Often, however, owing to very heavy thinnings having been made on account of Larch disease, underplanting has to be resorted to at a much earlier date; in such cases, the Douglas Fir should not be used, as it will catch up the Larch before they are ready to be felled.

Where Larch are mixed with other trees, they should usually be planted sporadically, at considerable distances apart (say 12 to 16 feet), or else in little sporadic groups of 3 or 5, so as to ensure obtaining one good tree in each group; and thus they will only leave a few badly pruned neighbours. If they be mixed by alternate trees or alternate rows, their neighbouring trees will nearly always be branching and badly pruned, unless artificial pruning be resorted to.

However, they may be thus mixed with Ash (forming about half the crop), for the young Ash will grow clean enough up to about 20 years of age, even when next to Larch; after that date, if a permanent mixture be required, the thinnings should be conducted so that a mixture by patches is left; and underplanting must be resorted to directly the land shows signs of becoming foul.

The mixture of Larch and Beech is very much recommended, but it is really only suitable for an uneven-aged mixture; unless, indeed, only a few Larch be planted amongst a practically pure crop of Beech.

If an even-aged mixture, in about equal proportions, be attempted, it will not be very successful. The Beech will all be coarse, as they are very slow growing when young, and both species will practically be growing like separate crops planted 8 feet apart.

Larch form excellent standards over coppice, and should be planted in little groups of 3 or 5, so as to ensure having one good tree from each group.

They require much protection from the vigorous coppice shoots, as they are very impatient even of side shade.

Larch, also, can advisedly be grown as standards in high forest with coppice ; new plantations under this system can be formed by planting Larch and Spanish Chestnut alternately, and subsequently coppicing the Spanish Chestnut.

Rotation.—The rotation should be from 70 to 80 years, though shorter rotations often prove very profitable for pit timber.

Average returns from pure crops in high forest should be, per acre :—

Thinnings	1360	cub. ft. to 2 in. q. g.
Final yield (at 70 years)	3000	" 6 "
Total production . . .	4760	" 2 "

Average annual increment, 68 cub. ft. q. g.

Equivalent net rental ¹ for land only	} at 3% = 17s. 2d. from date of planting } at 4% = 10s.
--	--

Of Fungi.—The *Dasyscypha calycina* (or *Peziza Willkommii*)= The **Larch Disease** or **Larch Blister Disease**, does immense damage to young crops, especially up to about the 20th year.

On account of this disease, the growing of European Larch is now a most risky undertaking ; the Japanese Larch has, however, hitherto proved more or less immune.

In order to combat the spread of the disease, great care should be taken that all seedlings be raised from seed obtained from strong, healthy trees ; for, the individual vigour of trees is hereditary. The produce of sickly trees has a predisposition to be attacked, though the disease is probably not actually hereditary.

In this connection the use of home-grown seed should always be tabooed, as the summer heat in this country is not sufficient for the production of the finest seed.

Phytophthora omnivera sometimes kills young seedlings.

Agaricus melleus= The **Honey Fungus**, characterised by its black rhizomorph strands and its cluster of mushroom-like

¹ After deducting interest on £8, the cost of planting and establishing the crop.

sporophores, attacks the roots of young and old trees, and usually very rapidly kills them.

Trametes pini attacks the stems, usually when more than 20 years old; it decomposes the heartwood, but does not affect the sapwood. The trees gradually become hollow or "pumped."

Polyporus sulphureus produces red rot in the timber.

Trametes radiciperda (*Fomes annosus*) attacks the roots. It produces a red rot, and causes the base of the stem to become hollow.

Of Insects.—**Argyresthia lavigatella** (or *Tinea lavigatella*) hollows out and destroys the leading shoot and also the side shoots.

Coleophora (or *Tinea*) *laricella* = **The Larch Mining Moth**, burrows into the needles and kills much of the foliage of the trees. The attacked foliage looks as though it were frost-bitten.

Chermes laricis = **the Larch Bug** or **Larch Aphid**, often does great damage, especially in plantations up to about 20 years of age. The sap is sucked from the leaves. In late spring and early autumn the trees often look as though covered by pieces of cotton wool; for the young lice, on hatching out, soon get covered with a white fluffy down.

This Aphid is the sexless form of *Chermes abietis*. Hence, this is another reason against having mixtures of Larch and Spruce.

THE JAPANESE LARCH.

The Japanese Larch is native to the central part of Japan, and was introduced about 1861.

As to Seed.—One pound of seed contains about 103,500 seeds, and the **germinative capacity** of the seed is about 35 per cent. The latter, however, varies very considerably from year to year, in some years being almost nil, whilst in other years it is as much as 60 to 65 per cent.

Cultivation, etc.—The tree is very similar to the European Larch in most of its requirements. It grows, however, con-

siderably faster when young, but, usually, gets caught up by the European species after about the 20th year. When quite young, it will often keep pace with Douglas Fir or Poplars. Up to the present time, it has proved much more immune to insect and fungous attacks than the European variety, and, as already stated, it has hardly ever been attacked by the Larch disease or canker.

Its foliage is flushed early, and it is even more liable to be injured by spring frosts than European Larch.

The chief advantage in growing Japanese Larch lies in the fact that they very quickly afford valuable thinnings; and, if necessary, mature trees can be grown, even though the European Larch would fail owing to disease.

However, the Japanese Larch is more expensive to raise from seed than the European Larch.

An excellent plan is to grow a mixture of the two species, and if disease do not make its appearance, the European variety should be left; for these trees will, as mature timber, give far better returns. The Japanese Larch grow faster when young, but usually they will not seriously interfere with the European Larch.

OTHER LARCHES.

The Western Larch is a tree native to British Columbia. Little, however, is known concerning its growth in this country. It should be largely experimented with, as there is every possibility of its proving most successful indeed.

In its native country it grows to a great height, and the boles are usually very clean. It is peculiar in possessing a very thick bark, which often enables it to resist destruction by forest fires.

The Kurile Larch is native to the Kurile Islands, in the north-east of Japan.

It is of little sylvicultural value in this country, as it does not ultimately form such a large tree as the European variety, and it is very expensive to raise.

It is usually very quick growing when young, and is said

to be hardy as to spring and autumn frosts, and also as to drought.

The Siberian Larch is native to Siberia. It is not, however, suited for growth in this country. As might be expected, it comes into growth very early in the spring, and is extremely tender as to late frosts.

PINES.

There are many varieties; and these may be classified according to the number of needles contained in each sheath.

The following Pines contain **2 needles** in each sheath:—

- Pinus sylvestris* = The Scots Pine.
- Pinus Austriaca* = The Austrian Pine.
- Pinus laricio* = The Corsican Pine.
- Pinus pinaster* = { The Star, or Cluster, or
 Maritime Pine.
- Pinus Banksiana* = { Bank's Pine, or the Scrub,
 or Jack Pine.
- Pinus Mugho.*
- Pinus pinea* = The Stone or Umbrella Pine.

The following Pines contain **3 needles** in each sheath:—

- Pinus ponderosa.*
- Pinus insignis* = The Remarkable Pine.
- Pinus rigida*, sometimes called Pitch Pine.¹
- Pinus sabiniana.*

The following Pines contain **5 needles** in each sheath:—

- Pinus strobus* = The Weymouth Pine.
- Pinus excelsa.*
- Pinus cembra* = The Swiss Stone Pine.
- Pinus Lambertiana.*

The above are only a few of the many varieties that are sometimes met with in this country; but, only those of sylvicultural interest in this country will now be considered.

SCOTS PINE.

The Scots Pine is a **native tree** to this country.

As to Seed.—The tree produces seed freely, and good crops are obtained from the 30th year onwards. Good seed years are very frequent, and occur every two or three years.

¹ The Pitch Pine timber as imported is the wood of the *Pinus palustris*.

Home-grown seed from strong, healthy, vigorous trees is far preferable to any imported seed.

One pound of seed contains about 75,000 seeds, and the **germinative capacity** is about 65 to 70 per cent.

The **timber** is rather soft, durable (especially when grown in close canopy), and resinous.

However, unless the trees be grown in close canopy, the timber is possessed of wide annual rings; such timber is then very soft and not durable.

The red Baltic deals and battens are cut from this tree. The timber is extensively used for the carpentry and joinery in house construction. Home-grown timber, especially that grown in Scotland, is quite as good as the imported timber, provided always, that the former has been grown under correct sylvicultural principles.

Soil and Situation.—Scots Pine is very accommodating as to the soils it will grow upon. Though, naturally, liking a deep gravelly loam, it will grow on stiff clays, or on very dry, practically pure, sands. It will accommodate itself to rather shallow soils, though not so shallow as those upon which the Norway Spruce will thrive. It will succeed on wet peaty soils, provided the water be not stagnant.

It is extremely hardy as to spring and autumn frosts; and trees raised from home-grown seed are practically never injured, though those produced from continental seed do not seem so hardy in this respect.

The trees are also very storm-proof¹ and hardy as to drought. As a pioneer crop Scots Pine is most valuable. On heather land it can often advantageously be raised *in situ* from seed.

On hot, dry, southern aspects this and the Corsican Pine are often the only trees that are likely to thrive and produce valuable timber; though their best growth is seen on cool northern aspects.

Cultivation, etc.—The trees are very light-demanding during all stages of their existence. Their side branches are

¹ Heavy falls of snow break off many branches, which are brittle; and the crowns of trees often suffer considerably.

very persistent ; and the canopy for the first 30 years must be very close, so as to prune them off naturally and prevent them from attaining any considerable size.

The plants grow quickly from the seedling stage onwards, and small plants, not over 4 years old, suffer but little check in being transplanted.

On ordinary heather land, with which the trees are naturally associated, 1- or 2-year-old plants will be quite big enough to plant out.

On grass land 3- and 4-year-old plants must usually be planted. Provided the heads of the plants be free, Scots Pine suffer less than most trees from a soil covering of grass. This is also the case with Corsican Pine, Hornbeam, Birch, Sycamore, and Norway Maple. The foliage of Scots Pine is comparatively thin, and pure crops cannot usually protect the soil after about the 40th year. However, they are not very suitable for being underplanted;¹ and, if the land be good enough to grow an undercrop, it will seldom be advisable to plant Scots Pine, except where it is used as a pioneer crop, as in frosted localities on good soil, where it may be planted, so as to render possible the introduction of a more valuable species at a later date.

Generally speaking, Scots Pine should only be grown as even-aged high forest. It is quite unsuited for standards over coppice.

Where Scots Pine must be grown, it will generally be advisable to grow it pure ; for, mixed crops, except the mixtures be by patches, are seldom satisfactory.

There are, however, one or two mixtures by alternate rows, etc., that can be recommended.

Scots and Corsican Pine may be grown together, especially if it be desired to have a mature crop of Corsican Pine, and if the success of a pure crop of Corsican Pine be doubtful.

The Corsican Pines grow much quicker when young than the Scots Pines ; so that the latter must be removed if the

¹ The necessary partial clearances may result in the production of unduly wide annual rings to the detriment of the technical quality of the timber.

former succeed. It is, however, preferable not to mix them unless there is any special reason for so doing.

Scots and Weymouth Pine may, in the same way, be advisable if the success of pure Weymouth Pine be doubtful.

Scots Pine often pay well when grown on short rotations of 35 to 40 years, if there be a market for pit wood.

The land is left clean at the end of a short rotation, but is very foul at the end of a long rotation, if a pure crop has been grown.

The natural regeneration of Scots Pine should only be attempted by leaving strips of trees, and allowing the seed to blow on to a vacant area. Wherever heather land exists, a young crop can usually be easily established from seed. But it will seldom be possible, except, perhaps, on northern aspects at high altitudes, to obtain natural regeneration on land from which a crop has just been cleared; for, though originally heather land, it will, in most cases, be found to be covered with grass, owing to the soil improvement that has taken place. Such would not, however, usually be the case in dry continental climates.

Rotation.—This should be about 80 to 90 years for large mature timber.

Average returns from pure crops in high forest should be, per acre:—

Thinnings	1050	cub. ft. to 2 in. q. g.
---------------------	------	-------------------------

Final yield (at 80 years)	3450	" 6 "
-------------------------------------	------	-------

Total production	5200	" 2 "
----------------------------	------	-------

Average annual increment, 65 cub. ft.

Equivalent net rental¹ for land only } at 3% = 1s. 3d.

(from date of planting) } at 4% = minus 3s. 4d.

Of Fungi.—*Phytophthora omnivora* attacks seedlings.

Hysterium pinastri (= *Lophodermium pinastri*), known as the **Leaf-shedding disease**, attacks young trees, especially those from 1 to 7 or 8 years of age.

Botrytis cinerea attacks the foliage and young shoots,

¹ After deducting interest on £8, the cost of planting and establishing the crop.

often doing very great harm to young trees and nursery stock.

Agaricus melleus (=the **Honey Fungus**) characterised by its black rhizomorph strands on the roots, and its mushroom-like fructifications, attacks the roots. The needles of infected trees turn pale, and the trees soon die.

Trametes radiciperda (=**Fomes annosus**), and known as the **Red Rot Root Fungus**, often attacks trees of all ages, which, when once attacked, usually quickly die. The needles of trees, when attacked, turn pale; and at the base of the stem, or on the roots just below the soil, the bracket-like fructifications may be found. These appear as somewhat flat, corky incrustations or brackets with wrinkled margins; at first they are of a yellowish-white colour, but later on they turn dark brown on the top, being snow-white underneath.

Trametes pini attacks the boles of trees, usually after they are about 35 years of age. Bracket-like fructifications appear on the stem; the heartwood rots away, and the tree becomes hollow. The sapwood of Pines and also of Larch is not affected, but the sapwood of Spruce and Silver Fir is decomposed just like the heartwood.

Peridermium pini acicola = The **Pine Needle Blister**, or **Bladder Rust**, attacks the foliage of Scots and other Pines.

Young trees up to 12 years of age are most frequently attacked, though often older trees. New foliage is never attacked, but only needles 1 or 2 years old.

In the spring, small orange vesicles or blisters may be seen on the leaves.

Peridermium pini corticola = The **Pine Bark Blister** or **Canker**, often does immense damage to Scots and other Pines, especially on southern aspects. Young trees up to about 15 years of age are chiefly attacked; if it occur in older trees, the attack is confined to the younger wood, the bark of which is thin.

It is characterised by the appearance on the smooth young bark, of bladder-like pustules filled with yellowish-red spores.

Cæoma pinitorquum, known as the **Pine Shoot-twisting**

fungus, is the *Cæoma* form of *Melampsora pinitorqua*, which causes a well-known rust on the leaves of Poplars. The *Cæoma* chiefly attacks Scots and Weymouth Pines up to about 12 years of age.

Yellow *Cæoma* pustules appear on the bark of the current year's shoots, causing a cankerous appearance, and the shoots become twisted and bent.

Cerastoma piliferum, a saprophyte, causes the bluish discolouration of Scots Pine and other coniferous timber.

Of Insects.—Scots Pines are perhaps more liable than any other trees to insect attacks.

Cockchafer grubs (the larvae of *Melolontha vulgaris*) gnaw through the roots of young trees, especially in new plantations made on grass land or on land recently ploughed. Nursery stock also often suffers from the ravages of the grubs, and also from **wireworms** (the larvae of *Agriotes lineatus*).

The **Pine Weevil** (= *Hylobius abietis*), sometimes known as the large brown Pine weevil, gnaws the bark off the stems of young conifers, usually from 2 to 7 years old, and consequently kills them. Scots Pine and Spruce are chiefly attacked, but also other conifers; and, occasionally, broad-leaved trees. On account of the great damage done by this insect, the fellings in Scots Pine and Spruce woods should never be consecutive, but should be arranged intermittently. Also, when replanting Scots Pine or Spruce areas with coniferous crops, it is advisable, where possible, to burn the area over or to wait for 2 or 3 years before replanting; the latter method, however, should be avoided if possible. Bark traps should be laid to catch the weevils.

The **Small Brown Pine Weevil** (= *Pissodes Notatus*), attacks Scots, Corsican, and Weymouth Pines in particular, and, occasionally, Spruce and Larch.

The weevils prick the bark through and suck the sap. The young trees look as if pricked with pins, and little beads of resin ooze out.

Young plantations of 3 to 8 years old are attacked. The insect is chiefly confined to Scotland.

The **Large Pine Beetle** = *Hylesinus* (or *Hylurgus*) *pini-*

perda, attacks Scots Pine in particular, though, occasionally, other Pines and Spruce.

Trees of any age may be attacked. Attacks are often worse along the edges of rides or roads, or in woods near timber yards. The eggs are laid along a "mother gallery" under the bark of recently felled timber, or of sickly trees.

The damage is occasioned by the beetles (not by the larvæ), and they are generally beetles of the second generation in any year, which bore into the tops of Pine shoots, just below the buds and feed on the pith, thus hollowing out the shoots, which break over with the first storm of wind.

The **Crutch Pine Beetle** (= *Hylesinus palliatus*), is chiefly confined to Scotland, where it attacks Scots and other Pines and conifers.

The **Pine Sawfly** (= *Lophyrus pini*), attacks Scots and Austrian Pines chiefly. The leaves are eaten by the larvæ or caterpillars.

The young caterpillars eat the edges of the leaves, leaving the midrib. But as they get older they eat the whole of the leaves.

The **Fox-coloured Sawfly** (= *Lophyrus rufus*), also does much damage, in the same manner as the *L. pini*.

The **Pine Shoot Tortrix** or **Twig Twister** = *Retinia (Tortrix) buolianana*, chiefly attacks young Scots Pine up to 12 years of age, though other Pines are sometimes attacked. The attack is especially prevalent on southern aspects.

The larvæ or caterpillars bore into the buds and there hibernate during the winter. Next spring, as the buds develop, the larvæ feed on and hollow out the young twigs, which only partially develop and then fall over and die.

Of other Pests.—**Squirrels** do much harm by eating off the bark high up in the trees.

AUSTRIAN PINE.

This is not a native tree to this country.

As to Seed.—One pound of seed contains about 25,000 seeds, and the **germinative capacity** is about 65 to 70 per cent.

The timber is soft, resinous, and durable, but is coarse and very knotty, as usually grown in this country.

Soil and Situation.—The tree delights in calcareous soils, and even thrives on poor thin soils resting upon chalk. Generally speaking, it prefers a deep dry gravelly loam. It will succeed on ordinary clay soils, but not on very stiff wet soils. It is very storm-proof, and very hardy as to drought and as to spring and autumn frosts.

Cultivation, etc.—It is a very light-demanding tree, though not so much so as Scots Pine; and its foliage is a little denser than that of Scots Pine. Its side branches are very vigorous and persistent, and a very close canopy indeed is necessary in order to kill off these branches. Trees, planted 3 feet apart, need not, usually, be thinned till they are 25 to 30 feet high. It is only suitable for even-aged high forest, and, in most respects, may be similarly grown as Scots Pine; but it is much faster growing when young.

It stands sea breezes well, and can be used for planting sandy tracts along the sea coast.

Except for such purposes, or as shelter belts, it will seldom be advisable to plant it, as the Corsican Pine, which is similar in most respects, will, in this country, grow timber of higher technical value.

The trees do not transplant well, and should be moved every year whilst in the nursery. They should be planted out late in spring.

Of Fungi and Insects.—Speaking generally, the fungi and insects which attack the tree are the same as those which attack Scots Pine.

CORSICAN PINE.

The Corsican Pine is not a native tree, and is said to have been introduced about the year 1815.

As to Seed.—One pound of seed contains about 31,000 seeds, and the germinative capacity is about 65 to 70 per cent.

The trees can produce good crops of seed from the 30th year onwards; but it is not advisable to use home-grown seed.

The timber is light, soft, resinous, and durable. It is very similar to that of Austrian Pine, but is, when grown in this country, of greater technical quality and possesses fewer knots. It is worth as much per foot as Scots Pine.

Soil and Situation.—Deep dry soils suit it best; but it is not very exacting in respect of soil.

Like Austrian Pine, it succeeds on soils overlying chalk, but, in such cases, it requires rather more surface soil than Austrian Pine.

It thrives quite well on moderately stiff clay land. However, nursery stock should always be raised on dry friable soil; for, on stiffish land, the seedlings will never form good root systems. Very wet soils are quite unsuited to it. In its early existence, say up to 3 years old, it is much injured by continual wet weather in the growing season. It prefers a dry atmosphere.

It is very hardy as to drought, and, also, as to spring and autumn frosts. It is, also, a very storm-proof tree.

It stands sea-spray very well, and is one of the best trees to plant on sandy, seaside tracts.

Cultivation, etc.—The tree grows very quickly when young; a good deal faster than Scots Pine. It is very light-demanding. Its side branches are very persistent, and a close canopy when young is very necessary in order to prevent their development. It has a deep root system, and nursery plants must be transplanted every year until planted out, say at 2 or 3 years old, otherwise they will be devoid of fibrous roots.

Corsican Pine is, perhaps, the most difficult tree to transplant. It should be planted out late in spring, just as the buds are expanding. It is far easier to transplant 2-year-old trees than 3- or 4-year-old trees. On heather land it is one of the best pioneer crops, as it grows so quickly; but, on grass land, Scots Pines may be preferable, as larger plants are necessitated, and the Scots Pines transplant readily.

Corsican Pine is only suitable for even-aged high forest. If its success be undoubted, it will generally be preferable to plant it pure—3 feet apart each way.

Corsican and Scots Pines may be evenly mixed when the success of the Corsican Pine is doubtful.

Corsican and Weymouth Pines make a good mixture in cases where the success of a pure crop of Weymouth Pine is doubtful. The Corsican Pines must be removed as thinnings, for the Weymouth Pines will surpass them.

Corsican Pine and Douglas Fir is an admissible mixture where a final crop of Douglas Fir is desired, and the expense of planting a pure crop is considered too great.

Rotation.—The best rotation is about 80 years, though, as with most coniferous crops, quite short rotations often pay very well for pit timber.

Average returns from pure crops in high forest should be, per acre:—

Thinnings	1680	cub. ft. to 2 in q. g.
---------------------	------	------------------------

Final yield (at 80 years)	3600	" 6 "
-------------------------------------	------	-------

Total production	5500	" 2 "
----------------------------	------	-------

Average annual increment, 75 cub. ft.

Of Fungi and Insects.—The fungous and insect attacks are similar to those mentioned as affecting Scots Pine.

Of other Pests.—Rabbits, usually, will not persistently attack Corsican Pine. But, in hard winters, if they can find nothing else to eat, they will readily feed on the bark.

In cases where only a few Corsican Pines have been planted, they are often attacked by rabbits, who, out of ignorance, like to sample the bark, but soon come to the conclusion that it is distasteful.

Squirrels do much harm by "ringing" the trees near the top.

THE STAR, CLUSTER, OR MARITIME PINE.

This is not a native tree, and is said to have been introduced in 1596.

The timber is coarse, resinous, and rather heavy. It is very inferior to Scots Pine timber. The tree never grows with a straight bole.

Soil and Situation.—It prefers deep, dry, sandy soils;

but it will grow on a variety of soils, provided they be deep.

Chalky or any calcareous soils are quite unsuited to it; so also are wet soils. It is tender as to frosts; but it is a storm-proof tree, and has been very successfully planted on sandy dunes by the sea-shore. It stands the sea blasts very well.

Cultivation, etc.—The tree is very light-demanding; and is of a coarse branchy habit, the ends of the branches turning somewhat upwards.

Like Corsican Pine, it is a very difficult tree to transplant. Nursery stock should be transplanted every year without fail, until planted out at, say, 3 years old. The planting out should take place late in the spring. The tree has a very long tap-root, and very few fibrous roots. Hence, where possible, it should be raised *in situ* from seed.

Except for sea-coast planting, there is little to recommend the cultivation of the tree.

BANK'S PINE.

This is a native tree of Eastern America.

The timber is of very little commercial value; and on poor soil the trees are only from 15 to 25 feet high.

Soil and Situation, etc.—It will grow on almost any soil; and its value lies in the fact that it may succeed on dry, nearly barren, rocky soils, where almost all other trees will fail. It is very hardy as to frosts, and will also withstand sea breezes very well. It has been successfully planted on sand dunes; and, in Denmark, is so planted on the coast along with the White Spruce (*P. alba*).

PINUS INSIGNIS.

The *P. insignis* is native to California, and is said to have been introduced in 1833.

Soil and Situation.—It prefers light, dry, deep soils, and is very tender as to spring and autumn frosts. Dry, cold, easterly winds are also detrimental to it.

Generally speaking, it has no sylvicultural value in this country; but on the west coast of England, it has been used with success in planting dry shifting sand in localities much exposed to the sea blast; though their development is small under such circumstances. The buds of the trees are not so liable to be pierced and riddled by the blowing sand as are the buds of most other Pines.

WEYMOUTH PINE.

The Weymouth Pine is not a native tree; but it was introduced from Eastern North America in 1705.

As to Seed.—Trees, 30 years old, produce good crops of seed; and good seed years occur every 2 or 3 years; the seed usually ripens in October in this country; and, if it be required, it should be collected at once, as the seed is almost immediately scattered.

However, home-grown seed should not be used, except experimentally.

One pound of seed contains about 27,000 seeds, and the germinative capacity is about 55 per cent.

The timber is **white**, light, soft, and contains but little resin. It is one of the lightest woods when seasoned; and it shrinks very little in seasoning, and does not warp. It is not durable when exposed to inimical influences, but is very suitable for all interior joinery; and it makes excellent pulp wood.

The **White** or **Yellow Pine** of commerce is cut from the Weymouth Pine.

Soil and Situation.—Deep, sandy loams, with a good supply of moisture, suit the tree best of all.

Calcareous soils in most cases seem quite unsuited to it. It often grows well on peaty soils, provided they contain no stagnant water; and, also, on clay soils, but under such circumstances, they are often difficult to establish, on account of spring and autumn frosts, to which the Weymouth Pine is very susceptible.

On dry, sandy soils the tree will often thrive well, but it is

rather liable to become diseased wherever the conditions for its growth are not favourable. In all cases a deep soil is essential. It prefers fairly sheltered situations, and cold, dry, east winds are inimical to it.

Cultivation, etc.—The tree is capable of withstanding considerable shade, especially if the soil be moist; and its foliage is denser than that of most Pines. It grows very fast when once it is established. It is rather shy of transplanting; but, if this be done late in the spring, there is not much danger to fear. Its side branches are very persistent, and a very close canopy is necessary in order to prune them off. The tree is peculiar in transpiring an enormous amount of moisture, and, for this reason, the greatest care is necessary if it be used for underplanting.

It may be grown pure as even-aged high forest; but, as it is rather liable to fungous attacks, it is less risky to plant a mixture.

Thus, Weymouth and Scots or Corsican Pines may be evenly mixed, the Weymouth Pines being left for the mature crop, if all goes well. They should be planted 3 feet apart each way.

It is rather difficult to make any other mixture by alternate rows or trees, unless the inferior growth of one of the species be not objected to.

However, Weymouth Pine and Sitka Spruce might give good results, though it would be a very expensive mixture; for both species are expensive to raise.

But, as is the case with most species, the most satisfactory manner of forming mixtures is, generally, by groups or patches, when, if fairly large groups be made, almost any species can be mixed, provided the soil be suitable.

Weymouth Pine is admirably suited for underplanting crops of Larch or Ash, provided that the soil be not too dry. The light overhead canopy will afford the Pines the shelter they require from frosts; and the cost of raising a crop can be very much reduced by planting 2-year-old plants.

Rotation.—The best rotation is about 80 years.

Average returns from pure crops in high forest should be, per acre :—

Thinnings	1350	cub. ft.	to 2 in. q. g.
Final yield (at 80 years).	4270	"	6 "
Total production . . .	6300	"	2 "
Average annual increment, 79 cub. ft. to 2 in. q. g.			
Equivalent net rental ¹ for land only } at 3% = 4s. 1d. (from date of planting) } at 4% = minus 1s. 5d.			

Of Fungi.—Many of those attacking Scots Pine also attack the Weymouth Pine.

Agaricus melleus and **Trametes radiciperda** very frequently cause much damage.

Peridermium strobi, sometimes called **P. ribicolum**, is the **Weymouth Pine Bark Blister**. It often does enormous damage to young crops. It is characterised by pinky red, bladder-like vesicles, which appear on the stems.

Other fungi attacking the Weymouth Pine are :— **Hysterium pinastri**, **Botrytis cinerea**, **Cæoma pinitorquum**, **Trametes pini**, and **Peridermium pini acicola**.

Of Insects.—Most of those attacking Scots Pine will also, occasionally, attack Weymouth Pine; though, generally speaking, the tree is not nearly so subject to insect attacks as the Scots Pine.

Pissodes notatus is, however, fairly common in Scotland.

¹ After deducting interest on £8, the cost of planting and establishing the crop.

SILVER FIR.

Abies pectinata = The Common Silver Fir.

Abies Nordmanniana = Nordmann's Silver Fir.

Abies concolor.

Abies grandis.

The Common Silver Fir is native to the mountains of Central Europe; and is said to have been introduced in 1603.

As to Seed.—Good crops of seed are produced from about the 65th year onwards, in its native habitat.

It bears seed in the warmer parts of this country; but home-grown seed should never be relied upon, except for experimental purposes.

One pound of seed contains about 10,000 seeds, and the germinative capacity is about 40 per cent.

The timber is white, soft, and light; and, if grown in close canopy, is of excellent quality. It may be used for the same purposes as Spruce. It is easily worked, and splits well. Strasburg Turpentine is obtained from this tree.

Soil and Situation.—A deep soil is essential, and a fair amount of moisture. On dry, sandy, or gravelly soils it will not, usually, succeed.

It is extremely tender as to spring and autumn frosts; and, also, as to hot summer sun, when the plants are young.

It will thrive on stiff clay soils, if it can get established; but, except when used as an undercrop, it will so often be killed by frosts, that it should seldom be planted in the open on such soils.

It likes a fairly moist atmosphere, and a warm climate; and it succeeds best in the south and south-west of England, or in the neighbourhood of the sea or inland lakes; and it prefers northern aspects.

It has a deep root system and is a storm-proof tree.

Cultivation, etc.—The tree is rather a bad "transplanter,"

and, like most conifers, succeeds best if planted out late in the spring. It is very slow growing when young, trees 12 years old being often only 6 or 8 feet high. It bears an immense amount of shade; more even than the Beech. Its side branches are not readily killed; and a very close canopy must be retained until the trees are 50 feet high. In the latter part of its rotation, its growth is very rapid indeed. It may be grown in even-aged high forest; but it should almost invariably be raised under a light shelter-wood, so as to protect the young crop from frosts and sun. It should be grown pure, or else mixed by patches or groups; for, its slow growth will prevent it being pruned by practically any other trees; nor will these other trees be pruned by the Silver Fir, for the vigorous growths of the latter will be too late to effect the desired end.

Silver Fir should, however, as a general rule, be used only for underplanting, for which purpose it is admirably suited. As the undercrop in two-storied high forest, it will generally give a better financial return than if grown as even-aged high forest. When used for underplanting, the overcrop can be removed when the Silver Fir are about 40 years old, and the latter should then be allowed to grow on to maturity.

Also, apart from the question of the advisability of raising crops from home-grown seed, Silver Fir can be grown under the group and selection systems.

Natural regeneration is very easy in its native country, and it is often found in the south and west of England, and in Ireland; but, it is doubtful if these trees will retain the vigour of, or produce as good seed as, their parents.

For experimental purposes, the seed from these self-sown English trees should be carefully collected, and the young trees raised therefrom should be carefully watched. Ultimately, a generation of acclimatised trees might be reared, whose seed could be relied upon, and which would, probably, then be preferable to any imported seed; and the extreme tenderness as to frosts might thus be eradicated.

Rotation.—The best rotation is from 80 to 100 years.

Average returns from pure crops in high forest should be, per acre :—

Thinnings	1160	cub. ft.	to 2 in. q. g.
Final yield (at 90 years).	6050	"	6 "
Total production . . .	7860	"	2 "
Average annual increment, 87½ cub. ft.			
Equivalent net rental ¹ for land only { at 3% = 1s. 1d.			
(from date of planting) { at 4% = minus 3s. 6d.			

Of Fungi.—*Phytophthora omnivera* causes “damping off” of seedlings.

Pestalozzia Hartigii produces a canker on the bark of young stems in nurseries and young plantations. The attack is generally near the ground level.

Agaricus melleus=the Honey Fungus, and *Trametes radiciperda* (*Fomes annosus*)=The Red Rot Root Fungus, attack the roots.

Trametes pini attacks the boles of trees, after the age of about 35 years, and decomposes the heartwood and also the sapwood; though in Pines and Larch the sapwood is not attacked.

Æcidium elatinum produces “Witches Broom.” This æcidium is the resting spore stage of *Melampsorella cerastii*.

It is characterised, in the early stages, by annular swellings which appear on the twigs and branches.

Triphosphæria parasitica=The Silver Fir Needle Blight Fungus, attacks plantations when about 20 to 40 years old. The young twigs are attacked and the needles turn brown and hang down.

Phoma abietina causes a canker on the twigs and branches of small Silver Firs.

Lophodermium nervisequum=The Silver Fir Leaf Scurf, attacks 2-year-old needles in the spring of their 3rd year. It takes the form of a rust, and afterwards causes leaf-shedding.

¹ After deducting interest on £8, the cost of planting and establishing the crop.

Of Insects.—On the whole these are not very destructive.

Cockchafer grubs gnaw the roots of young plants.

The Giant or Yellow Wood Wasp (= *Sirex gigas*), bores into the boles of the Silver Fir, and also of Larch and Spruce.

Hylobius abietis sometimes gnaws the bark of young stems, up to about 7 years of age.

Nordmann's Silver Fir.—This is native to the mountains in the south-east of Europe, and is said to have been introduced in 1845.

It is of about similar value to, and may be cultivated in the same manner as, the Common Silver Fir. It has the advantage of being less liable to be injured by spring frosts, as its growth in spring starts very much later than the common variety.

According to some writers, it can endure more shade even than the Common Silver Fir.

Abies concolor is well worth an extensive trial. It transplants better than most of the other Silver Firs; and the trees are quicker growing when young than most of the other varieties. It is less injured by spring frosts; and will grow on considerably drier soils than any other of the Silver Firs.

Abies grandis is recommended by some. It appears to be somewhat hardier, and rather quicker growing when young, and, also, more easy to transplant than the Common Silver Fir.

SPRUCE.

Picea excelsa = The Norway Spruce.

Picea Sitchensis = Sitka Spruce.

Picea alba = The White Spruce.

None of the Spruces are native trees.

NORWAY SPRUCE.

The Norway Spruce is said to have been introduced about 1550.

As to Seed.—Good crops of seed are produced from about the 15th year onwards; and the seed years are frequent. However, it is a difficult question to decide whether home-grown seed should be used.

One pound of seed contains about 64,000 seeds, and the germinative capacity is about 70 to 75 per cent.

The timber is white, light, and soft, but is not durable when exposed to inimical influences. It is the tree from which the white Christiana deals are cut. It makes excellent pulp wood.

Soil and Situation.—The Spruce will grow in a great variety of soils, but any dry soil is quite unsuited to it. It thrives on stiff clay soils, and also on peaty soils, provided they are not water-logged.

It requires a less depth of soil than almost any other tree, provided it can obtain sufficient moisture. It prefers a very moist atmosphere, and hence succeeds better on northern aspects. As explained elsewhere, its growth in England is seldom satisfactory, except on tablelands at high elevations, or on northern aspects, or where there is really a great deal of moisture in the soil. However, the climate in Scotland is much more suited to its growth. The tree likes a short growing season with a rapid transition from winter to summer; and it delights in being frequently shrouded in mist and fog.

It is rather susceptible to late spring frosts; and is very liable to be thrown by the wind.

Cultivation, etc.—It is a thickly foliaged tree. It is very fibrous rooted, and will transplant easily, but it generally takes a few years to become established after being planted out, after which it makes a rapid height growth, and, like Silver Fir, Larch, and Douglas Fir, preserves a straight central stem.

Its side branches are very persistent and are very difficult to prune off naturally, so that a close canopy, when young, is very essential.

It bears a good deal of shade where the conditions for its growth are really suitable; but, generally speaking, it is a very inferior shade bearer in most parts of England.

Even on good moist soils, its utility for underplanting is of doubtful value, for it transpires a very great amount of water in the spring, and robs the overcrop of its due supply, and hence often does more harm than good. If planted under Oak, it will often cause the latter to become "stag-headed."

The best timber will be grown, if it be planted pure in even-aged high forest. Mixtures, except by groups or patches, are very difficult to arrange.

Norway Spruce and Weymouth Pine should give good results; but, if the soil be suitable for Weymouth Pine, it will not usually be profitable to plant Spruce.

Leaving out of consideration the advisability of the growth of trees from home-grown seed, and also the expense of protection against rabbits, Spruce may be grown under the selection system; though the quality of the timber will not be very good.

And it may also be grown under the group system; but the groups must be small, as the tree is not storm-proof.

All thinnings must be very slight until the principal height growth has been attained.

Rotation.—The best rotation on average land is from 75 to 85 years.

Average returns from pure crops in even-aged high forest should be, in cubic feet, per acre :—

Thinnings	1000	cub. ft.	to 2 in. q. g.
-------------------	------	----------	----------------

Final yield (at 80 years) .	5000	"	6 "
-----------------------------	------	---	-----

Total production . . .	6400	"	6 "
------------------------	------	---	-----

Average annual increment, 80 cub. ft. to 2 in. q. g.

The rental equivalents will be about the same as those given for Silver Fir.

Of Fungi.—*Phytophthora omnivera* often causes the "damping off" of large quantities of seedlings.

Pestalozzia Hartigii produces a kind of canker or blister on the bark of the smooth stems of Spruce, and also of Silver Fir and other trees in nurseries, and in young plantations. The attack is generally near the ground level, and the trees wilt and die.

Septoria parasitica attacks the leading shoots of seedlings and young trees of Norway Spruce and Sitka Spruce. The base of the young shoots is generally affected in about June; they hang down, wither, and die. Later on, black fungous specks can be seen on the bark and the needle cushions of the attacked shoots.

Agaricus melleus (=the Honey Fungus) and *Trametes radiciperda* (*Fomes annosus*)=the Red Rot Root Fungus, attack the roots.

Trametes pini attacks the boles of trees after about the age of 35 years, affecting the heartwood and also the sap-wood and causing the bole to become hollow.

Lophodermium macrosporum (= the Spruce Leaf Scurf), attacks the leaves of 2-year-old shoots of young trees, generally from 10 to 30 years of age. It either merely produces a rust, or else causes actual leaf shedding.

Botrytis cinerea attacks the foliage of young trees and nursery stock.

Nectria curcubitula produces cancerous patches on the bark of small stems and branches.

Chrysomyxa abietis (= the Spruce Needle Rust or Blister), produces a rust on the current year's needles only.

It is most frequent in plantations from 10 to 30 years of age.

Polyporus vaporarius attacks the stems through wound surfaces.

Of Insects.—*Hylobius abietis* (=the Pine Weevil) gnaws the bark of 2- to 7-year-old trees. As mentioned, when dealing with Scots Pine, the fellings should always be intermittent, so that neighbouring Spruce areas differ by 6 to 8 years. If possible, Spruce should not be planted on areas from which a crop of Spruce or Scots Pine has just been removed. Bark traps should be laid.

Pissodes notatus (=the Small Brown Weevil), *Hylesinus* (or *Hylurgus*) *piniperda* (=the Large Pine Beetle), and Cockchafer grubs, also do much harm.

Chermes abietis (=the Spruce gall Aphid), is the sexual form of the sexless Larch Aphid. It attacks young Spruce from about 10 to 20 years of age. The lice suck the sap of the young shoots, and a cone-like gall results.

SITKA SPRUCE.

The Sitka Spruce, sometimes known as Menzies Spruce, is native to Sitka Sound and the coast region of British Columbia; it is said to have been introduced in 1831.

As to Seed.—One pound of seed contains about 197,000 seeds, and the germinative capacity is about 70 to 75 per cent. There is every reason to anticipate that home-grown seed will prove equal in every respect to that which is imported; but great caution is necessary until this be proved by generations of experience.

The timber of well-grown trees is of excellent quality; it is soft and white, and may be used for the same purposes as that of Norway Spruce.

Soil and Situation.—Deep soils are essential; so also is a plentiful supply of moisture, and a damp atmosphere, if its maximum development is to be attained. On very stiff clay soils it shows promise of being one of the most profitable trees that can be planted. It delights in a deep, moist,

humous soil resting upon a cool stiffish bottom. Shallow soils, or very dry soils are quite unsuited to it. But it will succeed on deep, somewhat dry soils, especially if the aspects be north. It has a deep root system and is a storm-proof tree.

Cultivation, etc.—It is capable of bearing considerable shade if the soil be moist enough; and it may be used for underplanting, where the overhead canopy is light.

It transplants readily, and is a very quick growing tree; and, in some cases, it will practically keep pace with Douglas Fir.

Its side branches are vigorous, and a close canopy is necessary in order to effect natural pruning.

It may be grown in even-aged high forest, when it is best grown pure.

Mixtures by alternate rows or single trees are difficult to arrange.

Sitka Spruce and Douglas Fir, or Sitka Spruce and Weymouth Pine will grow excellent timber; but, both these mixtures are very expensive.

Sitka Spruce and *Thuya gigantea* should give very good results.

In order to lessen the expense, a mixture of Sitka Spruce and Corsican Pine may be planted, all the latter being removed as thinnings.

Sitka Spruce will also, in all probability, succeed well under the group or selection systems.

It is very suitable for underplanting, if the overhead canopy be light.

Like all thickly foliaged trees, it is quite unsuited for standards over coppice.

Rotation.—The best rotation is from 70 to 75 years.

Average returns from crops grown in this country have yet to be proved. But it will, in all probability, prove rather more profitable than Weymouth Pine.

Of Fungi and Insects which will attack it in this country, it is somewhat premature to treat of; but, many of those enumerated when treating of Norway Spruce and Scots Pine have already attacked the Sitka Spruce.

Wherever the conditions are not really suited to the growth of the tree, it is almost certain to fall a prey, sooner or later, to attacks of fungi or insects.

Some species of fungus affecting the foliage seems very prevalent on young trees planted on dry land.

As to other Pests.—The needles of Sitka Spruce are very prickly, and to a great extent they afford protection against deer and other animals which like to feed on young trees.

WHITE SPRUCE.

The White Spruce is a native tree to North America.

Though it is of little importance as a timber producer in this country, it may possibly prove to have a great value for planting on exposed sand dunes on the sea coast.

It appears extremely hardy in every respect. It has been very successfully planted, along with the Banksian Pine, on exposed, sandy tracts on the coast of Denmark.

THUYA.

Thuya gigantea = The Giant Arborvitæ, or the Red "Cedar" of British Columbia.

Thuya occidentalis = The American, or Common Arborvitæ.

Only the *Thuya gigantea* will be considered, as the *T. occidentalis* is of little sylvicultural importance in this country.

The *Thuya gigantea* is a native tree to British Columbia, and grows most luxuriantly near the damp Pacific Coast. It is said to have been introduced in 1854.

As to Seed.—It bears abundant crops of seed from about the 30th year onwards. Home-grown seed is likely to prove satisfactory in all respects. Imported seed from European continental countries is likely, in time to come, to cause some disappointment, and may with advantage be avoided.

All seed should be obtained from near the sea coast of British Columbia.

One pound of seed contains about 341,000 seeds, and the **germinative capacity** is about 60 to 65 per cent.

The timber is soft and very resinous, brownish in colour, and splits well. It is a very durable timber, and, for outdoor fencing, gate posts, etc., is invaluable. In its native country, huge quantities of the timber are split or sawn into "shingles," which take the place of roofing tiles or slates. It is largely used for weather boarding. It is not much used for interior house work, except for "match lining."

The value of its timber on the British market has yet to be proved; but it should be worth about 6d. to 9d. a cubic foot, according to the current level of prices.

Soil and Situation.—A moist, porous soil is most suitable for its growth. It will succeed on almost any soils, except very dry or water-logged soils. It grows fairly well on stiff clay soils, or on thin clays resting on disintegrated limestone rock, though in such localities its development is not rapid. It is a storm-proof tree, and fairly hardy as regards spring and autumn frosts. It is apt to be much injured by a hot

sun inducing transplantation in the early spring. It possesses, however, an extraordinary recuperative power; and often survives the bad effects of the most inimical influences. It prefers a moist atmosphere, and succeeds best on northern aspects.

Cultivation, etc.—The tree is very thickly foliaged, and bears a great amount of shade on moist soils. It transplants fairly well, but takes a few years to become established, after which it makes a very rapid growth, often being 40 feet high when 25 years old. It does not, however, retain this rapid growth after the tree is about 55 feet high; but it still increases rapidly in girth measurement.

A close canopy is necessary, in order to prune off the side branches when young.

The *Thuya gigantea* is admirably suited for underplanting crops of thinly foliaged trees. It may also be grown in even-aged high forest, either quite pure, or mixed by patches. If mixtures by single trees be required, *Thuya* and Weymouth Pine, or *Thuya* and Douglas Fir, or *Thuya* and Sitka Spruce may be planted. In the two latter cases it will usually be finally suppressed, and will have to be cut out as thinnings.

The tree could also be grown under the **selection or group systems**.

Rotation.—The best rotation in even-aged high forest will be about 70 to 80 years.

Average returns.—An average annual increment of 80 to 85 cubic feet (to 2 inches quarter girth) may be anticipated.

The question, whether the cultivation of this tree will prove remunerative, will depend upon the reception of its timber in the open market. It ought to sell readily; but, until this be proved, any plantations that may happen to be made by planting this tree, must be looked upon in the light of an experiment.

The tree seems remarkably free from attacks by fungi or insects.

CHAPTER XVII.

MEASUREMENTS FOR PURPOSES OF FOREST MANAGEMENT.

THE ordinary method of measuring standing timber has been dealt with in another chapter.

But, for certain investigations into the growth of crops where large areas have to be measured and great accuracy is required, the ordinary method is not suitable; for it would require a very great deal of time, and, moreover, the actual height of the tree is more or less of an uncertainty.

Continental foresters adopt another method. It is very much quicker, and insures greater accuracy; and, where a large area under timber is being measured, their usual custom is to assess the total true mathematical contents measured over bark, including, also, branch wood.

It will be instructive to note their methods of measuring standing trees or whole crops of timber, as, to a great degree, their methods will be found indispensable in this country, when making scientific investigations; although quarter girth measurements should usually be adopted instead of true contents measurements.

Now, the true contents of standing timber are found by multiplying together, the exact height, the basal area at breast high, and the form factor.

The **exact height** of standing trees may be found by the use of various height measures, of which an instrument known as **Brandt's Hypsometer** is, perhaps, the best. It is somewhat like a miniature telescope containing a dial with angles marked upon it. This dial is pivoted and can be released by pressing a button; and becomes again fixed when the

pressure on the button is withdrawn. On fairly level ground the upward angle, from a line horizontal with the observer's eye to the very tip of the tree, is first ascertained, by looking through the eye-piece and releasing the dial by pressing the button ; when the cross wires cut the top of the tree and the dial is steady, it should be fixed by taking the pressure off the button. The angle can then be read ; and, having measured the horizontal distance from the centre of the tree to the observer, the height of the tree, from a point in a line horizontal with the eye, can be ascertained by reference to tables.¹ To the height thus ascertained must be added the length between the ground level and a point on the tree in a line horizontal with the observer's eye. This will give the correct height of the tree.

If the observer be standing on much higher ground than that upon which the tree is growing, it will be necessary to measure the tree in two lengths, and add the two together. The first length is from a line horizontal with the observer's eye to the top of the tree, and the second length is from the same horizontal line to the bottom of the tree.² The sum of these two will give the height of the tree.

There are other hypsometers, such as Weise's, Faustmann's, König's, which may be preferred by some. The principle of all is that of trigonometrical relations.

The **basal area at breast high** is obtained by taking the diameter over bark at $4\frac{1}{4}$ feet above the ground. The basal area is the product of :—

$$(Diameter)^2 \times \frac{\pi}{4}.$$

The diameter is taken in inches by means of callipers, or of a tree compass. Callipers are preferable to the tree compass, as the latter is usually heavier and is apt to give too small a diameter. For very great accuracy, two diameters at right angles to each other should be measured, and the mean of

¹ Tables for use with this instrument will be found in Appendix A. The hypsometer may be obtained from Herr Max Woltz, Bonn, Germany.

² The downward angle being read.

the two diameters taken; for trees often present a broader face one way than another.

As the height is taken in feet, the basal area must therefore be reduced to feet, and the two multiplied together, *e.g.*,

$$\frac{D^2 \text{ (in inches)}}{144} \times \frac{\pi}{4} \times \text{height in feet.}$$

In practice this will be obtained from tables.

This will give the true contents of a cylinder equal to the total length of the tree, and having a diameter, all the way up, equal to the diameter at breast high.

Thus the contents as found will be far too great. The correct contents are only a fraction of this amount. The proportion which the actual contents bear to this cylinder is known as the **form factor**. It is, therefore, necessary to multiply the product of the height and basal area (at breast high) by the form factor, in order to arrive at the actual contents.

The tables of average form factors in general use are all calculated on measurements taken at breast high; therefore, in applying them, it is very necessary to be strictly accurate in taking the measurements at breast high, or the results will not be correct.

These form factors are usually referable, either to the total contents, including all small branches, or else to such contents as have a diameter of $2\frac{3}{4}$ inches¹ and upwards, over bark. It is only these latter that are of any practical application in this country.

It must be clearly understood that these average form factors cannot be taken in order to find the accurate contents of any single particular tree. They are the average form factors obtained from measurements made on innumerable trees growing in close-canopied high forest.

Therefore, if only a single tree or a small number of trees is being measured, it is not correct to apply the form factor from average tables.

Under such circumstances, the mean diameter (for timber only) must be estimated by the eye, just as the taper of a

¹ 7 centimetres.

tree is estimated in the British method of measuring standing timber; and the height up to the timber limit must also be ascertained, and the contents of timber will be :—

$$\text{Timber height (in feet)} \times \frac{(\text{mean diameter})^2}{144} \times \frac{\pi}{4}$$

Hence it will be seen that the continental method has no advantage over the British method, where a single tree, or only a small number of trees, is being individually measured, except that the height is measured more accurately if an hypsometer be used.

The form factor is really the proportion which the basal area of a cylinder, having the contents of and being as long as a given tree, bears to the basal area of that tree at breast high. If trees have the same height, the form factor will nearly always be different in the case of trees having different diameters; though all trees, whatever their height or diameter, would have the same form factor if the degree of taper from the tip of the tree to the ground were uniformly even.

In well-grown, close-canopied high forest, it is found that the girth of trees of the same species will usually vary according to the height, during the period in which active height growth is taking place; and the form factor, as found in average tables, is usually made referable to the height of a tree.

Now, if a crop of timber were not uniform in any respect, it would be necessary to measure every tree individually, and no use could be made of average form factors or any other average data.

But, where crops are fairly uniform, the contents of any area, whether large or small, may be found through the use of average data by the following methods :—

- (1) Measurement of Sample Trees.
- (2) Measurement of Sample Plots.
- (3) By estimation from Average Yield Tables.

1. Measurement of Sample Trees.

This excellent method involves, in its simplest form, the finding of the true average stem and multiplying the contents

of that stem by the number of trees on the area. If the area be very large, the average tree and the number of trees, on a comparatively small measured area, are first ascertained, and the contents completed; and from this the contents of the large area are calculated.

The initial difficulty is to find the average stem.

An excellent method is that adopted by **Weise**, in which every stem is counted and assigned to a diameter class (each class usually varying 1 inch in diameter). When all the stems are thus counted and classified, a count back up to 40 per cent. of the total number of stems is made, beginning with the stems in the biggest diameter class. The diameter class into which this count back leads, will contain the true average stem which is required.

Thus if an area contained 3000 trees classified thus:—

Diameter. Inches.	Number.
8	51
9	159
10	345
11	685
12	764
13	500
14	336
15	122
16	38
Total . . .	3000

Then a count back of 40 per cent.—

$$\frac{40 \times 3000}{100}$$

$$= 1200$$

—equals 1200 trees from the 16-inch diameter class; this would lead into the 12-inch diameter class.

Hence by this rule the average tree is one of 12 inches diameter.

Having ascertained this, the height of several trees having this diameter is accurately measured, and the average height arrived at; then the average form factor, for the species of tree having this height, is ascertained from tables; and then the contents of this average stem are found, *e.g.*, basal area \times height \times form factor; and the contents of the whole area are equal to the contents of the average stem \times number of stems on the area.

If the crop be mixed, the species of trees must be kept separate; and their contents separately computed.

Whenever there is no objection to the contrary, a few of the average stems should be felled, and their contents accurately measured; for by this means, still greater accuracy will be obtained, and the use of an average form factor dispensed with.

A method giving still greater accuracy is to find the basal area and height for each class; and then the contents of all the trees in each diameter class; and finally the contents, on the whole area, by adding the contents of each class together thus:—

Diameter. Inches.	Number of trees.	Basal area, in feet.		Height, in feet.	Form Factor. Timber only.	Contents in cubic feet.
		Per stem.	Whole class.			
8	51	.349	17.799	44	.45	352.420
9	159	.441	70.119	48	.46	1,548.227
10	345	.545	188.025	51	.47	4,506.959
11	685	.659	451.415	54	.48	11,700.547
12	764	.785	599.740	56	.48	16,078.011
13	500	.921	460.500	58	.48	12,820.320
14	336	1.069	359.184	60	.47	10,128.876
15	122	1.227	149.694	62	.47	4,361.966
16	38	1.396	53.048	63	.46	1,537.331
	3000				Total .	63,034.657

Now, by **Weise's method**, the average sample stem is $21 \cdot 1008$ cubic feet, and the contents per acre = $21 \cdot 1008 \times 3000 = 63,302 \cdot 400$ cubic feet, a difference of less than $\frac{1}{2}$ per cent.

Various other methods have been evolved for determining the contents of an area by the estimation of sample trees.

These, for the most part, divide the total number of trees into classes of equal numbers, and take one or more sample trees for each class, and thus arrive at the total contents.

By **Draudt's method**, a constant proportion (usually 1 per cent.) of the number of trees in each class is taken for samples; the 1 per cent. being reckoned roughly on every hundred, or fraction of a hundred over fifty; and two or more diameter classes, if containing under 50 trees, are grouped together.

By **Urich's method**, one sample tree is taken for every 100 trees, and is considered to have the diameter of that class from which most of the trees making up that 100 are drawn.

But **Weise's method**, and that of finding the contents of each diameter class, are far preferable for ordinary use.

2. Measurement of Sample Plots.

By this method, several plots of about one-half or one acre each are selected and measured at various spots over the whole area; their contents computed; and then the contents of the whole area found according to the proportion the total area bears to the plots.

This method has to some extent already been indicated when describing the method of selecting sample stems on a single given measured area if the total area be very large.

But the method now under consideration presupposes the taking of several small plots; and it will often be expedient to measure every tree on each of the plots, or the contents may be found by the taking of sample trees as previously described.

In selecting the plots, care should be taken that they are

as nearly representative of the whole area as possible; and they should never be taken (or only a very small proportion of them) on the edges of rides or roads, as, in such places, the growth and development is usually greater than elsewhere.

The principle involved in these two methods of measuring large areas of timber should certainly be adopted largely in this country. If the true contents over bark be computed, the contents by quarter girth measurement under bark (allowing 1 inch to 1 foot) will be approximately 65 per cent.¹

The quarter girth measurement contents can also be found by using a reduced form factor when finding the contents by the true basal area method, *i.e.*, by taking the diameter.

Thus, in the case of a crop of Beech, the reduced form factors would be as follows, if the average form factors in continental tables, according to the height of trees, were:—

Height of Tree. Feet.	Form Factor. True Contents. For Timber only.	Reduced Form Factor. For Quarter Girth Contents, under bark if diameters were taken over bark.
45	.35	.23
50	.40	.26
60	.45	.29
90	.50	.32
100	.50	.32

However, in most cases it will be preferable to take the quarter girth measurements at breast high, and then to use the unreduced form factors direct, if form factors are going to be used at all. But the application of continental form factors must at present be used with great caution in this country; for, speaking generally, crops of timber are not raised in this country in the same density as was the case with the crops from which the average form factors have been taken. Therefore, it will be wise to omit the use of form factors, at any

¹ *Vide Chapter XIII.*

rate, until their efficiency has been assured by collecting the average form factors for innumerable crops of normal density in this country.

At present the average sample trees must be measured in the ordinary way, except that an hypsometer should be used for accurately gauging the height.

Where possible, the sample trees should be felled and accurately measured, and their form factors ascertained, and a careful record of them kept for future use.

3. Estimation by Reference to Average Yield Tables.

This is a method which will give approximately correct results if average yield tables be obtainable.

It is, therefore, very useful in the making of working plans, or in drawing up a report on any woodland area, especially for estimating the contents of the younger crops. But, when great accuracy is necessary, their use cannot be recommended.

There are no average tables in general use, at present, for crops grown in this country.¹ Any attempt to apply continental tables cannot be expected to give more than a rough estimate, as the conditions under which they are grown, both as to culture and climate, vary very greatly from those that obtain in Great Britain.

The application of the tables to an existing crop is not an easy matter. It is necessary to know the age of the crop and the quality of the land for the species of crop that is growing.

In order to ascertain the age of a crop, it is necessary to fell a few trees and count the annual rings, except that, in the case of young coniferous crops, it is nearly always possible to count the annual whorls, thus avoiding the necessity of felling any trees.

The quality of the land is much more difficult to estimate. It is, of course, necessary, because the average yield tables are referable to land of a particular quality for the particular crop under consideration.

For practical application there ought to be average yield

¹ But *vide* Chapter XI.

tables for at least three and by preference five qualities of land. It should be noted that the quality of the land is referable to its quality for a particular crop. Thus, any given area may be second quality for one particular crop, but only third quality for another.

One of the best guides as to the quality of land is the height of the crop at different ages; or, at any rate, the height considered in conjunction with the quarter girth measurement. If the crop be of normal density, the height alone would usually be a sufficient guide in the case of crops approaching maturity; though, in the case of younger crops, it is often found that up to a certain age a somewhat inferior soil may show as good height growth as a soil of better quality.

If a crop has been unduly thinned, increment in girth takes place to the detriment of height growth; and regard must always be paid to this fact when applying yield tables.

Various attempts have been made to assess the quality of the soil according to a scale, allotting points for different attributes somewhat after the method adopted in judging live stock in the show ring.

But this method cannot be recommended. It may have an academic interest; but that is all. It is of no more use in judging the quality of forest land than it would be in judging agricultural land for farming purposes.

Experience alone can determine the quality of the land. In this connection it will be of great advantage to have a few trial holes dug so as to inspect the nature of the subsoil. Then again, due regard must be paid to the nature of the natural surface vegetation, the altitude, the aspect, and many other considerations which present themselves to an experienced eye.

But even when the quality of the land and the age of the crop have been determined, the tables are not easy of application, for it will seldom be found that the number of trees per acre corresponds exactly with the number indicated in the tables for the particular age. To some extent the contents may be computed by taking an amount proportionate to the indicated number and the actual number; but this cannot

give a very accurate result, because the individual trees of the crop, the density of which is below normal, will, owing to their increased growing space, have a greater cubic contents per tree than the trees of the normal crop.

Thus it is evident that great experience is usually necessary in order to obtain a fairly accurate estimate.

CHAPTER XVIII.

ESTIMATION OF INCREMENT ON CROPS OF TIMBER.

IT is a matter of the very greatest importance, for those responsible for the management of woodland areas, to be able to correctly gauge the increment or increase in value of the timber crops under their charge. For, an accurate knowledge of the increment that is taking place in any crop, in any given year, or that is likely to take place during the next few years, affords, when compared with the present capital represented by that crop, the only data which can show, for the time being, the financial return that is being obtained from the invested capital. Whenever this increment in value falls short of the returns that could reasonably be obtained by investing the capital elsewhere, it will seldom be in accordance with the true principles of forestry, to allow the crop to continue growing in its present condition. In many cases it will indicate that the whole crop should be clear felled; in other cases, perhaps, a partial clearance of the crop will be indicated, in order to admit of an increased increment on the trees left, which may prove very remunerative.

The increment in value of any crop may be expressed as the sum of the increment in cubic contents and the increment in the price per cubic foot.

1. Increment in Cubic Contents.

One method of ascertaining this increment is to accurately measure the total contents of any crop at two different

periods, when, provided no thinnings have taken place, the difference in the total contents will give the increment over the period taken. To be of any real value, the measurements must be very accurate; and to avoid complications the contents just after a thinning should be known and compared with measurements taken before another thinning is made. Now, suppose that a crop, after being thinned, contained 1500 cubic feet of saleable timber, and that 10 years afterwards the saleable contents were computed at 2200 cubic feet. Then the increment for the period will have been 700 cubic feet, and the average annual increment for that period will have been 70 cubic feet.

Possessed of these data, it is quite easy to show at what rate of interest the volume of the crop has been increasing; this information of course being most valuable. It is most important to reckon the rate of **compound interest** (and not simple interest), for the result is the same whether one is reckoning in cubic feet or in £ s. d.

The easiest way to find this rate of interest is to find the proportionate amount to which 1 cubic foot has increased in the 10 years, and then to refer to interest tables¹ showing the amount of 1 (£) at different rates per cent. for different periods.

Now, 1500 amounts to 2200 in 10 years.

$$\text{Therefore, } 1 \quad " \quad \frac{2200}{1500} = 1.46.$$

Hence, on referring to tables, it is found that 1 amounts to 1.46 in 10 years at $3\frac{3}{4}$ per cent. or 3.75 per cent.

It is, of course, **absolutely fallacious to argue that**

On 1500 the gain is 700 in 10 years

" 100 " 46.6, 10 "

Therefore, in 1 year the gain per cent. is 4.66.

The true rate of compound interest as already found by reference to tables, can also be found in the following way, which is given here, because it will help to explain some of

¹ *Vide Appendix C.*

the formulæ usually adopted in scientific forestry investigations:—

Let α = present contents of the crop

, , A = former contents

, , n = the number of years between the two measurements

, , p = the rate per cent. yielded.

Hence, the increment $= \alpha - A$

and the average annual increment $= \frac{\alpha - A}{n}$.

Now, if n be only 1 year,

$$100 : p :: A : \alpha - A$$

$$\therefore p = \frac{\alpha - A}{A} \times 100$$

$$\text{and } \alpha = A \times 1.0p.$$

But, if n is for a greater period than 1 year,

$$\alpha = A \times 1.0p^n$$

$$\therefore 1.0p^n = \frac{\alpha}{A}$$

$$\therefore 1.0p = \sqrt[n]{\frac{\alpha}{A}}$$

This formula will give the true rate of compound interest. But it is not very readily applicable for ordinary use.

It may, however, be simplified with results approximately correct by expressing the per cent. as equal to the per cent. that the average annual increment for the period bears to the mean contents during that period.

Now, the mean contents are $\frac{\alpha + A}{2}$

and the average increment $\frac{\alpha - A}{n}$

Hence:—

$$p : 100 :: \frac{\alpha - A}{n} : \frac{\alpha + A}{2}$$

$$\therefore \frac{p}{100} = \frac{\frac{\alpha - A}{n}}{\frac{\alpha + A}{2}}$$

$$\therefore p = 100 \times \frac{\alpha - A}{n} \times \frac{2}{\alpha + A}$$

$$\therefore p = \frac{\alpha - A}{\alpha + A} \times \frac{200}{n}.$$

This formula gives a rate of compound interest very slightly lower than the true rate of compound interest.

It will readily be seen that where data are available, this formula is applicable for general purposes, whether a percentage increase in cubic feet or in money value is being considered; and, whether it is the percentage that has occurred in the past or will occur in the future.

For general purposes the formula might be expressed thus:—

$$p = \frac{200}{n} \times \frac{\text{Increment}}{\text{Contents or value now} + \text{contents or value at period of } n \text{ years}}$$

In the example given above the rate of interest that took place during the last 10 years is given; but, speaking generally, it will be found that it is of far more importance to be able to gauge the probable rate of interest that is likely to take place in the future, or is taking place at the present moment.

In this connection it is necessary to have regard to the fact, that, in crops of normal density, any change in the rate of height growth, or of the width of the annual rings for a short period of years, is nearly always very gradual, and when once the principal height growth has been attained the total increment per acre, from year to year, or from one short period to another, does not usually vary suddenly. Hence, the increment that may be expected in the immediate future may be considered as about the same as that which has just accrued. Perhaps a little more, or a little less, according to the vigour and density of the crop, and as other circumstances shall dictate.

But the rate per cent. that will be yielded will not usually be so high, for the increment has to be reckoned as a percentage on a much greater capital.

When, however, investigating the rate of growth of crops, it will not usually be found that any accurate measurements of that crop have been previously taken; hence, it will often be necessary to gauge the increment of the crop without previous measurements for comparison.

This may be done by finding the increment on average sample trees, and then calculating the increment per acre.

It is difficult to calculate the past increment for a whole crop for more than just a year or so by this means, as owing to the removal of trees by thinning it is difficult to estimate what are fair average sample trees of the crop that existed prior to the thinning. And, also, the trees that are selected will, owing to the increased growing space, have wider annual rings than the true average for the past period.

But this difficulty is not presented in reckoning the present or the future increment, except that in the latter case the annual rings will get narrower as the trees again require to be thinned, or if the trees are already mature; in these cases, however, any change will be very gradual.

In order to find the future increment the present contents are deducted from the estimated future contents; and in order to find the future contents, it is necessary to know what will be the increase in height, and in girth or diameter; and, as already indicated, this is taken as equal to the rate of increase in height and diameter that has just recently taken place.

Thus, if measurements be taken at breast high, and if

D = diameter in future (under bark)

d = present diameter (under bark)

H = height in future

h = present height

Ff = form factor

The increment will equal :—

$$\left(\frac{D^2 \times \pi}{4} \times H \times Ff \right) - \left(\frac{d^2 \times \pi}{4} \times h \times Ff \right).$$

Now, while timber is still standing, the average increase in height may be guessed; but the increase in diameter can only be found by finding the width of the recent annual rings; and this is best done by the use of a boring tool, known as Pressler's borer. With this tool a hole is bored about an inch or two inches into the stem, and a round spill of wood is extracted, whilst the borer is still left in the tree. This spill of wood will show the width of a certain number of annual rings, and by this means the diameter increase is ascertained. For purposes of greater accuracy, it

is well to make two borings at right angles to each other and to take the average between them. The boring should always be done in a horizontal plane and directed towards the centre of the tree. If the rings be not distinct, an alcoholic solution of aniline will usually make them more visible.

Now, since the average width of the annual ring is the average annual radial increase, it follows that the average annual increase of diameter is twice the width of this ring.

Hence, it is easy to estimate the future diameter 5 or 10 years hence; and, in practice, it is not advisable to exceed the latter number of years.

For example, supposing a tree be 10 inches diameter under bark at breast high, and that it be 45 feet high (to the top), and that the form factor for saleable timber be 0.4, and that it be required to find the increment that will take place in the next 8 years.

It is reckoned that the tree will be 9 feet higher in 8 years' time, and, as found with a Pressler borer, the last 6 years' growth show 1 inch radius.

Therefore, in 8 years' time the diameter will be increased by 2.66 inches. Hence, it will be 12.66 inches; and the form factor may be taken as the same as previously.

Hence, by the formula given, the increment will be, in feet :—

$$\begin{aligned} & \left(\frac{(12.66)^2 \times \pi}{144 \times 4} \times 54 \times .4 \right) - \left(\frac{(10)^2 \times \pi}{144 \times 4} \times 45 \times .4 \right) \\ &= \left(\frac{160.27 \times 22 \times 54 \times 4}{144 \times 4 \times 7 \times 10} \right) - \left(\frac{100 \times 22 \times 45 \times .4}{144 \times 4 \times 7 \times 10} \right) \\ &= 18.8 - 9.8 \\ &= 9 \text{ cub. ft.} \end{aligned}$$

And the percentage increment, if obtained by a formula already explained, will be :—

$$\begin{aligned} p &= \frac{200}{n} \times \frac{18.8 - 9.8}{18.8 + 9.8} \\ \therefore p &= \frac{200}{8} \times \frac{9}{28.6} \\ &= \frac{225}{28.6} \\ &= 7.86 \text{ per cent.} \end{aligned}$$

Now, in order to shorten and simplify the calculations, various formulæ have from time to time been suggested for readily obtaining the percentage increment on standing timber.

But in most cases it is necessary to assume that the height is the same for both periods, and so also the same form factor. Now, the assumption of the same height will not materially affect the results obtained. But, the assumption of the same form factor as well, will, in most cases, give results which are materially defective.

However, if the height and form factor are the same at both periods, the cubic contents at both periods are respectively proportionate to the basal areas at both periods ; and so also to the square of the diameters at both periods.

Hence, the rate of compound interest can be found by reference to the square of the diameters only, at the respective periods. Hence, if

D = future diameter (under bark)

d = present diameter (under bark)

n = number of years in period

p = the percentage

$$\text{Then } p = \frac{200}{n} \times \frac{D^2 - d^2}{D^2 + d^2}$$

and this is **Pressler's formula**.

Now, this formula has been still more simplified, thus :—

$$p = \frac{D - d}{D + d} \times \frac{400}{n}.$$

This latter simplification must, however, be used with very great care. It gives practically the same result, provided D and d are very nearly equal; but if there be a big difference, then the rate per cent. that is indicated will be far too great.

Hence, with this method, n must never represent a large number of years; and, the smaller the diameter of the tree, the greater will be the error.

If, however, n be taken for only one year, the percentage will be very slightly too much, if the percentage for the coming year is under consideration. If the formula be

applied for the percentage increment for the *past year*, the past diameter increment for the single year equals twice the breadth of the last annual ring ; equals $D - d$, if

D = present diameter,

d = diameter one year ago ;

and $D + d$ may be taken as equal to twice the breadth of the present diameter, although this is really somewhat too great, and therefore gives too small a percentage ; but, except with trees of small diameter, it will not materially alter the result. Hence :—

$$\phi = \frac{\text{Breadth of last ring in inches} \times 2}{\text{Present diameter} \times 2} \times \frac{400}{1}$$

$$\therefore \phi = \frac{\text{Breadth of last ring}}{\text{Diameter}} \times \frac{400}{1}.$$

Now, in order to obtain a true average ring, the number of rings forming the last inch of radius should be counted, and the above formula divided by this number.

Thus, if

n = number of rings in last inch of radius

D = diameter (at breast high),

$$\text{Then } \phi = \frac{1}{D \times n} \times \frac{400}{1}$$

$$\therefore \phi = \frac{400}{D \times n}.$$

This is **Schneider's formula**, and it gives the percentage¹ increment for the coming year that will take place on the basal area at breast high.

This formula may be represented in terms of quarter girth measurement thus :—

$$\frac{315}{\text{Quarter girth} \times n \text{ (years in 1 in. radius)}}.$$

Now, as already mentioned, the percentage as indicated by applying the above formulæ to data obtained from measurements made **at breast high on standing timber**, is not, generally speaking, correct.

It assumes that the height and form factor remain the

¹ This percentage is slightly too high ; and in the case of trees with small diameters the discrepancy is increased. Though for the past year, the percentage will be slightly too little.

same for both periods. This, however, is a wrong assumption if the width of the annual rings be the same all the way up the stem. For, in such a case, if the height be the same, the form factor must be greater; and conversely, if the form factor be the same, the height must be greater.

The application of the formulæ as above described will, on an evenly tapering tree, only give correct results if the width of the recent annual rings at half-way up the stem is in reality one-half of the width of such rings at ground level. But this should never be the case with trees that are growing under correct sylvicultural management. In trees approaching maturity the annual rings will usually be widest at the top of such part of the bole as is clean and free from branches, and therefore in the case of well-grown timber it is obvious that the percentage as indicated by the formulæ, when measurements are taken at breast high, is far too small.

Now, the assumption of the same height growth in trees approaching maturity will not materially affect the result; the chief error lies in the assumption of the same form factor.

In the application of Schneider's formula this error may be corrected by multiplying the percentage as indicated at breast high by

$$\frac{\text{Diameter at breast high}}{\text{Diameter at half-way up any evenly-tapering tree}},$$

if the width of the rings at half-way up be taken as the average width over the stem.

But the diameter half-way up the stem is an unknown quantity; it is, however, equal to

$$\sqrt{(\text{Diameter at breast high})^2 \times \text{form factor.}}$$

Therefore, if

ϕ = percentage as indicated at breast high by Schneider's formula,
 D = diameter at breast high,

the true percentage increment is equal to

$$\phi \times \frac{D}{\sqrt{D^2 \times \text{form factor (for total contents)}}}.$$

This method for correcting the percentage, as indicated at breast high, is also applicable to Pressler's formula, if a

period of only one year be taken ; but if Pressler's formula be applied for a period exceeding one year, it is not possible to correct the percentage by the above method.

However, the method of ascertaining the percentage increment for the coming year on **standing timber**, from measurements taken at breast height, may be still more simplified. Thus, if

n = number of rings in last inch of radius

D = diameter (at breast high, under bark)

Ff = form factor (for total contents)

ϕ = the percentage increment on total contents

Then

$$\phi = \frac{400}{n \times \sqrt{D^2 \times Ff}}$$

And this is **Maw's formula**.

Now, the percentage thus indicated will be slightly too high, both by this formula, and also by Schneider's formula (as corrected). Furthermore, the error will be greater in the case of trees with small diameters than in the case of those with large diameters, though the increased error that would otherwise arise in the former case, is somewhat lessened when the increment due to the next year's leading shoot is taken into account.

This formula may be represented in terms of quarter girth measurement.

Thus, if

QG = quarter girth (at breast high, under bark)

Ff = form factor

n = number of years in last inch of radius

ϕ = the percentage increment

Then

$$\phi = \frac{315}{n \times \sqrt{(QG)^2 \times Ff}}$$

Often, however, Schneider's formula, $\frac{400}{d \times n}$, may be applied direct to standing trees, with a fair degree of accuracy by ascertaining the mean diameter (d) by ocular estimation.

Generally speaking, it will be of more practical value to know the percentage increase which is taking place upon that which is timber only, instead of the percentage on the total contents.

Now, practically all the increase can be reckoned as timber, for in trees of timber size there is always, in the same species of tree, about the same quantity of material which is under timber size; and, although much of the increment takes place on that which is under timber size, yet it is about counter-balanced by that which was formerly just under timber size, being measured as timber, since the increment upon it has brought it up to timber size.

Therefore, in the case of trees with small diameters, this percentage will be very much greater than the percentage upon the total contents, for the proportion of that which is timber only to the total contents is very small; and thus, the mean diameter (or quarter girth) is less. So also, the mean diameter (or quarter girth) is less in the case of trees with large diameters, though not in the same ratio as in the former case.

It should be noted that this mean diameter is the diameter of a cylinder the full height of the tree, having a total contents equal to the cubic contents of that which is timber only. Obviously, this diameter must be less than the diameter of a cylinder whose contents are equal to the cubic contents of the whole tree, including that which is under timber size.

Now, the previous formula may be used for ascertaining the percentage increase (on standing timber) upon that which is timber only, if the form factor for timber only be substituted for the form factor for the total contents.

Hence, if

Fft = form factor for timber

ϕ = percentage increment on timber only

Then

$$\phi = \frac{400}{n \times \sqrt{D^2 \times Fft}}$$

Having regard to the foregoing details, as to gauging the

increment on standing trees by the use of a Pressler borer, it is evident that the method is complicated and uncertain.

The objections may be summarised by stating that:—

(1) The formulæ are complicated, and can apply to one year only.

(2) The form factor is an uncertainty.

(3) The increase in height growth is disregarded.

(4) The actual use of the borer is harmful to the trees.

(5) The width of the annual ring, at the base of the tree, is often not a fair average width.

Therefore, it will almost invariably be the better plan to fell a few average sample trees and investigate the increase that takes place on the average diameter.

The percentage increase on the total contents of felled timber can at once be found by the $\frac{400}{d \times n}$ formula; the diameter under bark being taken at half-way up the stem; and the width of the average annual ring can be found by Pressler's borer, or, better still, by cross-cutting the stem at this point.

But, in order to be quite accurate, it is preferable to find the total contents of the increment, and then to express this as a percentage on the total contents, or on the contents of that which is timber only, which latter must also be found.

For example, supposing that a felled tree be 50 feet long, and that the average diameter under bark be 7 inches, and that the average width of the last few rings is $\frac{1}{6}$ inch each, and that in the next year the height growth will be increased by 1 foot:—

Then, by Schneider's formula, the percentage increase for the current year equals:—

$$\begin{array}{r} 400 \\ \hline 7 \times 6 \\ = 9.5 \text{ per cent.} \end{array}$$

This, however, as already indicated, is slightly too high a percentage.

So again, the increment and percentage may be found by

means previously indicated. Thus, leaving out of account the increase in height growth, the increment equals :—

$$\begin{aligned} & \frac{(7\frac{1}{2})^2 \times \pi \times 50}{144 \times 4} - \frac{(7)^2 \times \pi \times 50}{144 \times 4} \\ &= \frac{1642}{112} - \frac{1925}{144} \\ &= 14.66 - 13.37 \\ &= 1.29 \text{ cub. ft.} \end{aligned}$$

And the percentage equals :—

$$\begin{aligned} & \frac{200}{1} \times \frac{1.29}{28.03} \\ &= 9.2 \text{ per cent.} \end{aligned}$$

This percentage is slightly too low, as the increase in height growth for 1 year has been left out of account.

Similarly, the increment can be expressed as a percentage on the contents of that which is timber only, after such contents have been ascertained.

Thus, if in the above example the length of the tree to 3 inches diameter be 36 feet, and the mean diameter of that length be 8 inches. Then the timber contents equals :—

$$\begin{aligned} & \frac{(8)^2 \times \pi \times 36}{144 \times 4} \\ &= \frac{64 \times 22 \times 36}{144 \times 4 \times 7} \\ &= 12.6 \text{ cub. ft.} \end{aligned}$$

And the percentage equals :—

$$\begin{aligned} & \frac{200}{1} \times \frac{1.29}{12.6 + 13.89} \\ &= 9.74 \text{ per cent.} \end{aligned}$$

In many cases a certain degree of accuracy, in obtaining the percentage increment on timber only, can be obtained by applying Schneider's formula, and using a somewhat smaller diameter than the average diameter.

Similarly also, as already described, the percentage of compound interest for a period of 5 or 10 years, or the increment for a period, may be ascertained, on felled timber,

by measurements taken at half the length of the tree; and, in the making of working plans, some such calculations should always be accurately made for crops approaching maturity.

For purposes of greater accuracy, the increment, or the percentage increment, may be obtained from data referable to trees belonging to different diameter classes in the crop; instead of from data referable only to the average diameter class.

Attempts are often made to estimate the percentage that is taking place in any crop by reference to average yield tables.

This is a method, however, that cannot be recommended. It is almost impossible to obtain an accurate result, unless the crop under consideration correspond almost exactly with the data yielded in the tables. For instance, supposing that on a soil of medium quality a smaller growing stock were found than was indicated by the tables, for a soil of similar quality, and that an attempt were made to assess the increment by taking a proportionate amount of that indicated in the tables, the result would be very inaccurate; inasmuch as, the actual crop, having been more heavily thinned than is indicated in the tables, will, owing to the greater amount of growing space allotted to the individual trees, increase at a greater rate per cent. than the normal crop as found in the tables.

Where, however, the tables are used for this purpose, care should be taken that the increment, for any period, be not expressed as a percentage on any stock, which includes an amount which should properly be removed as thinnings at the commencement of the period and before the calculations are made.

Current Annual Increment.

Another matter, which should receive a forester's attention, and by which much valuable data can be obtained, is the making of a comparison of the current annual increment per acre, or the current average increment for short periods in the life of a crop, with the average annual increment throughout the entire life of the crop.

Now, in the pole forest stages of any crop, the current annual increment per acre almost invariably far exceeds the average annual increment.

But the current annual increment per acre will usually reach its maximum towards the end of the pole forest stage, after which it decreases; it will continue longer in the case of shade-bearing trees which can be left thicker on the ground than is the case with light-demanding trees which, as the principal height growth is attained, require to be freely thinned.

On good soil the maximum current annual increment per acre is attained sooner than on poorer soil.

The culmination of the current increment per individual tree is attained long after the culmination of such increment per acre. It is most necessary to avoid confusion on this matter, and to remember that the latter is largely governed by the number of trees per acre.

However, the average annual increment attains its maximum a long time after the date of the culmination of the current increment; and it will continue to rise for so long as the current annual increment exceeds the average annual increment.

But the current increment, when it ceases to be equal to the average annual increment, decreases annually much more quickly than the average annual increment.

Practically speaking, however, the percentage increment is of far more value than the mere amount of the current or the average annual increment, if the treatment of any particular crop is under consideration.

Now, besides the increment, or the percentage increment in contents, that is taking place, or is likely to take place in the near future, it is of the greatest importance to consider, also, the **increment in quality** or in the price per foot cube that may be anticipated.

2. Increment in Quality.

The increment in quality or money value per foot, may be conveniently expressed as a percentage on the present price.

Thus, to take a previous example, if, 10 years ago, a crop contained 1500 cubic feet of saleable timber worth 8d. a foot, and is now estimated to contain 2200 cubic feet of saleable timber worth 10d. a foot:

Then the percentage of increment in money value will have been

$$\begin{aligned} &= \frac{200}{10} \times \frac{10-8}{18} \\ &= \frac{200}{10} \times \frac{1}{9} = 2.22 \text{ per cent.} \end{aligned}$$

Now, the percentage increment in contents has already been shown to have been 3.75 per cent.

Hence the **total increment in value** will have been 5.97 per cent.

This is the percentage of increment, **both in quality and contents**, which in the above example will have been yielded on the capital value represented by the present crop of timber.

For practical purposes, such an estimate is invaluable. It will help, along with other sylvicultural considerations, to govern the treatment which any particular crop is to receive. For crops approaching maturity, the percentage arrived at, as indicated above, may be taken as approximately equal to the percentage that will actually be earned by allowing the present crop to stand for the period under consideration.

3. Total Increment on Invested Capital.

To be strictly accurate, the percentage will not be quite so great, as the value of the land must be taken into consideration, thus increasing the capital upon which the return is obtained. And, so also, the return will be lessened by the annual outgoings in respect of the land and crop.

Therefore, it is necessary to find the total increase in value and to express this as a percentage on the total capital represented by the crop and the land. However, in order to arrive at the exact percentage increment, the outgoings must also be taken into account by increasing the capital, by such a sum as represents the net annual outgoings (*i.e.*, total

annual outgoings less any annual sum represented by a sporting rent, etc.) capitalised at 25 or 28 years' purchase, or as may be deemed expedient.

Now, it is difficult to assign any particular value to the land over and above its capitalised sporting value, for, as stated elsewhere, when once planted, it has practically no value as agricultural (farming) land, and can only be profitably utilised by replanting.

If the sporting be worth 1s. 6d. an acre (and this is ample if a large area of high forest be under consideration), the total capital value of the land may be usually taken at from £3 to £7 an acre for planting purposes.¹

If very great accuracy be required, the particular rental value obtainable for the land only,² after interest is charged on the cost of establishing the crop, should be added to the annual sporting value, and the sum of these capitalised at 25 to 30 years' purchase. By this means the value is made to depend upon the species of the crop that can be grown and its estimated rental value for land only.

Therefore, taking the previous example, in which

$$1500 \text{ cub. ft., at 8d.} = \text{£}50 \text{ (present value of crop)}$$

$$2200 \text{ cub. ft., at 10d.} = \text{£}91.6 \text{ (future value of crop in 10 years),}$$

and the increment in value is £41.6;

and supposing that the land, including the sporting value, be worth £5; and that a capital of £4 will provide for the annual outgoings over and above any sum received as a sporting rent:

The rate of compound interest yielded for the period of 10 years

$$\begin{aligned} &= \frac{200}{10} \times \frac{41.6}{50+5+4+91.6+5+4} \\ &= \frac{200}{10} \times \frac{41.6}{159.6} \\ &= \frac{416}{79.8} = 5.21 \text{ per cent.} \end{aligned}$$

¹ This assumes the capitalised sporting value to be (say) £2. and the capitalised rental value for planting to be £1 to £5.

² *Vide* Chapter XII.

In this instance, the difference in the percentage thus indicated, after taking into consideration the value of the land and the annual outgoings, is somewhat large; but, this difference is very much less when the value of the crop largely exceeds that of the land only; and becomes less as the value of the crop becomes larger.

In cases where a thinning has taken place during the period under consideration, it will be necessary to ascertain the sum to which the money value of that which was thinned out will amount at compound interest (say $3\frac{1}{2}$ per cent) by the end of the period, and to add this sum to the increment in value of the rest of the crop, and also to the mean capital as found by the $\frac{200}{n}$ formula.

Thus, taking the previous example, let it be supposed that in 4 years' time £6 worth be removed by a thinning. This £6 will amount, in the remaining 6 years of the period at $3\frac{1}{2}$ per cent. compound interest, to £7.37.

Hence the percentage will be

$$\begin{aligned} & \frac{200^*}{n} \times \frac{41.6 + 7.37}{59 + 100.6 + 7.37} \\ & = \frac{200}{10} \times \frac{48.97}{166.97} = 5.8 \text{ per cent.} \end{aligned}$$

* Wherever the $\frac{200}{n}$ formula is used, the percentage shown will be slightly less than the true mathematical percentage yielded.

Finally, it is well to remember that, when considering the treatment that any crop should receive, conclusions should not be hastily drawn from actuarial data alone. It is necessary to consider the particular demands of the species of trees, the quality of the timber, the condition of the soil, local markets, and many other details, which the circumstances of the case may suggest.

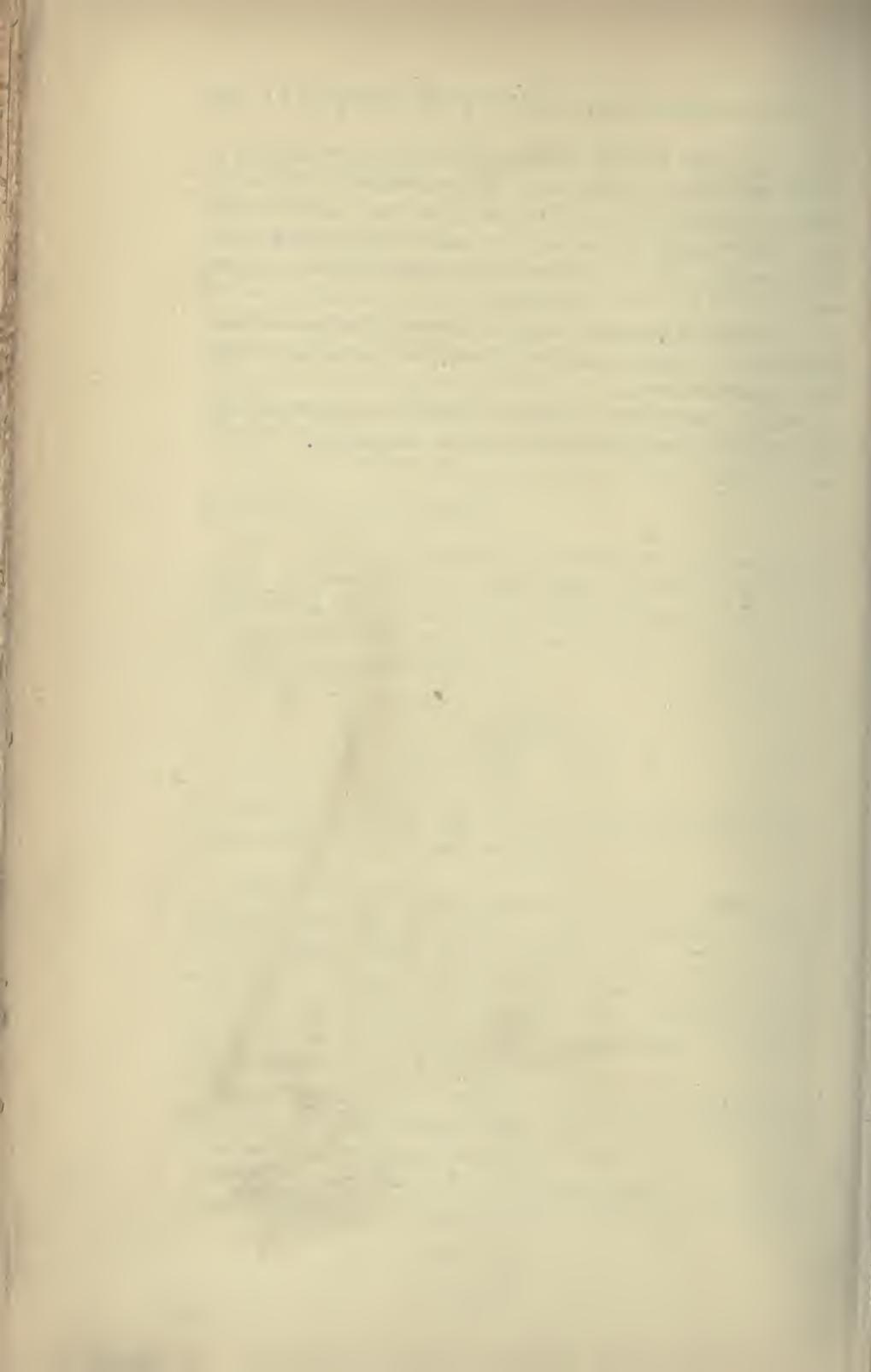
But, after giving due weight to all other considerations, actuarial calculations must largely govern the treatment that is meted out to any particular crop.

When the increment in quantity and value on any crop is not sufficient, it is imperative that some action should be

taken. It may be that only a thinning is necessary, or a partial clearance, in which case the increment of the crop which is left may be greatly stimulated, and may show a very high rate of interest on the capital upon which it is being earned. On the other hand, it may be that a total clearance will have to be effected.

A particular practice may be correct though actuarial data have not been considered; but, that is no proof that they are unnecessary.

Indeed, they alone will often afford the chief, if not the only, evidence that a particular practice is wrong. .



*NOTE.—These Tables may be obtained from Messrs
WALTER AND WALTER, Heatherside, Brockenhurst,
Hants, bound separately. Price, 1s. 6d. net.*

APPENDICES
OF
FOREST TABLES

SECRET
TREASON

APPENDIX A

TABLES TO BE USED ALONG WITH BRANDIT'S¹ HYP-SOMETER FOR ASCERTAINING THE HEIGHT OF TREES

EXPLANATION

The measurer first reads the upward² angle to the top of the tree. This upward angle will be the angle formed by a line horizontal with the observer's eye, and by a line from the observer's eye to the top of the tree.

The observer must move backwards or forwards until the angle, as read, is equal to one of the angles for which tables are given. When such angle is ascertained, the horizontal distance from the observer to the *centre* of the tree must be measured, and the height then ascertained from the tables. To this, however, must be added³ the height from the ground-level to the place where a line, horizontal with the observer's eye, cuts the trunk of the tree.

For instance, an angle of 38° is read, and the horizontal distance from the observer to the centre of the tree is 50 feet, and the vertical distance from the ground-level to a horizontal line from the observer's eye is 5 feet 6 inches.

Then, on reference to the tables, a height of 39.06 feet is obtained. To this must be added the 5 feet 6 inches.

$$\begin{aligned}\text{Hence, the total height of the tree} &= 39.06 + 5.5 \text{ feet} \\ &= \underline{\underline{44.56 \text{ feet}}}\end{aligned}$$

¹ Or other instrument for measuring the angle.

² *Vide* Chapter XVII.

³ This presumes that the observer's eye is not below the level of the base of the tree.

HEIGHT TABLES

**30° 35°
38° 40°**

Base.	Height from level of observer's eye, the angle being				Base.
	30°	35°	38°	40°	
1	0.58	0.70	0.78	0.84	1
2	1.15	1.40	1.56	1.68	2
3	1.73	2.10	2.34	2.52	3
4	2.31	2.80	3.13	3.36	4
5	2.89	3.50	3.91	4.20	5
6	3.46	4.20	4.69	5.03	6
7	4.04	4.90	5.47	5.87	7
8	4.62	5.60	6.25	6.71	8
9	5.20	6.30	7.03	7.55	9
10	5.77	7.00	7.81	8.38	10
11	6.35	7.70	8.59	9.23	11
12	6.93	8.40	9.37	10.07	12
13	7.51	9.10	10.16	10.91	13
14	8.08	9.80	10.94	11.75	14
15	8.66	10.50	11.72	12.59	15
16	9.24	11.20	12.50	13.43	16
17	9.81	11.90	13.28	14.26	17
18	10.39	12.60	14.06	15.10	18
19	10.97	13.30	14.84	15.94	19
20	11.55	14.00	15.62	16.78	20
21	12.12	14.70	16.41	17.62	21
22	12.70	15.40	17.19	18.46	22
23	13.28	16.10	17.97	19.30	23
24	13.86	16.80	18.75	20.14	24
25	14.43	17.51	19.53	20.98	25
26	15.01	18.21	20.31	21.81	26
27	15.59	18.91	21.09	22.66	27
28	16.17	19.61	21.87	23.49	28
29	16.74	20.31	22.66	24.33	29
30	17.32	21.01	23.44	25.17	30
31	17.90	21.71	24.22	26.01	31
32	18.48	22.41	25.00	26.85	32
33	19.05	23.11	25.78	27.69	33
34	19.63	23.81	26.56	28.53	34
35	20.21	24.51	27.34	29.37	35
36	20.78	25.21	28.13	30.21	36
37	21.36	25.91	28.91	31.05	37
38	21.94	26.61	29.69	31.89	38
39	22.52	27.31	30.47	32.72	39
40	23.09	28.01	31.25	33.56	40
41	23.67	28.71	32.03	34.40	41
42	24.25	29.41	32.82	35.24	42
43	24.83	30.11	33.60	36.08	43
44	25.40	30.81	34.38	36.92	44
45	25.98	31.51	35.16	37.76	45
46	26.56	32.21	35.94	38.60	46
47	27.14	32.91	36.72	39.44	47
48	27.71	33.61	37.50	40.28	48
49	28.29	34.31	38.28	41.12	49
50	28.87	35.01	39.06	41.96	50

HEIGHT TABLES

Base.	Height from level of observer's eye, the angle being				Base.
	30°	35°	38°	40°	
51	29.44	35.71	39.85	42.79	51
52	30.02	36.41	40.63	43.63	52
53	30.60	37.11	41.41	44.47	53
54	31.18	37.81	42.19	45.31	54
55	31.75	38.51	42.97	46.15	55
56	32.33	39.21	43.75	46.99	56
57	32.91	39.91	44.53	47.83	57
58	33.49	40.61	45.31	48.67	58
59	34.06	41.31	46.10	49.51	59
60	34.64	42.02	46.88	50.35	60
61	35.22	42.71	47.66	51.19	61
62	35.80	43.41	48.44	52.02	62
63	36.37	44.11	49.22	52.86	63
64	36.95	44.81	50.00	53.70	64
65	37.53	45.51	50.78	54.54	65
66	38.11	46.21	51.56	55.38	66
67	38.68	46.91	52.35	56.22	67
68	39.26	47.61	53.13	57.06	68
69	39.84	48.31	53.91	57.90	69
70	40.41	49.01	54.69	58.74	70
71	40.99	49.71	55.47	59.58	71
72	41.57	50.41	56.25	60.42	72
73	42.15	51.12	57.03	61.25	73
74	42.72	51.82	57.82	62.09	74
75	43.30	52.52	58.60	62.93	75
76	43.88	53.22	59.38	63.77	76
77	44.46	53.92	60.16	64.61	77
78	45.03	54.62	60.94	65.45	78
79	45.61	55.32	61.72	66.29	79
80	46.19	56.02	62.50	67.13	80
81	46.77	56.72	63.28	67.97	81
82	47.34	57.42	64.07	68.81	82
83	47.92	58.12	64.85	69.65	83
84	48.50	58.82	65.63	70.48	84
85	49.07	59.52	66.41	71.32	85
86	49.65	60.22	67.19	72.16	86
87	50.23	60.92	67.97	73.00	87
88	50.81	61.62	68.75	73.84	88
89	51.38	62.32	69.53	74.68	89
90	51.96	63.02	70.32	75.52	90
91	52.54	63.72	71.10	76.36	91
92	53.12	64.42	71.88	77.20	92
93	53.69	65.12	72.66	78.04	93
94	54.27	65.82	73.44	78.88	94
95	54.85	66.52	74.22	79.71	95
96	55.43	67.22	75.00	80.55	96
97	56.00	67.92	75.78	81.39	97
98	56.58	68.62	76.57	82.23	98
99	57.16	69.32	77.35	83.07	99
100	57.74	70.02	78.13	83.91	100

HEIGHT TABLES

**42° 44°
45° 46°
48°**

Base.	Height from level of observer's eye, the angle being					Base.
	42°	44°	45°	46°	48°	
1	0.90	0.97	1.00	1.04	1.11	I
2	1.80	1.93	2.00	2.07	2.22	2
3	2.70	2.90	3.00	3.11	3.33	3
4	3.60	3.86	4.00	4.14	4.44	4
5	4.50	4.83	5.00	5.18	5.55	5
6	5.40	5.79	6.00	6.21	6.66	6
7	6.30	6.76	7.00	7.25	7.77	7
8	7.20	7.73	8.00	8.28	8.88	8
9	8.10	8.69	9.00	9.32	10.00	9
10	9.00	9.66	10.00	10.36	11.11	10
11	9.90	10.62	11.00	11.39	12.22	II
12	10.80	11.59	12.00	12.42	13.33	12
13	11.71	12.55	13.00	13.46	14.44	13
14	12.61	13.52	14.00	14.50	15.55	14
15	13.51	14.49	15.00	15.53	16.66	15
16	14.41	15.45	16.00	16.57	17.77	16
17	15.31	16.42	17.00	17.60	18.88	17
18	16.21	17.38	18.00	18.64	19.99	18
19	17.11	18.35	19.00	19.68	21.10	19
20	18.01	19.31	20.00	20.71	22.21	20
21	18.91	20.28	21.00	21.75	23.32	21
22	19.81	21.25	22.00	22.78	24.43	22
23	20.71	22.21	23.00	23.82	25.54	23
24	21.60	23.18	24.00	24.85	26.65	24
25	22.51	24.14	25.00	25.89	27.77	25
26	23.41	25.11	26.00	26.92	28.88	26
27	24.31	26.07	27.00	27.96	29.99	27
28	25.21	27.03	28.00	28.99	31.10	28
29	26.11	28.00	29.00	30.03	32.21	29
30	27.01	28.97	30.00	31.07	33.32	30
31	27.91	29.94	31.00	32.10	34.43	31
32	28.81	30.90	32.00	33.14	35.54	32
33	29.71	31.87	33.00	34.17	36.65	33
34	30.61	32.83	34.00	35.21	37.76	34
35	31.51	33.80	35.00	36.24	38.87	35
36	32.41	34.76	36.00	37.28	39.98	36
37	33.31	35.73	37.00	38.31	41.09	37
38	34.22	36.70	38.00	39.35	42.20	38
39	35.12	37.66	39.00	40.39	43.31	39
40	36.02	38.63	40.00	41.42	44.42	40
41	36.92	39.59	41.00	42.46	45.54	41
42	37.82	40.56	42.00	43.49	46.65	42
43	38.72	41.52	43.00	44.53	47.76	43
44	39.62	42.49	44.00	45.56	48.87	44
45	40.52	43.45	45.00	46.60	49.98	45
46	41.42	44.42	46.00	47.63	51.09	46
47	42.32	45.39	47.00	48.67	52.20	47
48	43.22	46.35	48.00	49.71	53.31	48
49	44.12	47.32	49.00	50.74	54.42	49
50	45.02	48.28	50.00	51.78	55.53	50

HEIGHT TABLES

Base.	Height from level of observer's eye, the angle being					Base.
	42°	44°	45°	46°	48°	
51	45.92	49.25	51.00	52.81	56.64	51
52	46.82	50.22	52.00	53.85	57.75	52
53	47.72	51.18	53.00	54.88	58.86	53
54	48.62	52.15	54.00	55.92	59.97	54
55	49.52	53.11	55.00	56.95	61.08	55
56	50.42	54.08	56.00	57.99	62.19	56
57	51.32	55.04	57.00	59.03	63.30	57
58	52.22	56.01	58.00	60.06	64.42	58
59	53.12	56.98	59.00	61.10	65.53	59
60	54.02	57.94	60.00	62.13	66.64	60
61	54.92	58.91	61.00	63.17	67.75	61
62	55.83	59.87	62.00	64.20	68.86	62
63	56.73	60.84	63.00	65.24	69.97	63
64	57.63	61.80	64.00	66.27	71.08	64
65	58.53	62.77	65.00	67.31	72.19	65
66	59.43	63.74	66.00	68.34	73.30	66
67	60.33	64.70	67.00	69.38	74.41	67
68	61.23	65.67	68.00	70.42	75.52	68
69	62.13	66.63	69.00	71.45	76.63	69
70	63.03	67.60	70.00	72.49	77.74	70
71	63.93	68.56	71.00	73.52	78.85	71
72	64.83	69.53	72.00	74.56	79.96	72
73	65.73	70.50	73.00	75.59	81.07	73
74	66.63	71.46	74.00	76.63	82.19	74
75	67.53	72.43	75.00	77.66	83.30	75
76	68.43	73.39	76.00	78.70	84.41	76
77	69.33	74.36	77.00	79.74	85.52	77
78	70.23	75.32	78.00	80.77	86.63	78
79	71.13	76.29	79.00	81.81	87.74	79
80	72.03	77.26	80.00	82.84	88.85	80
81	72.93	78.22	81.00	83.88	89.96	81
82	73.83	79.18	82.00	84.91	91.07	82
83	74.73	80.15	83.00	85.95	92.18	83
84	75.63	81.12	84.00	86.98	93.29	84
85	76.53	82.08	85.00	88.02	94.40	85
86	77.43	83.05	86.00	89.06	95.51	86
87	78.34	84.01	87.00	90.09	96.62	87
88	79.24	84.98	88.00	91.13	97.73	88
89	80.14	85.95	89.00	92.16	98.84	89
90	81.04	86.91	90.00	93.20	99.96	90
91	81.94	87.88	91.00	94.23	101.07	91
92	82.84	88.84	92.00	95.27	102.18	92
93	83.74	89.81	93.00	96.30	103.29	93
94	84.64	90.77	94.00	97.34	104.40	94
95	85.54	91.74	95.00	98.38	105.51	95
96	86.44	92.71	96.00	99.41	106.62	96
97	87.34	93.67	97.00	100.45	107.73	97
98	88.24	94.64	98.00	101.48	108.84	98
99	89.14	95.60	99.00	102.52	109.95	99
100	90.04	96.57	100.00	103.55	111.06	100

HEIGHT TABLES

**50° 52°
55° 60°**

Base.	Height from level of observer's eye, the angle being				Base.
	50°	52°	55°	60°	
1	1.19	1.28	1.43	1.73	1
2	2.38	2.56	2.86	3.46	2
3	3.58	3.84	4.28	5.20	3
4	4.77	5.12	5.71	6.93	4
5	5.96	6.40	7.14	8.66	5
6	7.15	7.68	8.57	10.39	6
7	8.34	8.96	10.00	12.12	7
8	9.53	10.24	11.42	13.86	8
9	10.73	11.52	12.85	15.59	9
10	11.92	12.80	14.28	17.32	10
11	13.11	14.08	15.71	19.05	11
12	14.30	15.36	17.14	20.78	12
13	15.49	16.64	18.57	22.52	13
14	16.68	17.92	20.00	24.25	14
15	17.88	19.20	21.42	25.98	15
16	19.07	20.48	22.85	27.71	16
17	20.26	21.76	24.28	29.44	17
18	21.45	23.04	25.71	31.18	18
19	22.64	24.32	27.13	32.91	19
20	23.84	25.60	28.56	34.64	20
21	25.03	26.88	30.00	36.37	21
22	26.22	28.16	31.42	38.11	22
23	27.41	29.44	32.85	39.84	23
24	28.60	30.72	34.28	41.57	24
25	29.79	32.00	35.70	43.30	25
26	30.99	33.28	37.13	45.03	26
27	32.18	34.56	38.56	46.77	27
28	33.37	35.84	40.00	48.50	28
29	34.56	37.12	41.42	50.23	29
30	35.75	38.40	42.84	51.96	30
31	36.94	39.68	44.27	53.69	31
32	38.14	40.96	45.70	55.43	32
33	39.33	42.24	47.13	57.16	33
34	40.52	43.52	48.56	58.89	34
35	41.71	44.80	49.98	60.62	35
36	42.90	46.08	51.41	62.35	36
37	44.09	47.36	52.84	64.09	37
38	45.29	48.64	54.27	65.82	38
39	46.48	49.92	55.70	67.55	39
40	47.67	51.20	57.13	69.28	40
41	48.86	52.48	58.55	71.01	41
42	50.05	53.76	59.98	72.75	42
43	51.24	55.04	61.41	74.48	43
44	52.44	56.32	62.84	76.21	44
45	53.63	57.60	64.27	77.94	45
46	54.82	58.88	65.69	79.67	46
47	56.01	60.16	67.12	81.41	47
48	57.20	61.44	68.55	83.14	48
49	58.40	62.72	69.98	84.87	49
50	59.59	64.00	71.41	86.60	50

HEIGHT TABLES

Base.	Height from level of observer's eye, the angle being				Base.
	50°	52°	55°	60°	
51	60.78	65.28	72.83	88.33	51
52	61.97	66.56	74.26	90.07	52
53	63.16	67.84	75.69	91.80	53
54	64.35	69.12	77.12	93.53	54
55	65.55	70.40	78.55	95.25	55
56	66.74	71.68	79.98	96.99	56
57	67.93	72.96	81.40	98.73	57
58	69.12	74.24	82.83	100.46	58
59	70.31	75.52	84.26	102.19	59
60	71.51	76.80	85.69	103.92	60
61	72.70	78.08	87.12	105.66	61
62	73.89	79.36	88.54	107.39	62
63	75.08	80.64	89.97	109.12	63
64	76.27	81.92	91.40	110.85	64
65	77.46	83.20	92.83	112.58	65
66	78.66	84.48	94.26	114.32	66
67	79.85	85.76	95.69	116.05	67
68	81.04	87.04	97.11	117.78	68
69	82.23	88.32	98.54	119.51	69
70	83.42	89.60	99.97	121.24	70
71	84.61	90.88	101.40	122.98	71
72	85.81	92.16	102.83	124.71	72
73	87.00	93.44	104.25	126.44	73
74	88.19	94.72	105.68	128.17	74
75	89.38	96.00	107.11	129.90	75
76	90.57	97.28	108.54	131.64	76
77	91.76	98.56	109.97	133.37	77
78	92.96	99.84	111.39	135.10	78
79	94.15	101.12	112.82	136.83	79
80	95.34	102.40	114.25	138.56	80
81	96.53	103.68	115.68	140.30	81
82	97.72	104.96	117.11	142.03	82
83	98.92	106.24	118.54	143.76	83
84	100.11	107.52	119.96	145.49	84
85	101.30	108.80	121.39	147.22	85
86	102.49	110.07	122.82	148.95	86
87	103.68	111.35	124.25	150.69	87
88	104.87	112.63	125.68	152.42	88
89	106.06	113.91	127.10	154.15	89
90	107.26	115.19	128.53	155.88	90
91	108.45	116.47	129.96	157.62	91
92	109.64	117.75	131.39	159.35	92
93	110.83	119.03	132.82	161.08	93
94	112.02	120.31	134.25	162.81	94
95	113.21	121.59	135.67	164.54	95
96	114.41	122.87	137.10	166.28	96
97	115.60	124.15	138.53	168.01	97
98	116.79	125.43	139.96	169.74	98
99	117.98	126.71	141.39	171.47	99
100	119.18	127.99	142.81	173.21	100

50° 52°
55° 60°

APPENDIX B

TABLES SHOWING THE CONTENTS OF TIMBER, EITHER ROUND OR SQUARE, BY THE QUARTER GIRTH MEASUREMENT

Thus, a log 17 feet long by 9 inches quarter girth will, on reference to the tables, be found to contain 9 cubic feet and 6 inches.

Note.—According to custom, any fraction of a cubic foot is multiplied merely by 12 and expressed as inches—12 of such inches equal 1 cubic foot. Thus, in the above example, the correct cubic contents equal $9\frac{81}{144}$ cubic feet = 9 cubic feet 972 cubic inches.

But, in order to facilitate the use of the tables in practice, the fraction $\frac{81}{144}$ of a cubic foot is multiplied by 12, and the result, $\frac{81}{12}$, expressed as $6\frac{9}{12}$; or, leaving out fractions of an inch, merely as 6 inches—that is, one-half a cubic foot.

**CONTENTS OF TIMBER, QUARTER GIRTH
MEASUREMENT**

**5, 6, 7
inches**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	5	5½	6	6½	7	7½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6
I 0	I 3	I 6	I 9	2 0	2 4	2 8	7
I 2	I 5	I 9	2 0	2 4	2 8	3 1	8
I 4	I .8	2 0	2 4	2 8	3 0	3 6	9
I 6	I 10	2 3	2 7	3 0	3 6	3 II	10
I 9	2 I	2 6	2 II	3 5			
11							11
12	I II	2 3	2 9	3 2	3 9	4 3	12
13	2 I	2 6	3 0	3 6	4 I	4 8	13
14	2 3	2 8	3 3	3 9	4 5	5 I	14
15	2 5	2 II	3 6	4 I	4 9	5 5	15
	2 7	3 I	3 9	4 4	5 I	5 IO	
16							16
17	2 9	3 4	4 0	4 8	5 5	6 3	17
18	2 II	3 7	4 3	5 0	5 9	6 7	18
19	3 I	3 9	4 6	5 3	6 I	7 0	19
20	3 3	4 0	4 9	5 7	6 5	7 5	20
	3 5	4 2	5 0	5 IO	6 9	7 9	
21							21
22	3 7	4 5	5 3	6 2	7 I	8 2	22
23	3 IO	4 7	5 6	6 5	7 6	8 7	23
24	4 0	4 IO	5 9	6 9	7 IO	8 II	24
25	4 2	5 0	6 0	7 0	8 2	9 4	25
	4 4	5 3	6 3	7 4	8 6	9 9	
26							26
27	4 6	5 5	6 6	7 7	8 IO	IO 2	27
28	4 8	5 8	6 9	7 II	9 2	IO 6	28
29	4 IO	5 IO	7 0	8 2	9 6	IO II	29
30	5 0	6 I	7 3	8 6	9 IO	II 4	30
	5 2	6 3	7 6	8 9	IO 2	II 8	
31							31
32	5 4	6 6	7 9	9 I	IO 6	I2 I	32
33	5 6	6 8	8 0	9 4	IO IO	I2 6	33
34	5 8	6 II	8 3	9 8	II 2	I2 IO	34
35	5 II	7 I	8 6	9 II	II 7	I3 3	35
	6 I	7 4	8 9	IO 3	II II	I3 8	
36							36
37	6 3	7 6	9 0	IO 6	I2 3	I4 0	37
38	6 5	7 9	9 3	IO IO	I2 7	I4 5	38
39	6 7	8 0	9 6	II I	I2 II	I4 IO	39
40	6 9	8 2	9 9	II 5	I3 3	I5 2	40
	6 II	8 5	IO 0	II 9	I3 7	I5 7	

**CONTENTS OF TIMBER, QUARTER GIRTH
MEASUREMENT**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.	8, 9, 10 inches
	8	8½	9	9½	10	10½		
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6	
2	8	3 0	3 4	3 9	4 2	4 7		
7	3 1	3 6	3 11	4 4	4 10	5 4	7	
8	3 6	4 0	4 6	5 0	5 7	5 6	8	
9	4 0	4 6	5 0	5 7	6 3	6 10	9	
10	4 5	5 0	5 7	6 3	6 11	7 8	10	
11	4 10	5 6	6 2	6 10	7 7	8 5	11	
12	5 4	6 0	6 9	7 6	8 4	9 2	12	
13	5 9	6 6	7 3	8 1	9 0	9 11	13	
14	6 2	7 0	7 10	8 9	9 8	10 8	14	
15	6 8	7 6	8 5	9 4	10 5	11 5	15	
16	7 1	8 0	9 0	10 0	11 1	12 3	16	
17	7 6	8 6	9 6	10 7	11 9	13 0	17	
18	8 0	9 0	10 1	11 3	12 6	13 9	18	
19	8 5	9 6	10 8	11 11	13 2	14 6	19	
20	8 10	10 0	11 3	12 6	13 10	15 3	20	
21	9 4	10 6	11 9	13 2	14 7	16 1	21	
22	9 9	11 0	12 4	13 9	15 3	16 10	22	
23	10 2	11 6	12 11	14 5	15 11	17 7	23	
24	10 8	12 0	13 6	15 0	16 8	18 4	24	
25	11 1	12 6	14 0	15 8	17 4	19 1	25	
26	11 6	13 0	14 7	16 3	18 0	19 11	26	
27	12 0	13 6	15 2	16 11	18 9	20 8	27	
28	12 5	14 0	15 9	17 6	19 5	21 5	28	
29	12 10	14 6	16 3	18 2	20 1	22 2	29	
30	13 4	15 0	16 10	18 9	20 10	22 11	30	
31	13 9	15 6	17 5	19 5	21 6	23 8	31	
32	14 2	16 0	18 0	20 0	22 2	24 6	32	
33	14 8	16 6	18 6	20 8	22 11	25 3	33	
34	15 1	17 0	19 1	21 3	23 7	26 0	34	
35	15 6	17 6	19 8	21 11	24 3	26 9	35	
36	16 0	18 0	20 3	22 6	25 0	27 6	36	
37	16 5	18 6	20 9	23 2	25 8	28 4	37	
38	16 10	19 0	21 4	23 9	26 4	29 1	38	
39	17 4	19 6	21 11	24 5	27 1	29 10	39	
40	17 9	20 1	22 6	25 1	27 9	30 7	40	

**CONTENTS OF TIMBER, QUARTER GIRTH
MEASUREMENT**

**11, 12, 13
inches**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	11	11½	12	12½	13	13½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	
5 0	5 6	6 0	6 6	7 0	7 7		6
7 10	6 5	7 0	7 7	8 2	8 10		7
8 6	7 4	8 0	8 8	9 4	10 1		8
9 7	8 3	9 0	9 9	10 6	11 4		9
10 8	9 2	10 0	10 10	11 9	12 8		10
11	9 3	10 1	11 0	11 11	12 11	13 11	11
12	10 1	11 0	12 0	13 0	14 1	15 2	12
13	10 11	11 11	13 0	14 1	15 3	16 5	13
14	11 9	12 10	14 0	15 2	16 5	17 8	14
15	12 7	13 9	15 0	16 3	17 7	18 11	15
16	13 5	14 8	16 0	17 4	18 9	20 3	16
17	14 3	15 7	17 0	18 5	19 11	21 6	17
18	15 1	16 6	18 0	19 6	21 1	22 9	18
19	15 11	17 5	19 0	20 7	22 3	24 0	19
20	16 9	18 4	20 0	21 8	23 5	25 3	20
21	17 7	19 3	21 0	22 9	24 7	26 7	21
22	18 6	20 2	22 0	23 10	25 10	27 10	22
23	19 4	21 1	23 0	24 11	27 0	29 1	23
24	20 2	22 0	24 0	26 0	28 2	30 4	24
25	21 0	22 11	25 0	27 1	29 4	31 7	25
26	21 10	23 10	26 0	28 2	30 6	32 11	26
27	22 8	24 9	27 0	29 3	31 8	34 2	27
28	23 6	25 8	28 0	30 4	32 10	35 5	28
29	24 4	26 7	29 0	31 5	34 0	36 8	29
30	25 2	27 6	30 0	32 6	35 2	37 11	30
31	26 0	28 5	31 0	33 7	36 4	39 2	31
32	26 10	29 4	32 0	34 8	37 6	40 6	32
33	27 8	30 3	33 0	35 9	38 8	41 9	33
34	28 7	31 2	34 0	36 10	39 11	43 0	34
35	29 5	32 1	35 0	37 11	41 1	44 3	35
36	30 3	33 0	36 0	39 0	42 3	45 6	36
37	31 1	33 11	37 0	40 1	43 5	46 10	37
38	31 11	34 10	38 0	41 2	44 7	48 1	38
39	32 9	35 9	39 0	42 3	45 9	49 4	39
40	33 7	36 9	40 0	43 5	46 11	50 7	40

**CONTENTS OF TIMBER, QUARTER GIRTH
MEASUREMENT**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	14	14½	15	15½	16	16½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6
8	8 2	8 9	9 4	10 0	10 8	11 4	7
7	9 6	10 2	10 11	11 8	12 5	13 2	8
8	10 10	11 8	12 6	13 4	14 2	15 1	9
9	12 3	13 1	14 0	15 0	16 0	17 0	10
10	13 7	14 7	15 7	16 8	17 9	18 11	
11	14 11	16 0	17 2	18 4	19 6	20 9	11
12	16 4	17 6	18 9	20 0	21 4	22 8	12
13	17 8	18 11	20 3	21 8	23 1	24 7	13
14	19 0	20 5	21 10	23 4	24 10	26 5	14
15	20 5	21 10	23 5	25 0	26 8	28 4	15
16	21 9	23 4	25 0	26 8	28 5	30 3	16
17	23 1	24 9	26 6	28 4	30 2	32 1	17
18	24 6	26 3	28 1	30 0	32 0	34 0	18
19	25 10	27 9	29 8	31 8	33 9	35 11	19
20	27 2	29 2	31 3	33 4	35 6	37 9	20
21	28 7	30 8	32 9	35 0	37 4	39 8	21
22	29 11	32 1	34 4	36 8	39 1	41 7	22
23	31 3	33 7	35 11	38 4	40 10	43 5	23
24	32 8	35 0	37 6	40 0	42 8	45 4	24
25	34 0	36 6	39 0	41 8	44 5	47 3	25
26	35 4	37 11	40 7	43 4	46 2	49 2	26
27	36 9	39 5	42 2	45 0	48 0	51 0	27
28	38 1	40 10	43 9	46 8	49 9	52 11	28
29	39 5	42 4	45 3	48 4	51 6	54 10	29
30	40 10	43 9	46 10	50 0	53 4	56 8	30
31	42 2	45 3	48 5	51 8	55 1	58 7	31
32	43 6	46 8	50 0	53 4	56 10	60 6	32
33	44 11	48 2	51 6	55 0	58 8	62 4	33
34	46 3	49 7	53 1	56 8	60 5	64 3	34
35	47 7	51 1	54 8	58 4	62 2	66 2	35
36	49 0	52 6	56 3	60 0	64 0	68 0	36
37	50 4	54 0	57 9	61 8	65 9	69 11	37
38	51 8	55 5	59 4	63 4	67 6	71 10	38
39	53 1	56 11	60 11	65 0	69 4	73 8	39
40	54 5	58 5	62 6	66 9	71 1	75 7	40

14, 15, 16
inches

**CONTENTS OF TIMBER, QUARTER GIRTH
MEASUREMENT**

**17, 18, 19
inches**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	17	17½	18	18½	19	19½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6
12	0	12 9	13 6	14 3	15 0	15 10	
14	0	14 10	15 9	16 7	17 6	18 5	7
16	0	17 0	18 0	19 0	20 0	21 1	8
18	0	19 1	20 3	21 4	22 6	23 9	9
20	I	21 3	22 6	23 9	25 I	26 5	10
11	22 I	23 4	24 9	26 I	27 7	29 0	11
12	24 I	25 6	27 0	28 6	30 I	31 8	12
13	26 I	27 7	29 3	30 10	32 7	34 4	13
14	28 I	29 9	31 6	33 3	35 I	36 II	14
15	30 I	31 10	33 9	35 7	37 7	39 7	15
16	32 I	34 0	36 0	38 0	40 I	42 3	16
17	34 I	36 2	38 3	40 5	42 7	44 10	17
18	36 I	38 3	40 6	42 9	45 I	47 6	18
19	38 I	40 5	42 9	45 2	47 7	50 2	19
20	40 I	42 6	45 0	47 6	50 I	52 9	20
21	42 I	44 8	47 3	49 II	52 7	55 I	21
22	44 2	46 9	49 6	52 3	55 2	58 8	22
23	46 2	48 II	51 9	54 8	57 8	60 5	23
24	48 2	51 0	54 0	57 0	60 2	63 4	24
25	50 2	53 2	56 3	59 5	62 8	66 0	25
26	52 2	55 3	58 6	61 9	65 2	68 8	26
27	54 2	57 5	60 9	64 2	67 8	71 3	27
28	56 2	59 6	63 0	66 6	70 2	73 II	28
29	58 2	61 8	65 3	68 II	72 8	76 7	29
30	60 2	63 9	67 6	71 3	75 2	79 2	30
31	62 2	65 II	69 9	73 8	77 8	81 10	31
32	64 2	68 0	72 0	76 0	80 2	84 6	32
33	66 2	70 2	74 3	78 5	82 8	87 I	33
34	68 3	72 3	76 6	80 9	85 3	89 9	34
35	70 3	74 5	78 9	83 2	87 9	92 5	35
36	72 3	76 6	81 0	85 6	90 3	95 0	36
37	74 3	78 8	83 3	87 II	92 9	97 8	37
38	76 3	80 9	85 6	90 3	95 3	100 4	38
39	78 3	82 II	87 9	92 8	97 9	102 II	39
40	80 3	85 I	90 0	95 I	100 3	105 7	40

**CONTENTS OF TIMBER, QUARTER GIRTH
MEASUREMENT**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.	20, 21, 22 inches
	20	20½	21	21½	22	22½		
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6	
16	16 8	17 6	18 4	19 3	20 2	21 1		
7	19 5	20 5	21 5	22 5	23 6	24 7	7	
8	22 2	23 4	24 6	25 8	26 10	28 1	8	
9	25 0	26 3	27 6	28 10	30 3	31 7	9	
10	27 9	29 2	30 7	32 1	33 7	35 2	10	
11	30 6	32 1	33 8	35 3	36 11	38 8	11	
12	33 4	35 0	36 9	38 6	40 4	42 2	12	
13	36 1	37 11	39 9	41 8	43 8	45 8	13	
14	38 10	40 10	42 10	44 11	47 0	49 2	14	
15	41 8	43 9	45 11	48 1	50 5	52 8	15	
16	44 5	46 8	49 0	51 4	53 9	56 3	16	
17	47 2	49 7	52 0	54 7	57 1	59 9	17	
18	50 0	52 6	55 1	57 9	60 6	63 3	18	
19	52 9	55 5	58 2	61 0	63 10	66 9	19	
20	55 6	58 4	61 3	64 2	67 2	70 3	20	
21	58 4	61 3	64 3	67 5	70 7	73 10	21	
22	61 1	64 2	67 4	70 7	73 11	77 4	22	
23	63 10	67 1	70 5	73 10	77 3	80 10	23	
24	66 8	70 0	73 6	77 0	80 8	84 4	24	
25	69 5	72 11	76 6	80 3	84 0	87 10	25	
26	72 2	75 10	79 7	83 5	87 4	91 5	26	
27	75 0	78 9	82 8	86 8	90 9	94 11	27	
28	77 9	81 8	85 9	89 10	94 1	98 5	28	
29	80 6	84 7	88 9	93 1	97 5	101 11	29	
30	83 4	87 6	91 10	96 3	100 10	105 5	30	
31	86 1	90 5	94 11	99 6	104 2	108 11	31	
32	88 10	93 4	98 0	102 8	107 6	112 6	32	
33	91 8	96 3	101 0	105 11	110 11	116 0	33	
34	94 5	99 2	104 1	109 1	114 3	119 6	34	
35	97 2	102 1	107 2	112 4	117 7	123 0	35	
36	100 0	105 0	110 3	115 6	121 0	126 6	36	
37	102 9	107 11	113 3	118 9	124 4	130 1	37	
38	105 6	110 10	116 4	121 11	127 8	133 7	38	
39	108 4	113 9	119 5	125 2	131 1	137 1	39	
40	111 1	116 9	122 6	128 5	134 5	140 7	40	

CONTENTS OF TIMBER, Q. G. MEASUREMENT

 23, 24, 25
inches

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	23	23½	24	24½	25	25½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6
7	22 0	23 0	24 0	25 0	26 0	27 1	7
8	25 8	26 10	28 0	29 2	30 4	31 7	8
9	29 4	30 8	32 0	33 4	34 8	36 1	9
10	33 0	34 6	36 0	37 6	39 0	40 7	10
	36 9	38 4	40 0	41 8	43 5	45 2	
11	40 5	42 2	44 0	45 10	47 9	49 8	11
12	44 1	46 0	48 0	50 0	52 1	54 2	12
13	47 9	49 10	52 0	54 2	56 5	58 8	13
14	51 5	53 8	56 0	58 4	60 9	63 2	14
15	55 1	57 6	60 0	62 6	65 1	67 8	15
16	58 9	61 4	64 0	66 8	69 5	72 3	16
17	62 5	65 2	68 0	70 10	73 9	76 9	17
18	66 1	69 0	72 0	75 0	78 1	81 3	18
19	69 9	72 10	76 0	79 2	82 5	85 9	19
20	73 5	76 8	80 0	83 4	86 9	90 3	20

 26, 27, 28
inches

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	26	26½	27	27½	28	28½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6
7	28 2	29 3	30 4	31 6	32 8	33 10	7
8	32 10	34 1	35 5	36 9	38 1	39 5	8
9	37 6	39 0	40 6	42 0	43 6	45 1	9
10	42 3	43 10	45 6	47 3	49 0	50 9	10
	46 11	48 9	50 7	52 6	54 5	56 5	
11	51 7	53 7	55 8	57 6	59 10	62 0	11
12	56 4	58 6	60 9	63 0	65 4	67 8	12
13	61 0	63 4	65 9	68 3	70 9	73 4	13
14	65 8	68 3	70 10	73 6	76 2	78 11	14
15	70 5	73 1	75 11	78 9	81 8	84 7	15
16	75 1	78 0	81 0	84 0	87 1	90 3	16
17	79 9	82 11	86 0	89 3	92 6	95 10	17
18	84 6	87 9	91 1	94 6	98 0	101 6	18
19	89 2	92 8	96 2	99 9	103 5	107 2	19
20	93 10	97 6	101 3	105 0	108 10	112 9	20

CONTENTS OF TIMBER, Q. G. MEASUREMENT

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.	29, 30, 31 inches
	29	29½	30	30½	31	31½		
6	35 0	36 3	37 6	38 9	40 0	41 4	6	
7	40 10	42 3	43 9	45 2	46 8	48 2	7	
8	46 8	48 4	50 0	51 8	53 4	55 1	8	
9	52 6	54 4	56 3	58 1	60 0	62 0	9	
10	58 5	60 5	62 6	64 7	66 9	68 11	10	
11	64 3	66 5	68 9	71 0	73 5	75 9	11	
12	70 1	72 6	75 0	77 6	80 1	82 8	12	
13	75 11	78 6	81 3	83 11	86 9	89 7	13	
14	81 9	84 7	87 6	90 5	93 5	96 5	14	
15	87 7	90 7	93 9	96 10	100 1	103 4	15	

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.	32, 33, 34 inches
	32	32½	33	33½	34	34½		
6	42 8	44 0	45 4	46 9	48 2	49 7	6	
7	49 9	51 4	52 11	54 6	56 2	57 10	7	
8	56 10	58 8	60 6	62 4	64 2	66 1	8	
9	64 0	66 0	68 0	70 1	72 3	74 4	9	
10	71 1	73 4	75 7	77 11	80 3	82 8	10	
11	78 2	80 8	83 2	85 8	88 3	90 11	11	
12	85 4	88 0	90 9	93 6	96 4	99 2	12	
13	92 5	95 4	98 3	101 3	104 4	107 5	13	
14	99 6	102 8	105 10	109 1	112 4	115 8	14	
15	106 8	110 0	113 5	116 10	120 5	123 11	15	

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.	35, 36, 37 inches
	35	35½	36	36½	37	37½		
6	51 0	52 6	54 0	55 6	57 0	58 7	6	
7	59 6	61 3	63 0	64 9	66 6	68 4	7	
8	68 0	70 0	72 0	74 0	76 0	78 1	8	
9	76 6	78 9	81 0	83 3	85 6	87 10	9	
10	85 1	87 6	90 0	92 6	95 1	97 8	10	
11	93 7	96 3	99 0	101 9	104 7	107 5	11	
12	102 1	105 0	108 0	111 0	114 1	117 2	12	
13	110 7	113 9	117 0	120 3	123 7	126 11	13	
14	119 1	122 6	126 0	129 6	133 1	136 8	14	
15	127 7	131 3	135 0	138 9	142 7	146 5	15	

CONTENTS OF TIMBER, Q. G. MEASUREMENT

**38, 39, 40
inches**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	38	38½	39	39½	40	40½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6
7	60 2	61 9	63 4	65 0	66 8	68 4	7
8	70 2	72 0	73 11	75 10	77 9	79 8	8
9	80 2	82 4	84 6	86 8	88 10	91 1	9
10	90 3	92 7	95 0	97 6	100 0	102 6	10
	100 3	102 11	105 7	108 4	111 1	113 11	
11	110 3	113 2	116 2	119 2	122 2	125 3	11
12	120 4	123 6	126 9	130 0	133 4	136 8	12
13	130 4	133 9	137 3	140 10	144 5	148 1	13
14	140 4	144 1	147 10	151 8	155 6	159 5	14
15	150 5	154 4	158 5	162 6	166 8	170 10	15

**41, 42, 43
inches**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	41	41½	42	42½	43	43½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6
7	70 0	71 9	73 6	75 3	77 0	78 10	7
8	81 8	83 8	85 9	87 9	89 10	91 11	8
9	93 4	95 8	98 0	100 4	102 8	105 1	9
10	105 0	107 7	110 3	112 10	115 6	118 3	10
	116 9	119 7	122 6	125 5	128 5	131 5	
11	128 5	131 6	134 9	137 11	141 2	144 6	11
12	140 1	143 6	147 0	150 6	154 1	157 8	12
13	151 9	155 5	159 3	163 0	166 11	170 10	13
14	163 5	167 5	171 6	175 7	179 9	183 11	14
15	175 1	179 4	183 9	188 1	192 7	197 1	15

**44, 45, 46
inches**

Length in feet.	Average Quarter Girth (in inches) under Bark.						Length in feet.
	44	44½	45	45½	46	46½	
6	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	ft. in.	6
7	80 8	82 6	84 4	86 3	88 2	90 1	7
8	94 1	96 3	98 5	100 7	102 10	105 1	8
9	107 6	110 0	112 6	115 0	117 6	120 1	9
10	121 0	123 9	126 6	129 4	132 3	135 1	10
	134 5	137 6	140 7	143 9	146 11	150 2	
11	147 10	151 3	154 8	158 1	161 7	165 2	11
12	161 4	165 0	168 9	172 6	176 4	180 2	12
13	174 9	178 9	182 9	186 10	191 0	195 2	13
14	188 2	192 6	196 10	201 3	205 8	210 2	14
15	201 8	206 3	210 11	215 8	220 5	225 2	15

APPENDIX C

**TABLES SHOWING THE CAPITALISED VALUE OF £1
AND OF £1 PER ANNUM, AT VARIOUS RATES
OF INTEREST**

EXPLANATION OF TABLES

These tables may be used for a variety of purposes. And to all who may seek to express an opinion upon the financial aspect of afforestation, their use is almost indispensable.

For example, £10 is spent per acre in planting and fencing. What will be the debt per acre in 90 years time on the 4 per cent. tables?

By reference to the tables—

$$\begin{aligned} \text{£1 amounts at 4 per cent. to } & 34.119 \quad \text{in 90 years.} \\ \therefore \text{£10} \quad " \quad " \quad " \quad & = \frac{34.119 \times 10}{100} \quad " \\ & = \text{£341}, 3s. 10d. \end{aligned}$$

Or again, 1s. a year has been paid per acre for rates on a wood for the last 95 years. What sum of money does this represent at the present time on the 4½ per cent. tables?

By reference to the tables—

$$\begin{aligned} \text{£1 per annum will have amounted to } & \text{£1432.684} \\ \therefore \text{1s.} \quad " \quad " \quad " \quad " \quad & = \frac{\text{£1432.684}}{20} \\ & = \text{£71}, 12s. 7d. \end{aligned}$$

Or again, at the end of a rotation of 80 years there is a net credit sum of £120 per acre, which may be looked upon as deferred profits, after paying for all outgoings, etc. What yearly net rental is this equivalent to on the 3½ per cent. tables?

By reference to the tables, it is seen that—

£419.306 is the accumulated value of £1 per annum.

$$\begin{aligned} \therefore \text{£1} \quad " \quad " \quad " \quad " \quad & = \frac{\text{£1}}{419.306} \\ \therefore \text{£120} \quad " \quad " \quad " \quad " \quad & = \frac{\text{£120}}{419.306} \\ & = \frac{120 \times 20}{419.306} \text{ shillings.} \\ & = 5s. 8d. \text{ net rental} \\ & \qquad \qquad \qquad \text{per annum.} \end{aligned}$$

CAPITALISED VALUE OF £1 AND £1 PER ANNUM

 2 $\frac{3}{4}\%$ 3%

In Years.	2 $\frac{3}{4}$ per cent.		3 per cent.		In Years.
	£1 amounts to	£1 per annum amounts to	£1 amounts to	£1 per annum amounts to	
1	1.027	1.000	1.030	1.000	1
2	1.055	2.027	1.060	2.030	2
3	1.084	3.083	1.092	3.090	3
4	1.114	4.168	1.125	4.183	4
5	1.145	5.282	1.159	5.309	5
6	1.176	6.427	1.194	6.468	6
7	1.209	7.604	1.229	7.662	7
8	1.242	8.813	1.266	8.892	8
9	1.276	10.056	1.304	10.159	9
10	1.311	11.332	1.343	11.463	10
11	1.347	12.644	1.384	12.807	11
12	1.384	13.992	1.425	14.192	12
13	1.422	15.376	1.468	15.617	13
14	1.461	16.799	1.512	17.086	14
15	1.502	18.261	1.557	18.598	15
16	1.543	19.763	1.604	20.156	16
17	1.585	21.307	1.652	21.761	17
18	1.629	22.893	1.702	23.414	18
19	1.674	24.523	1.753	25.116	19
20	1.720	26.197	1.806	26.870	20
21	1.767	27.917	1.860	28.676	21
22	1.816	29.685	1.916	30.536	22
23	1.866	31.501	1.973	32.452	23
24	1.917	33.368	2.032	34.426	24
25	1.970	35.285	2.093	36.459	25
26	2.024	37.256	2.156	38.553	26
27	2.080	39.280	2.221	40.709	27
28	2.137	41.360	2.287	42.930	28
29	2.196	43.498	2.356	45.218	29
30	2.256	45.694	2.427	47.575	30
31	2.318	47.951	2.500	50.002	31
32	2.382	50.269	2.575	52.502	32
33	2.447	52.652	2.652	55.077	33
34	2.515	55.100	2.731	57.730	34
35	2.584	57.615	2.813	60.462	35
36	2.655	60.199	2.898	63.275	36
37	2.728	62.855	2.985	66.174	37
38	2.803	65.583	3.074	69.159	38
39	2.880	68.387	3.167	72.234	39
40	2.959	71.268	3.262	75.401	40
41	3.041	74.228	3.359	78.663	41
42	3.124	77.269	3.460	82.023	42
43	3.210	80.394	3.564	85.483	43
44	3.299	83.605	3.671	89.048	44
45	3.389	86.904	3.781	92.719	45
46	3.483	90.294	3.895	96.501	46
47	3.578	93.777	4.011	100.396	47
48	3.677	97.356	4.132	104.408	48
49	3.778	101.033	4.256	108.540	49
50	3.882	104.811	4.383	112.796	50

AT DIFFERENT RATES OF INTEREST

In Years.	2 $\frac{3}{4}$ per cent.		3 per cent.		In Years.
	£1 amounts to	£1 per annum amounts to	£1 amounts to	£1 per annum amounts to	
51	3.989	108.694	4.515	117.180	51
52	4.098	112.683	4.650	121.696	52
53	4.211	116.781	4.790	126.347	53
54	4.327	120.993	4.934	131.137	54
55	4.446	125.320	5.082	136.071	55
56	4.568	129.767	5.234	141.153	56
57	4.694	134.335	5.391	146.388	57
58	4.823	139.029	5.553	151.780	58
59	4.955	143.853	5.720	157.333	59
60	5.092	148.809	5.891	163.053	60
61	5.232	153.901	6.068	168.945	61
62	5.376	159.133	6.250	175.013	62
63	5.524	164.509	6.437	181.263	63
64	5.675	170.033	6.631	187.701	64
65	5.832	175.709	6.829	194.332	65
66	5.992	181.541	7.034	201.162	66
67	6.157	187.534	7.245	208.197	67
68	6.326	193.691	7.463	215.443	68
69	6.500	201.017	7.687	222.906	69
70	6.679	206.518	7.917	230.594	70
71	6.862	213.197	8.155	238.511	71
72	7.051	220.060	8.400	246.667	72
73	7.245	227.112	8.652	255.067	73
74	7.444	234.357	8.911	263.719	74
75	7.649	241.802	9.178	272.630	75
76	7.859	249.452	9.454	281.809	76
77	8.076	257.312	9.737	291.264	77
78	8.298	265.388	10.030	301.002	78
79	8.526	273.686	10.330	311.032	79
80	8.760	282.212	10.640	321.363	80
81	9.001	290.973	10.960	332.003	81
82	9.249	299.975	11.288	342.964	82
83	9.503	309.224	11.627	354.252	83
84	9.765	318.728	11.976	365.880	84
85	10.033	328.493	12.335	377.856	85
86	10.309	338.521	12.505	390.192	86
87	10.593	348.836	13.086	402.808	87
88	10.884	359.429	13.497	415.985	88
89	11.183	370.313	13.883	429.464	89
90	11.491	381.497	14.300	443.348	90
91	11.807	392.988	14.729	457.649	91
92	12.131	404.795	15.171	472.378	92
93	12.465	416.927	15.626	487.550	93
94	12.808	429.393	16.095	503.176	94
95	13.160	442.201	16.578	519.272	95
96	13.522	455.362	17.075	535.850	96
97	13.894	468.884	17.587	552.925	97
98	14.276	482.779	18.115	570.513	98
99	14.669	497.055	18.658	588.628	99
100	15.072	511.724	19.218	607.287	100

CAPITALISED VALUE OF £1 AND £1 PER ANNUM

3½% 4%

In Years.	3½ per cent.		4 per cent.		In Years.
	£1 amounts to	£1 per annum amounts to	£1 amounts to	£1 per annum amounts to	
I	1·035	1·000	1·040	1·000	I
2	1·071	2·035	1·081	2·040	2
3	1·108	3·106	1·124	3·121	3
4	1·147	4·214	1·169	4·246	4
5	1·187	5·362	1·216	5·416	5
6	1·229	6·550	1·265	6·632	6
7	1·272	7·779	1·315	7·898	7
8	1·316	9·051	1·368	9·214	8
9	1·362	10·368	1·423	10·582	9
10	1·410	11·731	1·480	12·006	10
11	1·459	13·141	1·539	13·486	11
12	1·511	14·601	1·601	15·025	12
13	1·563	16·113	1·665	16·626	13
14	1·618	17·676	1·731	18·291	14
15	1·675	19·295	1·800	20·023	15
16	1·733	20·971	1·872	21·824	16
17	1·794	22·705	1·947	23·697	17
18	1·857	24·499	2·025	25·045	18
19	1·922	26·357	2·106	27·671	19
20	1·989	28·279	2·191	29·778	20
21	2·059	30·269	2·278	31·969	21
22	2·131	32·328	2·369	34·247	22
23	2·206	34·460	2·464	36·617	23
24	2·283	36·666	2·563	39·082	24
25	2·363	38·949	2·665	41·645	25
26	2·445	41·313	2·772	44·311	26
27	2·531	43·759	2·883	47·084	27
28	2·620	46·290	2·998	49·967	28
29	2·711	48·910	3·118	52·966	29
30	2·806	51·622	3·243	56·084	30
31	2·905	54·429	3·373	59·328	31
32	3·006	57·334	3·508	62·701	32
33	3·111	60·341	3·648	66·209	33
34	3·220	63·453	3·794	69·857	34
35	3·333	66·674	3·946	73·652	35
36	3·450	70·007	4·103	77·589	36
37	3·571	73·457	4·268	81·702	37
38	3·696	77·028	4·438	85·970	38
39	3·825	80·724	4·616	90·409	39
40	3·959	84·550	4·801	95·025	40
41	4·097	88·509	4·993	99·826	41
42	4·241	92·607	5·192	104·819	42
43	4·389	96·848	5·400	110·012	43
44	4·543	101·328	5·616	115·412	44
45	4·702	105·781	5·841	121·029	45
46	4·866	110·484	6·074	126·870	46
47	5·037	115·350	6·317	132·945	47
48	5·213	120·388	6·570	139·263	48
49	5·396	125·601	6·833	145·833	49
50	5·584	130·997	7·106	152·667	50

AT DIFFERENT RATES OF INTEREST

In Years.	3½ per cent.		4 per cent.		In Years.
	£1 amounts to	£1 per annum amounts to	£1 amounts to	£1 per annum amounts to	
51	5·780	136·582	7·390	159·773	51
52	5·982	142·363	7·686	167·164	52
53	6·192	148·345	7·994	174·851	53
54	6·408	154·538	8·313	182·845	54
55	6·633	160·946	8·646	191·159	55
56	6·865	167·580	8·992	199·805	56
57	7·105	174·445	9·351	208·797	57
58	7·354	181·550	9·725	218·149	58
59	7·611	188·905	10·115	227·875	59
60	7·878	196·516	10·519	237·990	60
61	8·153	204·394	10·940	248·510	61
62	8·439	212·548	11·378	259·450	62
63	8·734	220·988	11·833	270·828	63
64	9·040	229·722	12·306	282·661	64
65	9·356	238·762	12·798	294·968	65
66	9·684	248·119	13·310	307·767	66
67	10·023	257·803	13·843	321·077	67
68	10·373	267·826	14·396	334·920	68
69	10·737	278·200	14·972	349·317	69
70	11·112	288·937	15·571	364·290	70
71	11·501	300·050	16·194	379·862	71
72	11·904	311·552	16·842	396·056	72
73	12·320	323·456	17·515	412·898	73
74	12·752	335·777	18·216	430·414	74
75	13·198	348·530	18·945	448·631	75
76	13·660	361·728	19·703	467·576	76
77	14·138	375·389	20·491	487·279	77
78	14·633	389·527	21·310	507·770	78
79	15·145	404·161	22·163	529·081	79
80	15·675	419·306	23·049	551·244	80
81	16·224	434·982	23·971	574·294	81
82	16·792	451·206	24·930	598·266	82
83	17·379	467·999	25·927	623·197	83
84	17·988	485·379	26·965	649·125	84
85	18·617	503·367	28·043	676·090	85
86	19·269	521·985	29·165	704·133	86
87	19·943	541·254	30·331	733·299	87
88	20·641	561·198	31·545	763·631	88
89	21·364	581·840	32·807	795·176	89
90	22·112	603·205	34·119	827·983	90
91	22·886	625·317	35·484	862·102	91
92	23·687	648·203	36·903	897·586	92
93	24·516	671·890	38·379	934·490	93
94	25·374	696·406	39·914	972·869	94
95	26·262	721·780	41·511	1012·784	95
96	27·181	748·043	43·171	1054·296	96
97	28·132	775·224	44·898	1097·467	97
98	29·117	803·357	46·694	1142·366	98
99	30·136	832·475	48·562	1189·061	99
100	31·191	862·611	50·504	1237·623	100

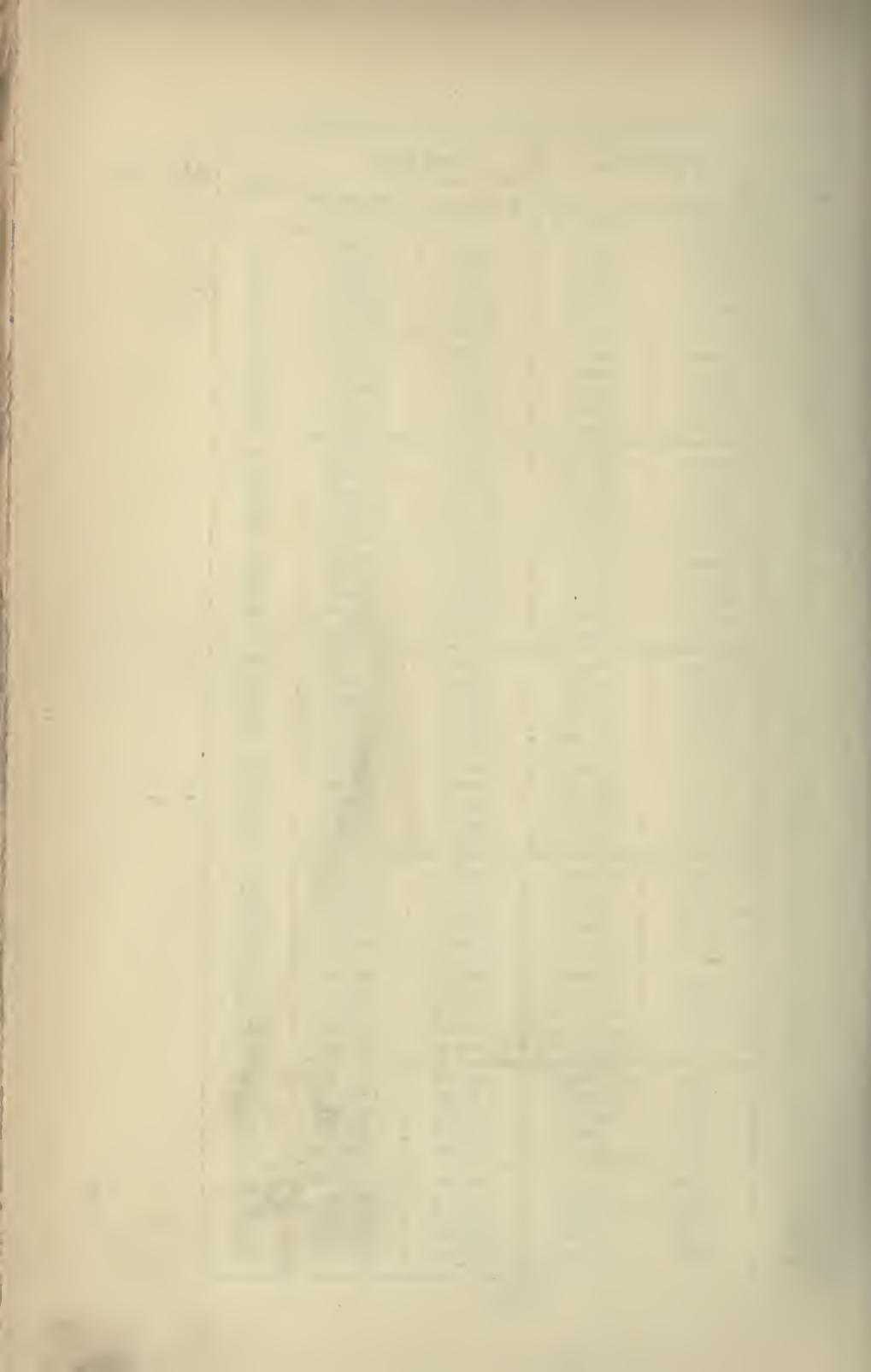
CAPITALISED VALUE OF £1 AND £1 PER ANNUM

4½% 5%

In Years.	4½ per cent.		5 per cent.		In Years.
	£1 amounts to	£1 per annum amounts to	£1 amounts to	£1 per annum amounts to	
1	1·045	1·000	1·050	1·000	1
2	1·092	2·045	1·102	2·050	2
3	1·141	3·137	1·157	3·152	3
4	1·192	4·278	1·215	4·310	4
5	1·246	5·470	1·276	5·525	5
6	1·302	6·716	1·340	6·801	6
7	1·360	8·019	1·407	8·142	7
8	1·422	9·380	1·477	9·549	8
9	1·486	10·802	1·551	11·026	9
10	1·552	12·288	1·628	12·577	10
11	1·622	13·841	1·710	14·206	11
12	1·695	15·464	1·795	15·917	12
13	1·772	17·159	1·885	17·712	13
14	1·851	18·932	1·979	19·598	14
15	1·935	20·784	2·078	21·578	15
16	2·022	22·719	2·182	23·657	16
17	2·113	24·741	2·292	25·840	17
18	2·208	26·855	2·406	28·132	18
19	2·307	29·063	2·526	30·539	19
20	2·411	31·371	2·653	33·065	20
21	2·520	33·783	2·785	35·719	21
22	2·633	36·303	2·925	38·505	22
23	2·752	38·937	3·071	41·430	23
24	2·876	41·689	3·225	44·502	24
25	3·005	44·565	3·386	47·727	25
26	3·140	47·570	3·555	51·113	26
27	3·282	50·711	3·733	54·669	27
28	3·429	53·993	3·920	58·402	28
29	3·584	57·423	4·116	62·322	29
30	3·745	61·007	4·321	66·438	30
31	3·913	64·752	4·538	70·760	31
32	4·089	68·666	4·764	75·298	32
33	4·274	72·756	5·003	80·063	33
34	4·466	77·030	5·253	85·066	34
35	4·667	81·496	5·516	90·320	35
36	4·877	86·163	5·791	95·836	36
37	5·096	91·041	6·081	101·628	37
38	5·326	96·138	6·385	107·709	38
39	5·565	101·464	6·704	114·095	39
40	5·816	107·030	7·039	120·799	40
41	6·078	112·846	7·391	127·839	41
42	6·351	118·924	7·761	135·231	42
43	6·637	125·276	8·149	142·993	43
44	6·936	131·913	8·557	151·143	44
45	7·248	138·849	8·985	159·700	45
46	7·574	146·098	9·434	168·685	46
47	7·915	153·672	9·905	178·119	47
48	8·271	161·587	10·401	188·025	48
49	8·643	169·859	10·921	198·426	49
50	9·032	178·503	11·467	209·348	50

AT DIFFERENT RATES OF INTEREST

In Years.	4½ per cent.		5 per cent.		In Years.
	£1 amounts to	£1 per annum amounts to	£1 amounts to	£1 per annum amounts to	
51	9·439	187·535	12·040	220·815	51
52	9·863	196·974	12·642	232·856	52
53	10·307	206·838	13·274	245·498	53
54	10·771	217·146	13·938	258·773	54
55	11·256	227·917	14·635	272·712	55
56	11·762	239·174	15·367	287·348	56
57	12·292	250·937	16·135	302·715	57
58	12·845	263·221	16·942	318·851	58
59	13·423	276·074	17·789	335·794	59
60	14·027	289·497	18·679	353·583	60
61	14·658	303·525	19·613	372·262	61
62	15·318	318·184	20·593	391·876	62
63	16·007	333·502	21·623	412·469	63
64	16·727	349·509	22·704	432·093	64
65	17·480	366·237	23·839	456·798	65
66	18·267	383·718	25·031	480·637	66
67	19·089	401·985	26·283	505·669	67
68	19·948	421·075	27·597	531·953	68
69	20·846	441·023	28·977	559·550	69
70	21·784	461·869	30·426	588·528	70
71	22·764	483·653	31·947	618·954	71
72	23·788	506·418	33·545	650·902	72
73	24·859	530·207	35·222	684·447	73
74	25·977	555·066	36·983	719·670	74
75	27·146	581·044	38·832	756·653	75
76	28·368	608·191	40·774	795·486	76
77	29·645	636·559	42·813	836·260	77
78	30·979	666·205	44·953	879·073	78
79	32·373	697·184	47·201	924·027	79
80	33·830	729·557	49·561	971·228	80
81	35·352	763·387	52·039	1020·790	81
82	36·943	798·740	54·641	1072·829	82
83	38·605	835·683	57·373	1127·471	83
84	40·343	874·289	60·242	1184·844	84
85	42·158	914·632	63·254	1245·087	85
86	44·055	956·790	66·417	1308·341	86
87	46·038	1000·846	69·737	1374·758	87
88	48·109	1046·884	73·224	1444·496	88
89	50·274	1094·994	76·886	1517·721	89
90	52·537	1145·296	80·730	1594·607	90
91	54·901	1197·806	84·766	1675·337	91
92	57·371	1252·707	89·005	1760·104	92
93	59·953	1310·079	93·455	1849·109	93
94	62·651	1370·032	98·128	1942·565	94
95	65·470	1432·684	103·034	2040·693	95
96	68·416	1498·155	108·186	2143·728	96
97	71·495	1566·572	113·595	2251·914	97
98	74·712	1638·067	119·275	2365·510	98
99	78·075	1712·780	125·239	2484·785	99
100	81·588	1790·855	131·501	2610·025	100



APPENDIX D

TABLE SHOWING THE BASAL AREA FOR TREES OF
DIFFERENT DIAMETERS, AND, FOR COMPARISON,
THE BASAL AREA ACCORDING TO QUARTER
GIRTH MEASUREMENT OF THOSE TREES

TABLE OF BASAL AREAS

Diameter (in inches).	True Basal Area. Square feet.	Quarter Girth (in inches).	Basal Area according to Quarter Girth Measurement. Square feet.
3	0.049	2.35	0.038
4	0.087	3.14	0.068
5	0.136	3.92	0.107
6	0.196	4.71	0.154
7	0.267	5.49	0.209
8	0.349	6.28	0.274
9	0.441	7.07	0.347
10	0.545	7.85	0.428
11	0.659	8.64	0.518
12	0.785	9.42	0.616
13	0.921	10.21	0.724
14	1.069	10.99	0.838
15	1.227	11.78	0.964
16	1.396	12.57	1.097
17	1.576	13.35	1.238
18	1.767	14.14	1.388
19	1.968	14.92	1.546
20	2.181	15.71	1.714
21	2.405	16.49	1.888
22	2.639	17.28	2.073
23	2.885	18.06	2.265
24	3.141	18.85	2.467
25	3.408	19.63	2.676
26	3.687	20.42	2.895
27	3.976	21.20	3.121
28	4.276	21.99	3.357
29	4.586	22.77	3.601
30	4.908	23.56	3.855
31	5.241	24.35	4.117
32	5.585	25.13	4.385
33	5.939	25.92	4.665
34	6.305	26.70	4.950
35	6.681	27.49	5.248
36	7.068	28.27	5.549
37	7.466	29.06	5.846
38	7.875	29.84	6.183
39	8.295	30.63	6.516
40	8.726	31.41	6.851
41	9.168	32.20	7.200
42	9.621	32.99	7.566
43	10.084	33.77	7.919
44	10.559	34.56	8.294
45	11.044	35.34	8.673
46	11.541	36.13	9.065
47	12.048	36.91	9.461
48	12.566	37.70	9.870

APPENDIX E

TABLE SHOWING THE BASAL AREA BY QUARTER
GIRTH MEASUREMENT FOR TREES OF DIFFERENT
QUARTER GIRTHS

TABLE OF BASAL AREAS

Quarter Girth. Inches.	Basal Area by Quarter Girth Measurement. Square feet.		Quarter Girth. Inches.	Basal Area by Quarter Girth Measurement. Square feet.	
	In decimals.	Fractions.		In decimals.	Fractions.
2*	0.027	$\frac{1}{36}$	19	2.51	$2\frac{1}{2}$
3	0.062	$\frac{1}{16}$	19 $\frac{1}{2}$	2.64	...
4	0.111	$\frac{1}{9}$	20	2.78	...
5	0.173	$\frac{1}{6}$	20 $\frac{1}{2}$	2.92	...
6	0.25	$\frac{1}{4}$	21	3.06	$3\frac{1}{5}$
6 $\frac{1}{2}$	0.29	...	21 $\frac{1}{2}$	3.21	...
7	0.33	$\frac{1}{3}$	22	3.36	...
7 $\frac{1}{2}$	0.39	...	22 $\frac{1}{2}$	3.52	$3\frac{1}{2}$
8	0.44	...	23	3.67	...
8 $\frac{1}{2}$	0.50	$\frac{1}{2}$	23 $\frac{1}{2}$	3.84	...
9	0.56	...	24	4.00	4
9 $\frac{1}{2}$	0.63	...	24 $\frac{1}{2}$	4.17	...
10	0.69	$\frac{2}{3}$	25	4.34	...
10 $\frac{1}{2}$	0.77	...	25 $\frac{1}{2}$	4.52	...
11	0.84	...	26	4.69	...
11 $\frac{1}{2}$	0.92	...	26 $\frac{1}{2}$	4.88	...
12	1.00	1	27	5.06	$5\frac{1}{8}$
12 $\frac{1}{2}$	1.09	...	27 $\frac{1}{2}$	5.25	...
13	1.17	...	28	5.44	...
13 $\frac{1}{2}$	1.27	$1\frac{1}{4}$	28 $\frac{1}{2}$	5.64	...
14	1.36	...	29	5.84	...
14 $\frac{1}{2}$	1.46	...	29 $\frac{1}{2}$	6.04	6
14 $\frac{3}{4}$	1.51	$1\frac{1}{2}$	30	6.25	$6\frac{1}{4}$
15	1.56	...	31 $\frac{3}{4}$	7.00	7
15 $\frac{1}{2}$	1.67	...	34	8.02	8
16	1.78	$1\frac{3}{4}$	36	9.00	9
16 $\frac{1}{2}$	1.89	...	39	10.56	$10\frac{9}{16}$
17	2.01	2	42	12.25	$12\frac{1}{4}$
17 $\frac{1}{2}$	2.13	...	45	14.06	$14\frac{1}{16}$
18	2.25	...	48	16.00	16
18 $\frac{1}{2}$	2.38	...	51	18.06	$18\frac{1}{8}$

* Two inches quarter girth under bark equals approximately $2\frac{3}{4}$ inches diameter over bark, the measurement down to which timber is included in continental tables (7 centimetres).

INDEX

- Abies* (*vide* Silver fir), notes on, 414-417
 concolor, 417
 grandis, 417
- Acacia, prices and uses of timber, 329
 seed of, 42, 334
 soils for, 74, 88, 334
 silvicultural notes on, 334, 335
 timber of, 334
- Accumulated debt on normal areas, 234-238
- Acer platanoides* (*vide* Norway Maple), notes on, 375, 376
pseudo-platanus (*vide* Sycamore), notes on, 375, 376
- Acidity in soils, 84
- Acorns, sowing of, in woods, 137
- Advantages of annual rental principle, 251
 of good roads, 312-314
 of mixed woods, 98
 of pure woods, 98, 99
- Æcidium elatinum*, 416
- Æsculus* (*vide* Horse Chestnut), notes on, 356
- Afforestation, considerations in favour of, 14
 financial aspect of, 231-263
 reasons showing inadvisability of, 15-18
 relief works, 8, 9
schemes, may result in disaster, 19
schemes, proposals for Government aid, 19
- Agaricus melleus* (=Honey Fungus), 344, 391, 396, 404, 413, 416, 420
- Age classes under selection system, 177, 178, 188, 189
- Age for planting trees, 96, 97
 of seed production, 184
 when thinnings commence, 147
- Agriotes lineatus* (=wireworm), 405
- Alaska cypress (*vide* *Cupressus Sitchensis*), notes on, 387, 388
- Alder coppice, 197, 201-203, 227
 coppice, use of, 288
 prices and uses of timber, 329
 seed of, 39, 41, 42, 45, 46, 336
 soils for, 74, 88, 89, 336
 silvicultural notes on, 336, 337
 timber of, 336
- Allowance for bark, 269, 270
- Alnus* (*vide* Alder), notes on, 336, 337
- Altitude, influence of, 72, 73, 185
 relative, 33
- American Ash, 341
 Elm, 351
 White wood, 377
- Annual increment, 450, 451
 rental principle, 244-262
 ring, effected by pruning, 157
- Aphis, 345
- Argyresthia lavigatella*, 397
- Arrangement of coppice felling areas, 288, 289
 of fellings, group system, 180
- Artificial sowing of crops of trees, 136-141
- Ash, American, 74, 341
 average annual increment, 221, 340
 bark beetle, 341
 branch bark beetle, 341
 coppice, 197, 201, 227
 coppice, use of, 287, 288
 cutting over at ground level, 154

- Ash, Green (*=F. viridis*), 341
height of, 91, 92, 160
high forest over coppice, 212-214
(mineral) percentage of, in leaves, 83
(mineral) percentage of, in timber, 82
natural regeneration of, 191, 192
Oregon, 208, 341
partial clearance of, and underplanting, 166, 167, 174
planting estimates for, 132
prices and uses of timber, 326
rental yielded by, 246-248, 260, 262, 340
returns from, 221, 340
rotation for, 340
seed of, 38, 39, 41, 45, 46, 338
soils for, 74, 78, 80, 84, 89, 338, 339
standards over coppice, 202, 203, 206, 207
sylvicultural notes on, 338-341
thinning of, 160
timber of, 338
two-storied high forest, 174, 192
yield table, coppice with standards, 226
yield table, high forest, 221
Aspect, 12, 183, 185, 186
influence of, 71, 72
in relation to thinnings, 148, 151
of nursery, 33
Aspen leaf beetle (*L. tremulae*), 371, 385
Poplar, notes on, 370, 371
Atmospheric moisture and tree growth, 74-76
moisture within woodlands, 2
temperature within woodlands, 2, 3
Auction sales of coppice, 285, 286
sales of large timber, 295, 296
Austrian pine, height of, 91, 92
seed of, 39, 42, 45, 46, 406
soils for, 74, 76, 77, 88, 89, 407
sylvicultural notes on, 406, 407
thinning of, 162
Autumn planting, objections to, 112, 113
wood, 164, 170
Average annual increment, 450, 451
annual increments of various trees, 216-224, 226, 227
yields from forest land, 215-230
Average yield tables, application of, 434-436, 450
BAD Mixtures, 105-107
Bank's pine (*vide P. Banksiana*), notes on, 410
Bark, allowance for, in measuring, 269, 270
price of, 310, 311
Barking, 307-311
Barrel hoops, 287, 288
Basal area, ascertaining, 426, 427
Bean sticks, 228
Beech, average annual increment, 217, 344
financial result of underplanting with, 255-257
height of, 91, 92, 159
natural regeneration of, 176-179, 187-191
partial clearance of, 166, 175
prices and uses of timber, 327
rental yielded by, 246-248, 256, 257, 262, 344
returns from, 115, 217, 344
rotation for, 344
seed of, 39, 41-43, 45, 46, 342
seed years, 184, 191
selection system, 177-179
sylvicultural notes on, 342-345
thinning of, 159
timber of, 342
yield table, 217
Betula (*vide Birch*), notes on, 346, 347
Birch, direct sowing, 138
for frost localities, 128
nurses, 101, 107, 144
prices and uses of timber, 329
seed of, 39, 41-43, 45, 46, 346
soils for, 74, 78, 88, 89, 346
sylvicultural notes on, 346, 347
timber of, 346
Black Poplars, notes on, 367-369
Walnut, 208
Walnut (*vide Walnut*), notes on, 379, 380
Bladder rust, 404
Board measurement, 278-282
Bombyx antiqua, 385
chrysorrhæa (=Brown tail moth), 363

- Bombyx neustria* (= Lackey moth), 363
pubibunda, 345
salicis, 371, 385
- Booking measurements, felled timber, 270, 271
 measurements, standing timber, 274, 275
- Bostrichus dispar*, 362
- Botrytis cinerea*, 56, 192, 391, 403, 404, 413, 420
- Douglasii* (*cineraria*), 391
- Box, 86, 88, 210, 323
 prices and uses of timber, 330
- Bracket fungi, 341, 344, 362, 376
- Branches, removal of, if large, 156
- Brandit's hypsometer, 426, 427
- Broad-leaved trees, pruning of, 154, 155
- Brown Oak, 324, 325
 tail moth, 363
- Burrs, 323-325, 328
- Caeoma laricis*, 371
pinitorquum, 371, 404, 413
- Calcareous soils, tree growth on, 83, 84
- Calliper measure, 277, 281, 282
- Canada, forest area of, 15
- Canadian Poplar, notes on, 367-369
 timber "limits," acquisition by Government, 19, 20
- Canal, transport by, 316
- Canary wood, 377
- Canopy, density of, 150, 151
- Capital in normally stocked areas, 234-238
- Carpinus* (vide Hornbeam) notes on, 354, 355
- Castanea* (vide Spanish Chestnut), notes on, 372-374
- Catchment areas, 5
- Cerambyx carcharias*, 371, 385
populnea, 371
- Cerastoma piliferum*, 405
- Chalky soils, trees for, 88
- Cheimatobia brumata* (vide *Geometra*), 355, 358, 363
- Chermes abietis*, 397, 421
laricis, 397
- Cherry, 323
 prices and uses of, 330
- sylvicultural notes on, 348
- Cherry, timber of, 348
- Choice of forest systems, 27-31, 109, 110
 methods of planting, 122, 123
 seed, 37-39
 system of Natural Regeneration, 195, 196
- Chrysomyxa abietis*, 420
- Clay soils, digging holes, 113
 planting of, 127, 128
 replanting, 111
 trees for, 88, 207
 under coppice with standards, 210
 unsuited for notching, 123
- Cleaning and preparing land for planting, 66-69
 young crops, 142-145
- Clearance of "mother" trees, 184-187, 190, 191
- Clogs, wood for, 288
- Cluster Pine (vide *P. pinaster*), notes on, 409, 410
- Coccus salicis*, 385
- Cockchafer grubs, 55, 341, 345, 355, 362, 376, 391, 405, 417, 421
- Coleophora laricella*, 397
- Comparison of cost of sowing and planting, 140, 141
 percentage of various measurements, 282
- Compartment system, 24-27
- Compartments, regeneration of, 182-187, 189-192, 195
- Compound interest, ascertaining, 438-454
 yielded on planting, 239-244
- Conditions of sale of coppice, 286, 287
 of sale of timber, 298, 301
- Conifers, pruning of, 153, 154
- Conversion of coppice or coppice with standards into high forest, 210, 211
- Coppice, felling arrangement, 288, 289
 sale of, 284-286
 simple coppice system, 21
 systems, 21, 197-214
 with standards, 22, 28, 202-210
 with standards, financial aspect of, 257-261
- Coppicing stools, 198, 199

- Coral spot disease (*N. cinnabarina*), 356, 358, 376
 Cord, size of, 283, 306
 Cordwood, 306
 prices of, 228, 333
 Corsican Pine, average annual increment, 219, 409
 height of, 91, 92
 natural regeneration of, 192, 193, 196
 prices and uses of timber, 330
 returns from, 115, 219, 409
 rotation for, 219, 409
 seed of, 39, 42, 45, 46, 407
 soils for, 74, 76, 77, 80, 88, 89, 408
 sowing of direct, 137
 sylvicultural notes on, 407-409
 thinning of, 162
 timber of, 408
 underplanting of, 167
 yield of, 219
Corylus (vide Hazel), notes on, 353
Cossus ligniperda, 371, 385
 Cost of annual outgoings, coppice with standards, 6, 7, 208, 209
 annual outgoings, high forest, 6, 7, 236
 bark and barking, 310, 311
 canal transport, 316
 cleaning or "cutting out" young plantations, 143
 cleaning sown areas, 139
 cording, 307
 cutting coppice (underwood), 199, 228
 dibbling, 122, 139
 dibbling acorns, 141
 drainage, 65, 66
 faggotting, 307
 felling trees, 307
 forest tramway, 314, 316
 hoeing up lines for sowing, 139
 horse haulage, 312
 labour in sowing, 139
 layering or plashing, 201
 making up underwood produce, 228
 manual labour in forests, 6, 7
 notching (*a*) with ordinary spade, 121
 notching (*b*) with Schlich's spade, 121
 nursery operations, 48, 49
 Cost of planting in pits, 117
 planting seedlings, 140, 141
 planting trees (per 100) in coppice areas, 200
 planting with curved planting spade, 119
 planting with planting spike, 118, 119
 planting various crops, 131-136
 rabbit fence, 60
 rabbit fence per acre, 61-64
 railway transport, 317, 322
 road making, 69, 313, 314
 rounding up felled timber, 310
 seedlings and transplants, 50, 51
 shipping timber from Baltic ports, 16
 shipping timber from Vancouver, 17
 slitting (*vide* notching), 121
 sowing (direct) crops of trees, 139-141
 steam traction, 312
 treading in young plants, 143
 underplanting, 168, 169
 Couch grass, 129
 Covert, absence of, 29
 plants, 209, 210
 Cratewood, wood for, 287
 Creeping willow, 129
 Cricket bat willows (*vide* Willow), 382-385
Cræsus septentrionalis, 337
 Crowns, shape of, 90
 Crutch pine beetle, 406
Cryptococcus fagi, 344
Cryptorhynchus lapathi, 385
Cupressus macrocarpa, seed of, 37, 39, 42, 45, 46, 386
 soils for, 74, 77, 78, 88, 89, 386
 sylvicultural notes on, 386, 387
 timber of, 386
 yield, 115, 225
Nootkatensis (*vide* *C. Sitkensis*), 387, 388
Sitkensis, seed of, 39, 42, 45, 46, 387
Sitkensis, sylvicultural notes on, 387, 388
 Current annual increment, 450, 451
 Cutting coppice, 198, 199, 284, 285
 over recently planted hardwoods, 144, 154, 155
 Cuttings or slips, 52, 53

- Cynips kollaris*, 363
querci, 363
- "DAMPING OFF" of seedlings (*vide Phytophthora*), 56, 344
- Dasydycypha calycina* (Larch Disease), 396
- Dead branches, pruning of, 158
- Decaying leaves and nitrogen, 81
- Density of timber, 164
- Denudation (*vide erosion*), 4
- Depth of soil and tree growth, 78, 79
to plant, 117
- Destruction of forests, evil effects of, 6
- Diameter classes, 431
- Dibbling, 122
- Die square measurement, 278, 280, 282
- Direct sowing of crops of trees, 136-141
- Direction of fellings, 290
- Distance apart for planting, 96, 97
- Distillation of wood, 230
- Divisor, " 113," " 144," 264, 318, 319
- Douglas Fir, average annual increment,
224, 391
height of, 91, 92, 162
natural regeneration of, 193-195
planting estimates for, 131, 132, 136
prices and uses of timber, 331
pruning of, 153
rental yielded by, 246-248, 250, 262
returns from, 115, 224, 246-248, 262,
391
rotation for, 224, 250, 391
seed of, 37-39, 42, 45, 46, 389
soils for, 74, 76, 78, 80, 86, 88, 89,
389, 390
sylvicultural notes on, 389-391
thinning of, 162
timber of, 389
yield table, 224
- Drainage of land, 64-66
- Draudt's method of measuring, 432
- Drifting timber, 316
- "Drifts," size of, 284
- Dry soils, trees for, 88, 89
- EASTERN PLANE, notes on, 365
"Eclaircie par le haut," 146, 147
- Effects of drainage on trees, 66
of forests upon labour market, 6-9
of pruning, 157, 158
- Effects of thinning upon humus, 150,
151
- of trees upon climatic conditions, and
upon the locality, 1-6
- Elm bark beetle, 350
- prices and uses of timber, 326, 327
seed of, 39-42, 45, 46, 349
soils for, 78, 88, 349
sylvicultural notes on, 349-351
timber of, 349
- Epicormic branches, 149
- Erosion and denudation, prevention of,
by trees, 4
- Estimates for planting, 131-136
- Estimation of increment in cubic con-
tents, 437-451
of increment in value or quality,
451-454
- European Larch (*vide Larch*), notes on,
392-397
- Even-aged high forest, compartments
of, 25
mixtures, 100-103
- Everlasting pea, 129
- Expenses of management, coppice with
standards, 6, 7, 208, 209
of management, high forest, 6, 7,
236, 245, 258
- Exposed land, planting of, 110, 128
- Extraction of roots, 111
- FAGGOTS, 228, 306
price of, 333
- Fagus* (*vide Beech*), notes on, 342-
345
- Fallacious estimates concerning forestry,
232-234
- Felled timber, lotting of, 303, 304
measurement of, 265-271
sale of, 291-293
- Felling standards over coppice, 209
season, 307
timber, 304-307
- Fellings, direction of, 290
under group system, 180
- Felted beech scale, 344
- Fences against stock, 61
- Fencing rods, 228
stakes, 228
trees against rabbits, 29
- Field Maple, 376

- Financial aspect of afforestation, 10-20,
231-263
aspect of coppice with standards, 257-
261
aspect of underplanting, 169, 252-
257
position of various trees, 115
Fire lines, 87, 346, 347
Floods, 86
Fomes, 350, 362, 385
 annosus (= *Trametes radiciperda*),
 391, 397, 404, 413, 416, 420
 fomentarius, 344
 igniarius, 341, 344
Food material, resources of, 164
 requirements of trees, 80-83
Foreign seed, when advisable, 39, 194
Forest roads, cost of, 313, 314
 tramway, 314-316
Form factor, 428, 429, 433
Formulae for compound interest, 439,
 443, 444, 446, 447
Fox-coloured sawfly, 406
Fraudulent girthling, 268, 269
Fraxinus (*vide* Ash), notes on, 338-341
Frost line, 77
 localities, planting of, 128
 localities, trees for, 77, 89
Frosts, in relation to aspect and altitude,
 72, 73
 susceptibility of trees to, 36, 37

GALES, liability to, 73
Gall wasps, 363
Gautheria, 210
Geometra (*Cheimatobia*) *brumata*, 355,
 358, 363
Germination capacity of seeds, 42
Giant arborvitæ (*vide* *Thuya gigantea*),
 notes on, 424, 425
 wood wasp, 417
Girth increment, 163-166
Girthling, fraud in, 268, 269
Goat moth, 371, 385
Good mixtures, 103-105
Graphic representation of yield tables,
 225
Grass land, frosts on, 68, 69
 soil covering of, 142, 171, 186, 192
Green Ash, 341
Grey Poplar, notes on, 370
Group system, 23, 179-181, 195
Groups, mixtures by, 102
Gunpowder, wood for, 288, 308
“HAGS,” size of, 284
Hard tissue, 164
Haulage by horses, 312
 by steam traction, 312, 313
 of timber (annual cost per acre), 6
Haws, 39, 352
Hawthorn, seed of, 352
 silvicultural notes on, 39, 352
Hazel coppice, 197, 201
 coppice, uses of, 288
 notes on, 353
 seed of, 39, 41, 353
Heat and tree growth, 84-86
Heather land, acid, 84
 land, planting of, 127
 land, sowing of direct, 137
pan, 79, 127
 soil covering of, often beneficial, 142
Height, ascertaining exactly, 426, 427
 growth, 91, 92
measurement of, 272, 274
of Ash, 91, 92, 160
of Beech, 91, 92, 159
of Douglas Fir, 91, 92, 162
of Larch, 91, 92, 161
of Oak, 91, 92, 159
of Scots Pine, 91, 92, 161
of Silver Fir, 91, 92, 160
of Spruce 91, 92
of Weymouth Pine, 91, 92, 162
High forest systems, 22-27
 with coppice, 26-29, 167, 211-214
 with standards, 27, 30
Hillsides, planting of, 127
 sowing of, 137
Hoeing in nursery, 49
Holly, 210
 prices and uses of timber, 330
Home-grown seed, 38, 39, 194
Honey fungus (= *Agaricus melleus*), 391,
 396, 404, 413, 416, 420
Hoops (barrel), wood for, 287, 288
Hop dog moth, 345
Hop poles, wood for, 287, 288
Hornbeam, prices and uses of timber,
 328
 seed of, 39, 42, 45, 46, 354

- Hornbeam, soils for, 74, 79, 88, 354
 sylvicultural notes on, 354, 355
 timber of, 354
- Horse chestnut, notes on, 356
 prices and uses of timber, 329
 haulage, 312
- Hot aspects, trees for, 85
- Humus, decay of, 182, 183
 effects of, 170, 171
 with reference to soil moisture, 150,
 170
- Hurdles, wood for, 287, 288
- Hydnellum diversidens*, 362
- Hydrogen peroxide, 5
- Hylesinus crenatus*, 341
fraxini, 341
oleiperda, 341
palliatius, 406
piniperda, 405, 406, 421
- Hyllobius abietis* (*vide* Pine Weevil),
 181, 307, 391, 405, 417, 421
- Hylurgus* (= *Hylesinus*) *piniperda*, 405,
 406, 421
- Hypsometers, 416, 427
- Hysterium* (= *Lophodermium*) *pinastri*,
 56, 192, 403, 413
- INCOME from normally stocked areas,
 236, 262
- Increment, average annual, of crops,
 216-224, 226, 227
 in cubic contents, 437-451
 in girth, 157
 in value, 165, 451, 452
 on felled timber, 448-450
 on invested capital, 452-454
 on standing timber, 441-448
 stimulation of, 163-166
- Inland sand dunes, 129, 130
- Interest yielded on planting, 239-244,
 258
- Intermittent fellings, 181, 290
- JANKER, 311
- Japanese Larch (*vide* Larch), notes on,
 397, 398
- Juglans* (*vide* Walnut), notes on, 379,
 380
- KURILE Larch, 398, 399
- LACKEY MOTH, 363
- Land, drainage of, 64-66
 rentals, 244-248, 253, 254, 260, 262
 "Lands," size of, 284
- Larch aphid, 397
 blister (= larch disease), 396
 bug (= larch aphid), 397
- European, average annual increment,
 222, 223, 396
- European, height of, 91, 92, 161
- European high forest over coppice,
 212-214
- European, natural regeneration in-
 advisable, 193
- European, partial clearance and
 underplanting, 166, 167, 173,
 174
- European, planting estimates, 132,
 136
- European, prices and uses of timber,
 330
- European returns from, 246-248, 260,
 262, 396
- European rotation for, 222, 223, 241,
 247, 396
- European, seed of, 37, 39, 42, 45, 46,
 392
- European, soils for, 74, 78, 80, 84,
 88, 392, 393
- European, standards over coppice,
 202, 203, 206, 207
- European, sylvicultural notes on, 392-
 397
- European, thinning of, 161
- European timber of, 392
- European, underplanting, finance of,
 252-254
- European, yield table, coppice with
 standards, 226
- European, yield table, high forest,
 222, 223
- Japanese, notes on, 397, 398
- Japanese, seed of, 37, 39, 42, 45, 46,
 397
- Kurile, notes on, 398, 399
- mining moth, 397
- Siberian, notes on, 399
- Western, notes on, 398
- Large longicorn beetle, 371, 385
- Pine beetle, 405, 406, 421
- Larix* (*vide* Larch), notes on, 392-399

INDEX

- Late spring planting, 112
 Laurel, 210
 Layering or plashing, 201
 Layers, 52
 Laying out rides or roads, 69
 Leaf shedding disease, 56, 192, 403, 413
 Leaves, retention of, 183
 Light-demanding trees, 95, 188
 demanding trees, thinning of, 147-149, 152
 Lime, 323
 prices and uses of timber, 328
 seed of, 42, 357
 silvicultural notes on, 357, 358
 timber of, 357
 (CaO), a poison to some trees, 83, 89
 (CaO), in soil and tree growth, 83, 84
 Limestone soils, trees for, 88
Lina populi, 371, 385
 tremulae, 371, 385
 Lining out seedlings and transplants, 49
Liriodendron tulipifera (*vide* Tulip Tree), 377, 378
 Lombardy Poplar, notes on, 371
 London Plane, notes on, 365
 Long rotations, inadvisability of, 241-243, 250
Lophodermium macrosporum, 420
 nervisequum, 405, 406, 421
 pinastri, 56, 403, 413
Lophyrus pini, 406
 rufus, 406
 Loss of plant food by tree growth, 80
 Losses in respect of timber growing, 10
 Lotting timber, 302, 304

 MARKETING of mature timber, 290-304
 of thinnings, 289, 290
 Marking timber, 302
 Maritime Pine (*vide P. pinaster*), notes on, 409, 410
 Marram grass, 129
 Maw's formula, 446, 447
 Measurement by board measure, 278-282
 by calliper measure, 277, 281, 282
 by die square, 278, 280, 282
 Measurement by quarter girth, 264-275, 279, 280, 282
 by true contents, 276, 279, 282
 of felled timber, 265-271
 of sample plots, 432-434
 of sample trees, 429-432
 of standing timber, 272, 273
 Mechanical condition of soil and tree growth, 79, 80
Melampsora, 371, 385
 larici tremulae, 371
 pinitorquata, 371, 405
 populina, 371
Melampsorella cerastii, 416
Melolontha vulgaris (=Cockchafer), 341, 345, 355, 362, 376, 391, 405
 Method of pruning, 155, 156
 Methods of mixing trees, 100-103
 Mice, damage done by, 57
 Mico-rhizas, 81
 Micro-organisms and tree growth, 81
 Mistletoe, 371
 Mixed coppice, 201
 woods, merits and demerits of, 98-100
 woods, thinning of, 151, 152
 Mixtures, natural regeneration of, 186
 of trees, 100-108
 rules for, 108
 Moisture, demands of trees as to, 74-76
 in soil, 170, 179
 Moor pan, 79
 Mother trees, 181
 gradual clearance of, 184-187, 190, 191
 Mound planting (*vide* "tumping"), 127
 Mutual pruning effects, 93, 94
Myxoderra, 324

 NATURAL REGENERATION, 176-196
Nectria cinnabarinina, 356, 358, 376
 curcubitula, 420
 ditissima, 341, 344, 355, 358, 362
 Net expenses in forests, 236, 245, 258
 Nitrogen, utilization of, and requirements, 81
 Nordmann's silver fir, notes on, 417
 Normal growing stock, coppice with standards, 226
 growing stock, high forest, 216-224
 Normally stocked areas, capital invested in, 234-237

- Normally stocked areas, revenue from, 234-237, 262
Northern aspects, pay to plant, 12
Norway maple, natural regeneration, 192
prices and uses of timber, 327
rotation for, 376
seed of, 42, 45, 46, 375
soils for, 74, 76-78, 88, 89, 375
silvicultural notes on, 375, 376
timber of, 375
Norway spruce, average annual increment, 218, 420
height of, 91, 92
natural regeneration of, 193-195
partial clearance of, 166, 174, 175
prices and uses of timber, 331
rotation for, 218, 419
returns from, 115, 218, 246-248, 262, 420
seed of, 39, 42, 45, 46, 418
soils for, 74-76, 79, 88, 89, 418, 419
silvicultural notes on, 418-421
thinning of, 160
timber of, 418
yield of, 218
Notching or slitting, 120-122
Number of trees from 1 lb. of seed, 46
of trees per acre to plant, 123, 124
Nursery, advantages of home nursery, 32, 33
pests, 55-57
plants, weeding and transplanting, 49
seed beds, 36
site of, 33
size of, 34
"Nurses," 100, 101, 107, 108, 144, 346
- OAK apple galls, 363
Oak average annual increment, 216, 362
bark, 307-311
boring bark beetle, 362
burrs, 323-325
coppice, 197, 201, 227
coppice, uses of, 288
height of, 91, 92, 159
high forest over coppice, 214
Holm Oak, 363, 364
invested capital in normal areas, 237
marble galls, 363
- Oak, natural regeneration of, 187, 191
partial clearance of, and underplanting, 166, 167, 172, 173
planting estimates for, 133, 134
prices and uses of timber, 324, 325
Red Oak, 363
returns from, 216, 246-248, 260, 262, 362
root seedling fungus, 56
rotation for, 246-248, 262, 362
seed of, 38, 41-43, 45, 46, 359
soils for, 74, 77-79, 88, 359, 360
standards over coppice, 202-205, 207
silvicultural notes on, 359-364
thinning of, 149, 159
timber of, 359
Turkey Oak, 363
underplanting, finance of, 255-257
yield table, coppice with standards, 226
yield table, high forest, 216
Objections to statement of rate of compound interest yielded, 243
to very close sowing, 138, 145
Orchestes fagi, 344
querci, 362
Oregon Ash, 208, 341
Pine, 331
Pine (*wide* Douglas Fir), notes on, 389-391
Ornamental trees, nursery management of, 130
Osiers, 202
Outgoings (net minimum), 236, 245
Ozone, 5
- PAN, 79, 127
Paper Birch, 347
Partial clearances, 163-175
advisability of, 250
tables for, 173-175
Patches, mixtures by, 102
Pea sticks, 228
Peat land, planting of, 127
Peaty soils, trees for, 88, 89
Pedunculate Oak, notes on, 359-363
Percentage increment on felled timber, 448, 449
increment on invested capital, 452, 454
increment on standing timber, 441, 448

- Peridermium pini acicola*, 404, 413
pini corticola, 404
ribicolum (*P. strobi*), 413
- Persistency of side branches, 92-95
- Pestalozzia Hartigii*, 56, 344, 376, 391, 416, 420
- Peziza Willkommii*, 396
- Philaphis*, 345
- Phoma abietina*, 416
pithya, 391
- Phytophthora omnivora*, 56, 344, 376, 396, 420
- Picea* (*vide* Spruce), notes on, 418-423
- Pine bark blister (=Canker), 404
needle blister, 404
- Pine saw-fly, 406
shoot tortrix, 406
shoot twig twister, 406
shoot twisting fungus, 404
- weevil, 55, 290, 307, 391, 405, 417, 421
- Pine weevil, influence of, on replanting, 111, 181
- Pines, sylvicultural notes on, 400-413
- Pinus* (*vide* Pines), sylvicultural notes on, 400-413
Banksiana, notes on, 410
Banksiana, soils for, 77, 89, 410
insignis, notes on, 410, 411
insignis, soils for, 77, 89, 410, 411
pinaster (= Star Pine), notes on, 409, 410
pinaster, soils for, 77, 84, 89, 410
- Pissodes notatus*, 405, 413, 421
- Pit timber, prices for, 332
- Plane leaf fungus, 366
tree, prices and uses of timber, 329
tree, soils for, 365
tree, sylvicultural notes on, 365, 366
- Planting clay soils 127, 128
estimates, 131-136
exposed places, 128
financial considerations, 115
foul land, extra cost of, 169, 170
frost localities, 77, 89, 128
heather land, 127
in pits, 116, 117
iron, 121, 122
modus operandi, 125
ornamental trees, 130
peat land, 127
- Planting sand dunes and shifting sand, 128, 129
season, 111-113
up coppice areas, 199, 200
with curved planting spade, 119
with planting spike, 118
- Plashing (=Layering), 201
- Platanus* (*vide* Plane), notes on, 365, 366
- Ploughing land, before planting, 67, 68
- Poisoning vermin, 57
- Pollards, 324, 325
- Polyporus*, 341, 344, 350, 362, 376
(= *Fomes*) *fomentarius*, 362
(= *Fomes*) *ignarius*, 362, 385
sulphureus, 344, 362, 371, 385, 397
vaporarius, 421
- Poor soils, trees for, 83
- Poplar (Black), average annual increment, 369
height of, 91, 92
returns from, 115, 225, 369
rotation for, 369
soils for, 74, 79, 88, 367
- Poplar nurses, 107, 108
seed of, 41, 367, 369, 370
sylvicultural notes on, 367-371
timber, 367, 369, 370
timber, non-inflammability of, 14, 15
prices and uses of, 329
- Poplar (White), soils for, 74, 77, 79, 88, 89, 369, 370
- Populus* (*vide* Poplar), notes on, 367-371
- Preparatory fellings, 182, 183, 190
- Pressler's borer, 441, 442
formula, 443
- Prices of cordwood, 333
faggots, 333
pit timber, 332
timber, 323-333
timber, probability of advances in, 13, 14
- Private contract, sales by, 297
- Privet, 210
- Prolongation of rotation, 165
- Pruning, 153-158
by natural agencies, 93, 94
effected in mixtures, 100, 101
green branches, 153-155
large branches, 156
nursery stock, 54

- Pruning standards over coppice, 207
Prunus avium (*vide* Cherry), notes on,
 348
 "Pumped" larch, 80
 Purchased plants, receipt of, 126
 Pure coppice, 201
 woods, merits and demerits of, 98
 woods, rules for, 109
- QUALITY** of increment, 451-454
 bark, 309
 of soils, 213
 Quarter girth measurement, 264-275,
 279, 280, 282
Quercus (*vide* Oak), notes on, 359-364
- RABBIT fences, 58-64
 specification for, 60
 Rabbits, 341, 409
 Rafting timber, 316
 Railway carriage of timber, 317-323
 sleepers, 332, 333
 Rates for railway carriage of timber,
 321, 322
 "Raw" humus, 182
 Red Cedar (*vide* *Thuya gigantea*), notes
 on, 424, 425
 deal, 330
 Oak, 325
 Poplar leaf beetle (*L. populi*), 371,
 385
 rot, 362, 371, 385
 rot root fungus, 391, 397, 404, 413,
 416, 420
 Regeneration felling, 183, 184, 190
 Relative height growth, 91
 humidity of woodland atmosphere, 3
 Remarkable Pine (*P. insignis*), notes
 on, 410, 411
 Removal of mother trees, 184-187, 190,
 191
 Rental of sporting, 208
 Rentals yielded by afforestation, 246-
 248, 250, 260, 262
 Reproductive power of trees, 197, 198
 Reserves of food material, 164
 Retention of leaves, 183
Retinia buoliana, 406
 Revenue from normally stocked areas,
 262
Rhododendron, 210
- Rhytisma acerinum*, 376
 Rides and roads, laying out, 69
 Ring-pored trees, 164
 Roads, cost of, 313, 314
Robinia (*vide* *Acacia*), notes on, 334,
 335
Rosellinia quercina, 56, 362
 Rotation, length of, 141-243, 246-248,
 250, 262
 of cropping, 110, 111
 prolongation of, 165
 Rotations for coppice, 197, 198, 202,
 212, 214
 Rules for mixed woods, 108
 pure woods, 109
- SALE** by auction, 295, 296
 by private contract, 297
 by tender, 295-297
 conditions of, 298-301
 of mature timber, 290-304
 of thinnings, 289, 290
 of timber, choice between standing
 and felled, 291-293
Salix (*vide* Willow), notes on, 381-385
 Salt spray and tree growth, 77
 Sample plots, measurement of, 432-434
 trees, measurement of, 429-432
 Sand dunes, planting of, 128-130
 trees for, 89
 Sand grasses, 129
 Sandy soils, 88, 89
 Saplings, 203
 Sapwood, of Douglas fir, 331
 Satin moth (*B. salicis*), 371, 385
 Saw for timber, 306
 Schlich's spade, 121
 Schneider's formula, 444
 correction for standing timber, 445
Sclerenchyma, 164
Scolytus destructor, 350
 Scots elm (*vide* Wych Elm), notes on,
 349, 350
 Scots Pine, average annual increment,
 219, 403
 height of, 91, 92, 161
 invested capital in normal areas, 234,
 235, 237
 natural regeneration of, 187, 192,
 193, 196
 planting estimates, 134, 135

- Scots Pine, prices and uses of timber, 330
 returns from, 219, 236, 246-248, 262,
 403
 rotation for, 219, 246-248, 403
 seed of, 37, 39, 42, 45, 46, 400, 401
 soils for, 74, 76-78, 80, 88, 89, 401
 sowing of direct, 137
 sylvicultural notes on, 400-406
 thinning of, 161
 timber of, 401
 underplanting of, 167, 174
 yield table, 219
- Sea *Carex*, 129
- Sea coast, trees for, 89
- Sea Lyme grass, 129
- Season for, barking, 308
 cutting underwood, 199
 felling, 307
 planting, 111-113
 pruning, 156, 157
- Seaside planting, 77
- Seed bed in forest, 182, 183
- Seed beds, 36
 "can," 44
 choice of, 37-39
 "felling," 183, 184, 190
 germination capacity, 42
 home grown, 38, 39, 193, 194
 marking board, 44
 number of, per lb., 45
 price per lb., 46
 production, age at which, 184
 quantity to sow in nurseries, 45
 quantity to sow in forest, 139
 storage of, 39, 40
 sowing of, 40-44
 years, 184, 191
- Seedlings, cost of, 50, 51
 treatment of, 47-49
- Selection system, 23, 176-179
- Septoria parasitica*, 56, 420
- Sessile Oak, notes on, 359-363
- Shade-bearing conifers, natural regeneration of, 193-195
 trees, 23-26, 95, 167, 187, 188
 trees, rate of growth, 91, 92, 168
 trees, thinning of, 147, 148, 152
- Shallow soils, trees for, 78, 79
- Shingles, 332
- Short rotations, advisability of, 250
 interest yielded by, 241-243
- Side branches, effect of thinnings upon, 148, 149, 152
 vigour of, 92-95
- Silver fir, average annual increment, 218, 416
 financial return of underplanting with, 252-254
 height of, 91, 92, 160
 leaf scurf, 416
 natural regeneration of, 193-195
 needle blight fungus, 416
 (Nordmann's), notes on, 417
 partial clearance of, 166, 174, 175
 prices and uses of timber, 330
 returns from, 115, 218, 246-248, 252-254, 262, 416
 rotation for, 218, 246-248, 415
 seed of, 39-42, 45, 46, 414
 soils for, 74, 75, 78, 79, 88, 89, 414
 sylvicultural notes on, 414-417
 thinning of, 160
 timber of, 414
 yield table, 218
- Simple coppice, 21, 197, 202
- Sirex dromedarius*, 385
gigas, 417
- Sitka Cypress (*vide Cupressus Sitchensis*), notes on, 387, 388
- Sitka Spruce, natural regeneration of, 193-195
 returns from, 115, 225, 422
 seed of, 38, 39, 42, 45, 46, 421
 soils for, 74, 76, 78, 79, 88, 421, 422
 sylvicultural notes on, 421-423
 timber of, 421
- Sleepers, railway, 332, 333
- Slips or cuttings, 52, 53
- Small black weevil (*O. querci*), 362
 brown pine weevil (*Pissodes notatus*), 405, 413, 421
- Poplar longicorn beetle, 371
- Snowberry, 210
- Soil covering of grass, 142, 171
 moisture, 170-172
 moisture, effects of woodlands on, 4
- temperature within woodlands, 2
- Sour soils, 84
 owing to decay, 182
- Sowing acorns, 137
 acorns in coppice areas, 200
 direct, crops of trees, 136-141

- Spanish Chestnut, average annual increment, 374
coppice, 197, 201, 203, 227
coppice, uses of, 287
planting estimates, 132
prices and uses of timber, 326
returns from, 115
rotation for, 373
seed of, 39, 41-46, 372
soils for, 74, 78, 79, 83, 88, 89, 372
sowing of, in woods, 137
silvicultural notes on, 372-374
timber of, 372
- Sporting rent, 208
- Spring frosts, 36, 37, 68, 89, 128, 142, 170
planting, 112
wood, 164, 170
- Spruce (*vide also* Norway Spruce) (*vide also* Sitka Spruce)
gall aphid, 421
leaf scurf, 420
natural regeneration of, 193-195
needle rust, 420
notes on, 418-423
partial clearance of, 166, 174, 175
planting estimates for, 136
"Square" planting, 123, 124
- Squirrels, 406, 409
- Stag-headed trees, produced by pruning, 157, 158
- Staking trees, 130
- Standard (a), 283
- Standards over coppice, felling and removal, 285
financial aspect of, 257-261
land rentals for, 260
number of trees to plant, 203-207
pruning of, 153, 154
sale of, 285
suitable trees for, 22, 207, 208
tables for, 204-207
- "Standils," 203
- Standing timber, increment on, 441-448
lotting of, 303
sale of, 291-293
- Star pine (*vide P. pinaster*), notes on, 409, 410
- Stereum hirsutum*, 362
- Stiff clay soils, 210
soils, trees for, 79, 80
- Stimulation of increment, 163-166
of trees by pruning, 157
- Stocking a nursery, 53, 54
- Stool shoots, reproduction by, 198
- Storage of seed, 39, 40
"Stores," 203
- Storm-proof trees, 76
- St Petersburg standard, 283
- String, use of, when measuring, 267, 268
- Strip system, 187
- Suckers, 52
reproduction by, 198
- Summer wood, 164, 170
- Sycamore, natural regeneration of, 192
prices and uses of timber, 327
rotation for, 376
seed of, 42, 45, 46, 375
soils for, 74, 76-78, 88, 89, 375
silvicultural notes on, 375, 376
timber of, 375
- Symbiosis, 81
- TABLE of invested capital in normal areas, 237
- Tables for partial clearances, 173-175
of thinnings, high forest, 159-162
of thinnings, high forest with coppice, 212, 213
of thinnings, standards over coppice, 204-207
of yield, coppice with standards, 226
of yield, high forest, 216-224
- Tannin, 307
- Tape, use of, when measuring, 267
- Tarred felt (tree guards), 29, 200
- Tellers, 203
- Tender, sales by, 295-297
- Thatcher's rods, 228
- Thickly foliated trees, 95, 96
- Thinly foliated trees, 22, 25, 26, 28
treatment of, 166, 167
- Thinning, 145-152
selection system, 179, 188, 189
tables for, 159-162, 204-207, 212, 213
- Thinnings, sale of, 289, 290
value of, when small, 152
volume of, removed, 216-224
- Thuya gigantea*, natural regeneration of, 193-195
prices and uses of timber, 332

- Thuya gigantea*, returns from, 115, 425
 rotation for, 425
 seed of, 38, 39, 42, 45, 46, 424
 soils for, 74, 78, 79, 88, 89, 424, 425
 sylvicultural notes on, 424, 425
 timber of, 424
- Thuya occidentalis*, 424
- Tilia* (*vide Lime*), notes on, 357, 358
- Timber bob, 311
 felling, 304-307
 lotting, 302-304
 marking, 302
 saw, 306
 slides, 316
 strap, 272
 supply, consideration of the world's supply, 14-17
- Tinea laricella*, 397
levigatella, 397
- Tortrix buoliana*, 406
viridana, 362
- Tracheids, 164
- Trametes pini*, 397, 404, 413, 416, 420
radiciperda, 391, 397, 404, 413, 416, 420
- Tramway in forests, 314-316
- Transplanting large trees, 130
 seedlings, 47, 48
- Trees for coppice, 22, 26
 high forest over coppice, 212
 standards over coppice, 22, 207, 208
 per acre to plant, 123, 124
 "Triangle" planting, 123
- Trichosphaeria parasitica*, 416
- True contents measurement, 276, 279, 282
- Tulip tree, 208
 soils for, 84, 89, 377
 sylvicultural notes on, 377, 378
- "Tumping," 127
- Turkey Oak, prices and uses of timber, 325
 sylvicultural notes on, 363
- Tushing wheels, 311
- Two-storyed high forest, 25, 26, 167, 174, 192, 340
- ULMUS (*vide Elm*), notes on, 349-357
- Underplanting, 166-169
 effects of, 171, 172
 financial aspect of, 252-257
- Underplanting Oak woods, 150
- Undersowing, 166
- Underwood (*vide Coppice*)
- Underwood, sale of, 284-286
- Unemployed in reference to afforestation, 8, 9
- Uneven-aged mixtures, 103
- Urich's method of measuring, 432
- Uses of coppice produce, 197, 287, 288 timber, 323-333
- Utilisation of free nitrogen, 81
- VALUE of coppice produce, 227-229
 of final crops of timber, 216-224, 226
 of thinnings, 216-224
- Vancouver Douglas Fir (*vide Douglas Fir*), notes on, 389-391
- Veneers, 324, 328
- Vermin, poisoning, 57
- Volume of final crops of timber, 216-224, 226
 thinnings, 216-224
- WALNUT, 323
 prices and uses of timber, 328, 329
 rotation for, 380
 seed of, 39, 41, 379
 sowing direct in woods, 137
 sylvicultural notes on, 379, 380
 timber of, 379
- Waste lands, acreage of, 11
 general afforestation of, a failure, 11
- Water catchment areas, 5
 demands of trees as to, 74-76
 in soil, effect of thinnings upon, 150, 170-172
- Weeding nursery stock, 49
- Weight of timber per foot, 318-322
- Weise's method of measuring, 430-432
- Western Larch (*vide Larch*), notes on, 398
- Plane, notes on, 365, 366
- Weymouth Pine, average annual increment, 220, 413
 bark blister, 413
 height of, 91, 92, 162
 natural regeneration, 193-195
 prices and uses of timber, 331
 returns from, 115, 220, 246-248, 262, 413
 rotation for, 220, 246-248, 412

- Weymouth Pine, seed of, 39, 41, 42, 45, 46, 411
soils for, 74, 78, 88, 411, 412
sylvicultural notes on, 411-413
thinning of, 162
timber of, 411
yield table for, 220
White Alder, notes on, 336, 337
White Ash, 208, 341
deal, 331
Poplar, notes on, 369, 370
rot, 362, 385
Spruce, notes on, 89, 423
Width of annual rings, 164, 165
Willow coppice, uses of, 288
prices and uses of timber, 328
propagation of, 381, 383
returns from, 225
rotation for, 385
soils for, 74, 383
sylvicultural notes on, 381-385
timber of, 381-383
Willow coppice, wood wasp, 385
Winter moth, 355, 358, 363
Wire netting, 29
tree guards, 200
Wireworm, 55, 405
Witches broom, 416
Wych Elm, sylvicultural notes on, 349, 350
Xyleborus (vide *Bosstrichus*) *dispar*, 362
YELLOW Birch, 347
Pine, 331
wood wasp, 417
Yew, 86, 88, 210
Yield from coppice, 227-230
Yields from forest land, 215-230
Yield of bark, 309, 311
tables, coppice with standards, 226
tables, graphic representation of, 225
tables, high forest, 216-224

PRINTED BY
OLIVER AND BOYD,
EDINBURGH.

SD
409
M3

Maw, Percival Trentham
The practice of forestry

Forestry

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

[100742]
LIBRARY
FACULTY OF FORESTRY
UNIVERSITY OF TORONTO

