PRINCIPLES

OF

FOREST ORGANISATION

BY

CHARLES BROILLIARD

Professor of Forest Economy, Nancy, France,

TRANSLATED INTO ENGLISH

BY

E. E. FERNANDEZ,

INDIAN FOREST DEPARTMENT,

INSTRUCTOR OF FORESTRY, IMPERIAL FOREST SCHOOL, DEHRA DOON.

Printed at the Eagle Press, Bombay, and at the Alexandra Press, Buckle & Co., Mussoorie.

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PREFATORY NOTE.

This translation was originally issued in fascicles, the first of which appeared so long ago as December 1880. The entire Manuscript was then already complete and nothing remained but to pass it through the press as quickly as possible. In the meantime, however, circumstances occurred which have delayed up to this the publication of the final sheets. To narrate those circumstances here would take too long; suffice it to say that for more than three years I received no proofs, and to complete the work even now, although only four forms remained to be printed, I have had to go to Bombay and after infinite trouble to secure and bring to Dehra Dun all the previously printed matter comprising pp. 1—304, which were ready in November 1882! This explanation I owe to those who so readily accorded me their generous support when I first proposed to undertake the translation.

In then undertaking it I wrote as follows:—

"A work embodying in a compact form the first principles of Forest Organisation and Working treated in a simple manner and taking into account the peculiar administrative, economic and physical conditions obtaining in India, is what is chiefly and urgently required. Data for such a work in an immediately available form do not exist, nor can they be collected and marshalled together for a considerable number of years yet. In the meanwhile, English Translations and Abridgments of French, German and Italian books on the subject cannot fail to be extremely useful."

"Guided by these considerations I have ventured, with the full approval of the author, to attempt a translation of M. Ch. Broilliard's recently published work entitled "*Cours d'Aménagement.*" This work is designed to supply a textbook for the students attending the course of Lectures on Forest Organisation and Working at the Forest School at Nancy in France. It is not meant to take the place of the lectures, but only to furnish a convenient skeleton or summary, which the Lectures fill up, expand and illustrate. The summary is, however, so perspicuously written and so well connected together in all its parts, that it is perfectly intelligible by itself and gives a clear and sufficiently complete idea of Forest Organisation as it is understood and practised in France.'.

I had intended to append to the translation a short account of the state and progress of Forest Organisation in India and an essay on the application of general principles to the peculiar circumstances of this country. My present post of Instructor of Forestry at the Imperial Forest School, Dehra Dun, will necessitate my shortly bringing out a special treatise on those subjects, and hence anything I could add thereon to this book would be purely a work of supererogation.

I also then proposed, in the event of sufficient leisure, to write a summary description of the principal methods of Forest Organisation at present in vogue in Germany; but the appearance, during the interval that has elapsed, of Mr. Laird-MacGregor's work has rendered that superfluous.

During this interval we have also had in the Indian Forester, from the pen of Mr. Fisher, a translation of M. Puton's *brochure* on Forest Organisation, which is conceived in a different spirit from M. Broilliard's work and, therefore, possesses a utility distinct from that of the latter book.

With regard to the technical terms employed in this translation, such as are connected with sylviculture and which are mostly the same as those used in Mr. Smythies' and my translation of M. Bagneris' Manual, have received almost unqualified approval in England. The term "Organisation" itself has already been adopted by Mr. Laird-MacGregor and in official reports. But, without attempting to justify every term, I shall feel that I have fully attained my object, if I have succeeded in making M. Broilliard's work at once intelligible to English readers.

DEHRA DUN,
15th March 1886.

E. E. FERNANDEZ.

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BOOK III.

The Working Scheme in the Organization of High Forests.

PREFACE.

THIS work is only the second edition of the COURSE OF AMENAGEMENT, published in 1860, by M. NANQUETTE. It is the continuation of the Course of Lectures founded at the Forest School thirty years ago, and delivered ever since with the modifications which time and experience have made necessary in so young an art as the Organisation of Forests. The main principles are what they were in 1860; only owing to facts established since then, certain points have acquired more prominence, while others have had to be abandoned altogether. Besides this, the study of a variety of forests situated all over France, which, thanks to the kind initiative of M. Faré, at that time Director General of Forests, the Professors of the Forest School have been able to pursue year after year since 1869, has enabled them to define in a precise manner the more important ideas and to develope the Course by the addition of new ideas and illustrations.

The publication of this work is intended to enable our students to follow more easily the Course of Lectures on Forest Organisation by putting into their hands a succinct *exposé* of abstract principles and theoretical studies of a kind quite new to them. It is preceded by an Introduction meant to impart a fair idea of the constitution and distribution of the forests of France, and of the task our forest officers are called upon to fulfil.

The First Book presents, in a summary manner before the student, the essential facts connected with the various *Régimes*, and explains the fundamental ideas on which the exploitation of forests is based, and which are the laws themselves according to which forests are to be worked. It was not an easy task to treat of the question of choice of *Régime* after the masterly comparison of the various Régimes made by Messrs. Lorentz and Parade in their "Course of Forest Culture." But this subject necessarily stands at the very threshold of our course, and there was thus no alternative but to recall the principal points. This we have done in a simple manner, in a form different to that adopted in the book in question, to which [illegible] profit to themselves.

The study of the principles of Exploitability, altogether peculiar to forests, and so important and difficult besides, has seemed to us to require some further development suggested to us by the condition of our forests, which is growing every day more and more precarious in the times in which we live. To speak truly, there are only two different classes of circumstances under which forests are exploited; either they are utilised when mature like all other fruits of the earth in general, or they are cut prematurely as a speculation in view of securing a high rate of interest on capital expended. In order to render this idea clear, we have adopted the term Economic Exploitability to express the state of a forest worked under the first class of circumstances, because they are in strict conformity with the general economy of the State or the public good. This Exploitability, as we shall see, comprises, according to the results sought, or to the circumstances under which it is applied, (1) the "*Exploitabilité absolue*" of the "Course of Forest Culture," (2) the Exploitability relative to the most useful produce, which may be more simply termed Qualitative Exploitability, because it furnishes the most useful ligneous products employed in the arts and manufactures, and (3) National Exploitability, suitable for adoption in blocks of regular high forest. In the same manner we have adopted the term "*Commercial Exploitability*," to denote, as opposed to Economic Exploitability, the circumstances under which a forest is worked with a view to obtaining the highest possible rate of interest on capital invested. In this respect, what is far more important than mere words, are principles. In France these latter have always remained the same, and it is interesting to note here that at the French Forest School the fundamental principles on which the working of forests rests, *viz.* NATURAL REGENERATION and the MOST USEFUL PRODUCTION have never been questioned.

The Second Book, which treats of the operations common to all Forest Organisation, explains in the first place how to set about in order to study a given forest, by dividing it into compartments and then describing each of these compartments and drawing up the statistics of the forest. It gives in the second place the rules to observe in forming Working Circles, which are perfectly independent portions of one and the same forest. Next it describes the special procedure to follow in order to determine, in the various cases that may occur, the rotation or age at which the standing crops should be cut. Lastly, this Book ends with an *exposé* of the circumstances which regulate the order to be observed in the exploitations.

These general facts and studies, indispensable in the case of every forest without exception, whether they are detailed or take a broad general view of the forest, whether they head the report or are implied and understood, lead one, so to say, on to the very threshold of the Organisation Project. Accurately observed and carefully thought out, they guarantee the proper carrying out of the prescriptions which are to regulate the treatment and the exploitation of the forest. Incorrectly noted or carelessly worked out, they make room for all kinds of errors, even of the most grave character, a circumstance which cannot but render defective some portion of the Organisation Project, or be an obstacle to its proper execution.

As regards our Course, this Book is perhaps the most important part of it. Once the student has gone, methodically and with a thorough understanding of the facts, through the practical work which it describes, his mind will be able to take in at once the whole subject of Forest Organisation, the various combinations, rules and principles that enter into it becoming perfectly clear to him. We will even go further and say that we do not fear to assert that it is almost impossible to acquire a full and complete knowledge of any forest without possessing both a theoretical and practical knowledge of the operations described in this the Second Book. And this is the reason why we have therein entered into an exhaustive and detailed account of those operations.

The Third Book treats of the general features of the Working Plan for high forests. With reference to the subject of a sustained yield in the State Forests, we have established the fact that it is often expedient to subordinate it to the treatment applied and to the requirements of the future, because every year it becomes more and more clear that it ought to make way for the savings that must be effected in order to enable these forests to yield the most useful products, *viz.* large timber, the scarcity of which is already felt in France. Moreover, the method of Forest Organisation by Area is described here in the same spirit in which it has always been taught at the Forest School; but, thanks to a more intimate knowledge of facts since acquired, we have been able to separate it from purely theoretical considerations and to place it before the student in an entirely practical light.

The study of the organisation of regular high forests, which is more complete in itself and, all points considered, more natural than of that of copses, is the best beginning to make in the theoretical and practical study of Forest Organisation. One can scarcely understand sufficiently the rearing of copses without having an intimate acquaintance with that of high forests ; and similarly one cannot appreciate thoroughly the complex facts and the difficulties to be met with in organising copses without a knowledge of the organisation of high forests. Far then from seeking in the organisation of copses the key to the organisation of high forests, we consider that we must begin by studying this latter, even although we may not actually have to put it into practice, in order to master in a sure manner the general rules which govern all forest organisation.

In the Fourth Book, devoted to the organisation of irregular high forests, we have treated in a general manner the Selection System and developed the theory of the organisation of forests treated in accordance with that system. The necessity of this course seemed to us to be proved by the more active working of our mountain forests, following inevitably upon the opening up of lines of transport and the rise in the prices of standing timber. Moreover, the study of this subject throws no inconsiderable light on the organisation of forests under transformation from the Selection System to the Natural Method with Thinnings, and may serve to modify it, as far as regards the selection fellings that are temporarily continued in such forests, after the work of transformation has been commenced.

With respect to irregular high forests of broadleaved species, we have almost limited ourselves to giving an example of the various operations they require. The practical application of the theory acquires, in their case, so much more importance than the pure theory itself, that outdoor work which forms an indispensable part of our Course, is alone capable of enlightening the youthful minds of our students as to the difficulties offered by the organisation of this class of high forests and the means of resolving them.

The Fifth Book has for subject the organisation of copses, both simple and compound. The Coppice Regime is applied more widely than any other in France. However inferior the produce it yields may often be, it deserves on that account to be profoundly studied. But the organisation of copses cannot be properly effected, whatever the general opinion to the contrary may be, without a knowledge of the cultural facts connected with the constitution and growth of copses, and without a clear appreciation of the results to be sought in the annual selection of the standards. We have hence been led, not to study, as a preliminary step, the rearing of copses with all the developments it is capable of, but to lay down its main points in so far as they are connected in an indissoluble manner with the organisation of such forests.

As regards simple copses, we have sought to demonstrate the advantages, hitherto too much misunderstood, of adopting a long rotation. The desirable harmony between a good division of a forest into coupes and the natural configuration of the ground, the establishment of surrounding belts of denser forest which protect at the same time that they adorn, the necessity of an effective fence, all these are so many facts often lost sight of nowadays, It was expedient to recall attention to them.

With respect to Coppice with Standards we have, by means of the definition itself, clearly indicated the object to be sought in this method of treatment. We have then described the means of attaining this end, 1stly with the aid of a good selection of Standards, and, 2ndly, by the organisation itself of the forest. The number of Standards, more precious than the underwood and valuable in direct proportion to their size, ought only to be limited by their own requirements as they spread themselves out and not by any theory or fixed idea as to allotting a certain amount of space to the underwood. The price of large timber brings into clear prominence the truth of this doctrine, which is the true basis on which the treatment of copses with standards rests, and is besides in perfect conformity with the prescriptions of the Royal Edict of 1827, as it was with those of the Edict of 1669.

We have given a specimen Working Plan of a Working Circle of copse and an example of a really practical Selection Plan for Standards, which explain how the general theory of the organisation of copses, both simple and compound, is applied in practice. With respect to the control of the exploitations, a specimen form, in which a record of the exploitations ought to be kept, will be found in its proper place. It may be used for coppice as well as high forest exploitations.

With regard to the auxiliary operations to be carried out in copses, such as thinnings and the pruning off of epicormic branches, we have, entered into some details, which cannot well be omitted from our Course, for the organisation of copses with standards, so simple as it appears at the first glance, is of itself necessarily incomplete, at least in so far as the standards are concerned. The result is that the rules to be observed in the execution of certain auxiliary operations, as, for example, in the selection of standards, form a necessary complement to the Organisation Project for a copse.

The reserved fourth of communal forests represent taken together a considerable area, and are for the most part treated as copse. We have brought together the statutory prescriptions concerning them, showing how they do not require any Organisation Project. And we have indicated the principal points to attend to in treating these portions of larger forests so valuable not only in themselves, but also on account of the indirect service they render in guaranteeing, under most contrary circumstances, the conservation and preservation of the whole forest.

In the Sixth and last Book, treating of the methods of converting copse into high forest, we have endeavoured to give a clear idea of a good Organisation Project by laying down the principles and the general rules that guide such operations. We have laid particular stress on those conditions of production which render conversions necessary and on the cultural operations which can alone bring them to a successful issue. We believe that in so doing we have placed before the student the question in its entirety. In order to resolve it by drawing up an Organisation Project for a given forest and by carrying out that Project during the whole period of time which such an undertaking requires, one must be thoroughly conversant with the practical working of forests and the methods of observation required by cultural phenomena, and practised in the manipulation of Organisation Projects for the working of high forests as well as of copses. We cannot therefore profess to teach in a book how to draw up Organisation Projects for the conversion of copses into high forests, much less indeed than any other kind of Organisation Project.

After mere theoretical studies it would be foolish to think of drawing up an Organisation Project, or even to execute any cultural operation whatsoever. To do so would be as rash as to undertake the construction of a large building the moment one has finished attending a course of lectures on Arthitecture. The Course taught at the Forest School must hence only be considered as an Introduction to the study of Forest Organisation. The outdoor work done by the students during the summer is quite as necessary as the theoretical studies. It is only while engaged in that work that the mind opens itself out to a true knowledge of the forest under examination, and is able to grasp the complex relations with one another of the different parts of an Organisation Project, as interdependent and inseparable one from the other as Sylviculture and Forest Organisation are themselves.

But one or two practical studies in drawing up Organisation Projects does not suffice to complete the education of the Aménagiste.† To be master of the theory as well as of the practice, one must, to speak truly, have studied under various conditions both organised and unorganised forests, have devoted to the work the important element time, without which the mind is incapable of assimilating the knowledge it acquires of facts—in a word, have been in a position to observe, compare, and judge for oneself.

Within the compass of a few lines serving as a conclusion to this work, we have endeavoured to point out that every Organisation Project is a work by itself, special to the forest it concerns and of necessity different from every other Organisation Project. It is this very circumstance that is a criterion of its merit and that makes it so interesting, but it is also one which constitutes its difficulty. And a correct appreciation of the difficulties presented by the practical exercise of an art is a quality that belongs only to those minds that have already mastered its secrets.

In an Appendix we have added two short notes, one on mountain forests given over to grazing, the other on pine forests exposed to fires. These notes are intended to furnish a few useful facts and hints, and will in any case serve to show the reader how, so to say, unlimited a field for study and practice the organisation of forests presents in France, owing to the diversity of conditions found in them. This very diversity makes us afraid to give examples of Organisation Projects, which must either be imperfect or applicable only to a few forests possessing the same characteristics. We have therefore limited ourselves, on the score of examples, to giving a specimen form for keeping a record of the compartments of a forest in, and an analysis of a compound coppice cutting.

† A convenient term to denote the person commissioned to draw up on Organisation Project.

This volume which M. Nanquette, whose humble disciple I am, has asked me to publish in my own name, is his handiwork more than mine. As for myself I have only re-written the Course, which I learnt at his feet. He has even been kind enough to revise my manuscript and retouch with his own hand the more important portions. It will hence not be affirming enough if I say that it is our joint work. If the form is chiefly my own, the matter is principally his.

CH. BROILLIARD.

Nancy, 1*st May* 1878.

COURSE OF FOREST ORGANISATION.

INTRODUCTION.

It is the conservation and development of the forest wealth of France that forms the object of the teaching at the Forest School. Hence before commencing the study of the course of Forest Organisation properly so called, it is useful to cast a *coup d'œil* over the distribution of the forests of France and the wants that are to be satisfied by the produce furnished by them.

Alsace and the portion of Lorraine wrested from us contain 1,250,000 acres of our best forests. What still remains, nevertheless, comprises nearly 22,500,000 acres, as follows :—

	Acres.
State Forests	2,417,895.
Forests belonging to commerce and public foundation.	4,650,733.
Private Forests...	15,432,472.

In other words our forests together occupy more than a sixth of the area of France. We do not here include the ground covered by solitary trees scattered here and there on land under agriculture or pasturage, no more than the trees growing in hedges, along roads and canals, and in avenues and parks.

Nevertheless, the actual production of timber in France already falls far short of present requirements, and the state of matters is growing worse every year. We have to import even now more large timber from abroad than we produce at home, and we pay the foreigner on this account alone a tribute of £ 6,000,000. This sum represents the value in our ports of wroughtwood, *i. e.* beams, scantlings, boards, staves, &c., obtainable from 70,634,000 cubic feet of dealwood in the baulk and 17,658,500 of oak.

These enormous quantities of imported wood show clearly that our area does not suffice for the production of timber. It is true that besides area there are other considerations which combine to produce the same result one way or the other, the chief among these being time and the actual state of the growing timber. But these essential elements cannot be made to work on our side in forests periodically brought under the axe, except with the aid of good Organisation Projects.

Out of the 22,500,000 acres under wood in France just a little over 7,000,000 are under State management, and, therefore, in a position to be treated with a view to the production of large timber. The remainder is in the hands of private individuals, and cannot be relied upon to furnish for the national consumption any constant considerable supply of timber. It therefore behoves us for the prosperity of the country to obtain as large a quantity as possible of large timber from the State and Communal Forests. To estimate the extent of this task we must ascertain in what condition these forests are, and in what proportion they are treated

(i.) as High Forest, the principal object of which is the production of timber,

(ii.) as Simple Coppice, which aims chiefly at producing firewood, and

(iii.) as Compound Coppice, which combines the two preceding methods of treatment.

This proportional distribution is indicated approximately in the following tabular statement:—

		Acres.	Acres.
High Forest	Belonging to the State............	1,000,000	2,500,000
	Do. do. Communes and to public foundations	1,500,000	
Compound Coppice	Belonging to the State, (two-thirds at present under Conversion into High Forest)...................about	1,250,000	3,750,000
	Belonging to Communes and to Public Foundations......	2,500,000	
Simple Coppice	Belonging to Communes and to Public Foundations		750,000
		Total......	7,000,000

Private forests are fairly uniformly distributed throughout the country. Each Department possesses an aggregate extent of such forest varying from 100,000 to 300,000 acres. Still there are a few notable exceptions, such as the Gascon Landes which are covered by an immense forest of the Pinus Pinaster, and the Var, the Dordogne and the Nièvre each of which contains extensive tracts under simple coppice and scrub.

As regards the forests under the control of the Forest Department, they are very unequally distributed. We have attempted to give some idea of their distribution in the following Table, in which we have divided France into nine forest regions of nearly equal extent

TABLE SHOWING THE DISTRIBUTION OF FORESTS IN FRANCE.

REGION.	DEPARTMENT.	State Forests in 1876	Forests belonging to Communes and Public Foundation in 1876.	Total area under the control of the Forest Department	Proportion of such Forests to total area of country.	Private Forests and others, not under the control of the Forest Department in 1876.
		Acres.	Acres.	Acres.	...	Acres.
PARISIAN (Northern Coast and Neighbourhood of Paris.) 15,073,710 acres.	Nord	47,462	4,443	...	...	54,876
	Pas-de-Calais	18,472	1,638	...	...	63,757
	Somme	10,423	1,371	...	...	88,287
	Seine-Inférieure	83,948	1,448	...	...	154,414
	Eure	29,485	346	...	...	250,793
	Calvados	8,436	...	...	...	86,036
	Aisne	65,487	9,988	...	...	169,626
	Oise	78,418	3,733	...	...	16,960
	Seine	850	29	...	...	1,972
	Seine-et-Oise	72,828	1,129	...	...	17,886
	Seine-et-Marne	57,661	2,310	...	...	192,733
		473,470	26,438	499,908	$3\frac{1}{3}$	1,410,966
BRETON (Armorican Plateau) 16,062,150 acres.	Manche	825	49	...	...	50,474
	Ille-et-Vilaine	18,135	136	...	...	106,806
	Côtes-du-Nord	...	...	...	...	89,980
	Finistère	8,463	...	...	...	78,904
	Morbihan	4,147	...	...	...	109,852
	Loire-Inférieure	11,078	...	...	...	100,359
	Mayenne	353	...	...	...	69,544
	Maine-et-Loire	4,465	...	...	...	128,779
	Vendée	5,619	...	...	...	61,345
	Deux Sèvres	14,436	282	...	...	91,502
		67,521	467	67,988	$\frac{3}{5}$	887,545
LIGERIAN (Plains of the Loire) 16,309,260 acres.	Orne	57,015	...	...	...	148,569
	Eure-et-Loir	16,191	232	...	...	130,585
	Sarthe	25,964	838	...	...	190,508
	Indre-et-Loire	21,736	...	...	...	217,913
	Loir-et-Cher	29,935	4,722	...	...	253,805
	Vienne	15,355	749	...	...	192,053
	Indre	27,380	5,204	...	...	187,659
	Cher	30,567	14,624	...	...	252,223
	Loiret	94,752	37	...	...	200,868
	Allier	60,268	3,464	...	...	160,320
		379,168	29,870	409,038	$2\frac{1}{2}$	1,934,503

REGION.	DEPARTMENT.	State Forests in 1876.	Forests belonging to Communes and Public Foundations in 1876.	Total area under the control of the Forest Department	Proportion of such Forests to total area of country.	Private Forests and others, not under the control of the Forest Department in 1876.
		Acres.	Acres.	Acres.		Acres.
LORRAINE (North-east) 10,378,620 acres.	Ardennes	58,748	88,424	...	...	178,714
	Marne	32,893	33,147	...	...	264,781
	Aube	36,291	59,679	...	...	178,727
	Haute-Marne ...	40,131	217,805	...	...	211,909
	Meuse	75,623	241,060	...	...	122,089
	Meurthe-et-Moselle	78,677	171,566	...	...	81,413
	Vosges	139,814	281,402	...	..	87,198
		462,178	1,092,483	1,554,661	15	1,124,782
BURGUNDY (Burgundy Country) 13,343,940 acres.	Haut-Rhin	...	32,005	...	...	18,635
	Haute-Saone ...	16,885	281,411	...	...	106,586
	Doubs	11,799	240,305	...	...	81,803
	Jura	61,011	206,772	...	...	124,158
	Côte-d'Or	98,997	244,906	...	...	279,546
	Yonne	33,609	81,302	...	...	299,344
	Saône-et-Loire...	33,672	68,447	...	...	280,727
	Ain	7,660	114,481	...	...	182,785
	Nièvre	36,262	58,060	...	...	412,177
		29,989	1,327,689	1,357,678	12	1,785,761
ALPINE (The Alps & Provence) 13,838,160 acres.	Haute-Savoie ...	...	109,437	...	...	155,501
	Savoie	1,416	190,494	...	...	121,274
	Isère	26,764	136,605	...	...	287,253
	Drôme	20,772	75,475	...	...	334,973
	Hautes-Alpes ...	4,665	199,195	...	...	65,400
	Basses-Alpes ...	1,426	121,752	...	...	193,252
	Vaucluse	7,819	70,214	...	...	118,741
	Bouches-du Rhone...	...	48,475	...	...	130,435
	Var	23,698	104,960	...	...	510,559
	Alpes-Maritimes	1,287	97,915	...	...	133,123
		87,847	115,452	203,299	9	2,050,511
AUVERGNE (Mountains of Central France) 15,320,820 acres.	Rhone	...	64	...	...	84,057
	Loire	...	5,896	...	...	165,242
	Haute-Loire ...	1,680	19,703	...	...	191,700
	Puy-de-Dôme ...	2,039	28,344	...	...	200,886
	Creuse	1,327	2,677	...	...	89,659
	Haute-Vienne...	...	820	...	...	162,111
	Corrèze	...	6,758	...	...	104,666
	Cantal	3,457	28,687	...	...	146,672
	Aveyron	8,533	16,766	...	...	183,351

REGION.	DEPARTMENT.	State Forests in 1876.	Forests belonging to Communes and Public Foundations in 1876.	Total area under the control of the Forest Department	Proportion of such Forests to total area of country.	Private Forests and others, not under the control of the Forest Department in 1876.
		Acres.	Acres.	Acres.		Acres.
	Lozère............	1,314	26,213	...	...	127,351
	Ardèche	8,656	24,283	...	...	215,055
		25,494	160,211	185,705	$1\frac{1}{5}$	1,670,750
LANGUEDOC (Between the two Seas) 14,826,600 acres.	Gard	3,496	106,274	...	...	208,338
	Hérault	...	27,350	...	...	185,081
	Tarn	16,702	23,089	...	...	170,555
	Tarn-et-Garonne ...	3,308	316	...	...	113,306
	Gers...............	412	3,672	...	...	127,283
	Lot	...	...	...	...	229,540
	Lot-et-Garonne.	...	3,506	...	...	179,238
	Dordogne.	...	...	...	...	465,688
	Charente	12,592	193	...	...	199,289
	Charente Inférieure.	4,895	1,208	...	...	177,303
		41,405	165,608	207,013	$1\frac{2}{5}$	2,055,631
PYRENEAN (The Pyrenees, the Landes and Corsica) 15,320,820 acres.	Pyrénées-Orient......	44,277	52,192	...	...	83,649
	Aude	25,220	28,514	...	...	109,388
	Arige	189,271	49,123	...	...	157,775
	Haute-Garonne.	36,103	53,052	...	...	149,405
	Haute-Pyrénées.	12,165	117,518	...	...	85,095
	Basses Pyrénées.	736	136,106	...	...	249,012
	Landes	66,327	20,169	...	...	988,907
	Gironde	68,269	2,429	...	...	739,548
	Corse	110,923	180,699	...	...	225,276
		55,329	639,802	695,131	$7\frac{3}{4}$	2,788,055
	Grand Total...	1,622,396	3,558,023	5,180,419	...	15,708,504

The northern coast country and that round Paris comprises the richest and best cultivated provinces that feed Paris. The agricultural produce of this region, which is remarkable for the industrial character of its cultivation, represents, area for area, double the average value of all the regions taken together. This average is £4,360,000. The forests here are relegated to the least fertile soils, and those under state control occupy only 505,000 acres or about 3 per cent. of the total area of the region. They yield the very best descriptions of wood and timber, especially in the level country of the Department of the North. The Lower Seine is distinguished for its fine beech forests.

The country round Paris, comprising the five last departments of the region, is one of the best wooded districts of France. The sandy composition of the soil has preserved from agriculture 1,000,000 acres of both state and private forests distributed in large blocks. These comprise one-sixth of the area of the entire region, being the average proportion for the whole of France. But here the State still owns more than one-fourth of the aggregate wooded area, including extremely rich forests, such as that of Villers Cotterets, and others of great beauty like those of Compiègne and Fontainebleau.

The Armorican Plateau, abounding in furze, possesses scarcely any true forests, or, at least, is the poorest wooded region of all. In the midst of the moors and heather rise up a few groves or small woods belonging to private owners. The few exceptions of woods still remaining state property, lie scattered about here and there, and only serve as evidence that at one time Brittany did possess forests. Fortunately the hedgerow trees planted between estates, the sea which brings cheap wood from the northern countries of Europe to the very doors of the population, and the cool ocean breezes that are constantly blowing attenuate to a great extent the effects, economical and climatic, of forest denudation. The three departments of la Manche, of the Mayenne, and of the Côtes-du-Nord have really no forests or woods under state control, and throughout the whole district such a thing as a communal forest is unknown.

The plain of the Loire, the region of high forests of oak, forms in the centre of France a generally fertile district, yet, nevertheless, intersected by large barren areas. On one of these stretches the forest of Orleans, our most extensive plain forest, containing 85,000 acres all belonging to the State, worked as copsewood and impoverished long ago. On the other side of the Loire, to the south, lies the Sologne, a poor district, which was covered with fine forests three hundred years ago, but has since been denuded and become private property, the owners practising largely both Agriculture and Sylviculture. Here we could find 500,000 acres fit for high forests capable of producing all the oak timber that we now obtain from abroad. The district of la Brenne, more feverish still than the Sologne, could also contribute towards the same end on a magnificent scale. Indeed it is in the mild climate of Central France that we find our finest high forests of oak; as instances we need mention only the forests of Bellême, of Bersay, and of Tronçais, too little known, although so deserving to be known. But these forest masses preserved here and there are as rare as they are valuable. In the entire region the forests under State control do not comprise more than 412,500 acres, or 2½ per cent. of the total area.

The North-East region, with the seven Departments which now remain after the cession of Alsace and part of Lorraine, is still the richest of our forest districts. One-fourth of its area is occupied by forests, and these good forests—copses with standards in the plains and high forests of silver fir in the hills. In other words, the wooded area aggregates 2,750,000 acres, of which 1,125,000 acres belong to private individuals, the same acreage to Communes, and 500,000 acres to the State. These forests, so beneficial from a climatic point of view in an entirely continental region, produce on the hills and mountains very valuable and esteemed timber. In the spaces intervening between them, agriculture is prosperous and obtains from the soil produce, the value of which, £4,480,000 per Department, exceeds the average in France and is daily increasing. It is a fact to be noted that the forests improve as you go from the plains of Champagne to the highest ridge of the Vosges, at the same time that the proportion of them belonging to the State goes on increasing. To see this, we may, for example, compare the hill near Rheims with the valley of Gérardmer. The first, a large circular round topped hill, situated between Rheims and Epernay, wears a girdle of all the finest vines of Champagne; the top is crowned with a forest of about 68,000 acres (7,130 acres state, 5,130 communal, and 55,150 private), which produces oak of excellent quality, just what is wanted by the vinegrower. But the greater portion of this forest is in the hands of private owners, and yields at this day only small wood. On the contrary the steep slopes which surround the lakes of the Gérardmer Valley, are clothed with 15,000 acres of rich silver fir forests belonging to the State ; and these bare rocks, that would have been utterly barren if denuded, produce every year from 883,000 to 1,060,000 cubic feet of timber.(1)

Burgundy and the neighbouring provinces of Franche-Comté and Nivernais, form together a rugged region, the principal and central portion of which is the valley of the Seine. In the lowlying parts of this valley, the chief cultivated crop, as in the level country of the Garonne, is Indian Corn. The valley also produces fine oak. In the east of this region, the range of the Jura bears silver fir forests, which are the most celebrated we possess, if not for their extent, at least for the size and excellence of their timber. In the west the table land of the Côte-d'Or and the Morvan range of mountains are covered with copses throughout more than half their area. The region is thus well wooded, as it ought to be near the source of large rivers. But the 3,500,000 acres of its forests, representing one-fourth of its entire area, are distributed between the State, Communes and private owners, the respective shares being the largest for the last class of proprietors, and the least for the State, the exact reverse of what the topography and general interests require. Thus, although the productive capabilities of the soil are admirable, yet it is the exception to find these forests in a satisfactory state.

The Alps and Provence, enriched by arborescent cultivation and impoverished by migratory flocks of goats, comprise the six departments lying to the east of the Rhone. It contains the highest mountains to be found in France, grouped together to form a huge range. Originally, in the course of nature, forest growth clothed the mountain sides up to the limit of woody vegetation, viz., from about 6,600 to 8,200 feet. Owing to absence of lines of export, the forests possessed no market value. They were destroyed. Scattered trees more than five centuries old, dead stools, almost indestructible in the climate of the Alps, these are standing witnesses of the fact in many a denuded canton. The destruction of the forests

(1) Alsace-Lorraine, one-third of whose extent is wooded, contains 375,000 acres of State and 500,000 acres of communal forests, being 23 per cent. of the total area. It has besides 250,000 acres of private woods. These forests occupy all the mountain country and are well distributed in the level portions of the double province. They supplied the wants of a population numbering 260 souls per square mile, and exported besides excellent timber to Paris. This portion of France was thus at one and the same time one of the best wooded and most thickly peopled.

and the injury resulting from unrestricted grazing have given an ever widening field to landslips and avalanches, to torrents and inundations. At the present day scarcely one-eleventh of the original area, about 1,255,000 acres, of which a large proportion consists of bare rock, remains under the conservation of the State. It is nearly all communal woods given up to grazing. These woods present themselves in broken, seedy looking patches or strips, the remains of former primeval forest. In spite of this ruined state they are still a priceless possession. They afford the inhabitants both fuel and shelter, and considered as materials to use in restoring the forest, they offer the most sure means of preserving and rehabilitating those districts. For there indeed the forests, the soil and the inhabitants must prosper or perish together. The population of the Higher and Lower Alps has doubled itself within the last century, and yet is only in the proportion of 50 souls to a square mile. The restriction of grazing in the Alps, a measure of the highest necessity, would entail on the inhabitants but very small sacrifices, for the greater portion of the land there commands a rent of only abont 8 pence an acre. The private forests borne in the district cadastral lists as containing some hundreds of thousands of acres scarcely deserve the name of forest, and are generally worth extremely little. To such a point does this go that these so-called forests have occasionally been given up by the owners, more anxious to avoid the reality of paying a tax than to maintain and keep up the delusive idea of an imaginary income.

The mountains of Central France are still more denuded of wood than the Alps ; but happily the soil there is not liable to erosion, and the climate is moist. The remains of all the old forests and some recent reboisements, concentrated for the most part in the Puy-de-Dôme, do not occupy even the eighth part of the area of the entire region. The forests under state management aggregate only 187,500 acres. In the last century Auvergne still sent its silver fir to Paris ; at the present day not a vestige of this tree remains in the province. And yet there are in this region hundreds of thousands of acres of which no use whatsoever is made, and extensive tablelands from which the most laborious people in France can only eke out a miserable existence. The cultivation of the sweet chestnut, (a culture that yields but small profits, and a fruit that affords but little sustenance,) is one of the universal characteristics of the region ; but it requires sheltered localities. The plateaux and mountains of this region present, instead of forests, more than 2,500,000 acres of moors, pastures and ling bushes, and the value of the annual agricultural produce is on an average only £2,880,000 per department.

The ten departments included between the two seas in one direction and the Central Plateau and the Pyrenees in the other, forms a zone which is not without some analogy with the region just described. It is equally poor in forests. These, moreover, are confined to a few isolated points, and abound in the sweet chestnut, which delights in the silicious soils surrounding the mountains of Central France. But below the zone of the sweet chestnut, the climate is milder and suited to the cultivation of the vine. It is this shrub which above every other thing makes the fortune of the region, for this regiou produces nearly half the wine grown in France and unites in itself all the great centres for the manufacture of brandy. The two Departments of the Lot and of the Dordogne do not possess a single forest under the management of the State. The remainder are still worse off, and the area they possess under wood is extremely large compared to the value of the contained stock. They consume for casks for holding their wines and spirits an enormous quantity of wood. This they import from the level country of the Loire, the valley of the Saône, from the United States, from Italy, and, above all, from Austria. They produce no portion of it themselves. The wood, excluding fuel, yielded by the 2,000,000 acres of forests now remaining, and belonging to private owners, consists chiefly of vine props and hoops for casks.

The Pyrenees, the Landes of Gascony, and Corsica present the ordinary aspects common to wild pastoral and forest regions. In spite of this, they do not possess any extensive area under the control of the Forest Department ; all that remains to them of such forests does not aggregate even 1,250,000 acres or one-half the percentage obtaining in the North-East region. As regards the private forests, the acreage of which is more than double that of the state forests they may be almost left out of account. As a rule they are not meant to furnish wood, but pasturage and resin.

The six Pyrenean Departments were at one time well wooded. The Valley of the Adour would have sufficed alone to supply the wants of the State Navy both in respect of oak and pine and fir wood. But since the days of Henry IV. the forests of the

Pyrenees have gone on steadily falling off in extent as well as in condition. Each century diminishes what it receives by half. Moreover, during the last century the big trees were felled or destroyed in masses. Prescriptive rights of a most disastrous nature and unlicensed grazing have completed the work of destruction, and at the present day one third of the area of the state forests consists of blanks. The forests belonging to Municipalities are universally relegated to hill tops presenting the greatest difficulty of access to cattle. Whereas in the Alps the grazing begins in the highest forests and works on downwards, in the Pyrenees, on the contrary, it begins by attacking those lowest down and works its path of ruin upwards. The condition of the communal forests just referred to is even sadder than that of the state forests. Nevertheless they still cover large areas, which due control exercised over the grazing would suffice to restore in a short time.

The Landes of Gascony contain at the present day 1,750,000 acres of pine forests belonging for the most part to private proprietors. The pines are tapped for resin without the moderation necessary for their proper development and longevity. But the State has an opportunity of setting the right example in the wooded dunes it still possesses, for it is possible to combine the production of resin with that of timber.

In Corsica private forests are represented chiefly by the *makis*. But 112,5C0 acres of valuable forest, now free from grazing and all prescriptive rights, still remain to the State. A little husbanding and thrift in the exploitations for half a century, while waiting until the standing stock has acquired some value, will be sufficient to transform in the most happy manner these forests, which, very soon perhaps, will be a last and supreme resource for the island. Under the effects of grazing, the forests made over in full proprietary right to Communes, in lieu of the prescriptive rights formerly enjoyed by them but now bought off, are, it is said, visibly disappearing.

The distribution of the state forests in France is quite different from that of the communal woods. The former are grouped together in large masses chiefly in the North-East, in Lorraine, in Burgundy and in Champagne. The better amongst them have descended to us from the domains of the ancient Dukes and Counts of those provinces. The neighbourhood of Paris, Normandy, and the banks of the Loire still contain some very fine forests belonging to the State.

These forests originally formed a part of the royal domains. In the south it is only in the county of the Foix (Department of the Ariége) that we now find a large forest area belonging to the State ; this was the patrimony of Henry IV. Unfortunately half of it consists at the present day of pure blanks. The state forests in Corsica, no less important than those just referred to, labour under unfavorable economic conditions. The dunes of Gascony have now been fixed by a young pine forest raised by the State, which still possesses the greater portion of it. In the last place, as a result of the confiscation of the property of religious houses effected under the decree of the National Assembly of 19th December 1789, the State owns a few forests in every Department, twelve excepted. But the mountains of Auvergne and the elevated peaks and ridges of the Alps are almost without state forests.

The forests belonging to Communes, which compose two-thirds of the whole area managed by the State Department, are found, so to say, in one huge compact mass east of the meridian of Paris. This line, passing through Dunkirk, Beauvais, Paris, Bourges and Carcassonne, cuts France into two halves, one of which contains all the communal forests, the other none at all. The communal forest is an institution totally unknown in the west of France. The constitution of communal property and even of the Commune itself probably grew out of different circumstances in the east and in the west.

There is, however, one grand exception to the rule that there are no communal forests west of the meridian of Paris, and that is in the Pyrenees and in the sub-Pyrenean region comprising the Black Mountain of Tarn and the Landes of Gascony. It is there that the Visigoths settled in the fifth century of our era. We there find to this day about 500,000 acres of wood owned by Communes. But north of the Gironde, Western France has, if we except the state forests, scarcely 37, 500 acres under the management of the Government Department. These woods, belonging as well to Public Foundations as to Communes, obviously owe their preservation to accidental circumstances. Scattered over so vast an extent of country, they offer a strong contrast to the communal forests of Eastern France, which, before the loss of Alsace-Lorraine, aggregated as much as nearly 5,000,000 acres. The Departments containing the largest extent of communal forests are those of the Meurthe and Moselle, and of the Meuse, of the Vosges and of the Haute-Marne, of the

Haute-Saône and of the Côte-d' Or, of the Doubs and of the Jura. Each of these possesses about 625,000 acres of such forests. The majority of the old Communes hold some acres. More or less extensive, more or less richly stocked, these latter, clearly demarcated and enclosed by a ditch or a wall, are protected and well conserved. They yield wood and timber for the inhabitants as well as form a valuable source of income for the municipal treasury.

This simple sketch of the general distribution of our forests shows that the poorest districts from a forest point of view are not, as one might expect, our fertile plains. They are the bare rocks of Brittany and the elevated plateaux of the centre of France. At a date far removed from the present, these districts lost nearly all the forest wealth with which nature had originally endowed them. The prosperous regions possess excellent forests, and the majority of them have even large extents of such forests. [1]

Besides the extreme variety which our forests offer in point of geographical and hypsometrical distribution, they present a most admirable variety in other respects also. To take species, aspect, régime, and density of standing material, there is not one of these elements of forest growth that does not vary from point to point. From the larch to the Aleppo pine, from the holm oak to the aspen,

(1) Algeria, out of a total area of 75,000,000 acres, has scarcely 5 millions under forest, and more than half of this is situated in the province of Constantine, which contains the greater proportion of the high forests of the colony. If we throw out of account 425,000 acres of forests of cork-oak made over in full proprietorship to private individuals, 187,500 acres given up to the tribes, and 2,500,000 acres devastated by grazing and kept down thus in the condition of scrub, we see that the area for the production of trees does not exceed 2,000,000 acres.

The most widely distributed species are the Aleppo pine, the holm and the cork oaks. Those most important as timber yielding trees are the *Chêne Zéen* (Quercus Lusitanica) and the cedar. The Aleppo pine is found chiefly on the interior plateaux of the Tell, and notably in the province of Algiers.

The holm oak grows, in company with other trees, at elevations not exceeding 3,300 feet. The habitat of the cork oak is well defined on the coast by the crystalline schists. It is said that 672,500 acres of forests of this tree still belong to the State. The Zëan oak is met with throughout the Tell district. It grows up to 4,900 feet above the sea. Forests of it are those of Beni Salah (Bone), of Beni Foural (Djidjelli), of Akfadour (Bougie), of Ouled-D'hia (Tunisian frontier). The area of the high forests of this species is estimated at 240,000 acres. The cedar grows over an area of about 75,000 acres in the mountains which separate the intermediate region from the high plateaux and the Sahara, at an elevation of about 5,000 feet. It forms the forests of the Aurès, the Belezma (province of Constantine) and of Téniet-el-Had (Great Atlas) west of the province of Algiers. This last forest is, it appears, a marvel to behold.

But the forests of Algeria are devastated every year by fire. In 12 years, from 1861 to 1875, this pest swept over 625,000 acres. The Arab seeks to destroy, in a country that is escaping from his grasp, what remains of the forests, although these are more necessary there from a hydrological point of view than as a source of fuel supply.

we possess a collection of indigenous arboreal species that are as precious for the qualities of the timber they produce as for their variety. Thanks to the soil and the climate, no less diverse than the species, we are able to obtain from the latter produce that is at the same time abundant, choice and varied. The more we study our forests, the more we marvel at their productive capabilities. They possess vast potential wealth. Ours the duty of assuring its preservation and development.

The task before us is not of the easiest. In the north-west are situated the principal high forests of broad-leaved species; in the North-east the large mass of copses with standards as well as the great forests of silver fir; then in the southern half of France forests of all species, the treatment of which is subordinated to the requirements of grazing. This last class of forests includes a considerable area consisting only of glades or scattered trees, and in many places they are of less value as regards the production of wood than on account of the influence they exercise on the climate, the soil, and the drainage and storage of water derived from the clouds.

If we leave out broad general characteristics, there are a number of districts which possess forests of an entirely special character. In the north of France and on the banks of the Adour, peduncled oaks, raised in the midst of, and above, copse underwood or in open high forests, are distinguished by their great size and the density of their wood. In the French Ardennes copses of pure oak cover the whole area occupied by primary geological formations or about 50,000 acres, and yield some agricultural crops under a special system of cultivation following immediately each coppice cutting.(1) In the Morvan, the oak and beech copses, instead of being exploited so as to clean-fell each clump of stool shoots, are worked on the system known as *furetage*, according to which the exploitations are made on a rotation of 10 years and remove only the thickest shoots of a clump.

In the west, in the neighbourhood of Alençon, side by side with the finest regular high forests of beech and oak, like those of Bellême, we find the most irregularly wooded masses, like that of Perseigne, and others extremely impoverished by the Coppice

(1) *Sartage*—An improved system of Dahya, Kumri or Jhooming. See Manual of Sylviculture.

Régime, like the forest of Ecouves. In the centre of France, where the oak greatly predominates over every other species, areas worked on the system of *tire et aire* with long rotations, bear splendid forests, while those portions worked as coppice wood are in a half ruined state. The forest of Tronçais itself presents both these aspects over large areas. The high forests of the Vosges, originally worked by Selection, grow on silicious soils in large masses containing an abundant close growth of species possessing dense cover. The beech there gets ahead of the silver fir by its exuberant growth. On the limestone crests of the Jura the silver fir forms forests cut up into long ribbon-like patches and becomes, on the higher, ridges the companion of fine, numerous, well-grown spruce. It yields timber of the very largest dimensions and of the finest quality. To find silver fir comparable with it for firm, close-grained tissne, we have to go as far as the Aude in the district of Sault.

In traversing the Alps from north to south, one soon leaves silver fir and spruce to enter into forests of coniferous species possessing light cover, viz., pines and the larch. Here the great diversity of species, climate and soil, beginning from the glaciers right down to the sea, yields the most varied and the most curious types of forest. From the frozen recesses, planted with Cembran pines at an elevation of 8,000 feet to the bare scorched and dusty rocks which bear Aleppo pines on the Mediterranean coast, the distance, from a climatic point of view, is as great as from Siberia to Syria, the whole breadth of Asia from north to south. The Pyrenees alone present a perfect forest panorama. Nearly all our forest species are indigenous there and are located in some portion of the range. The beech is the only species that traverses the whole length of the chain. But everything is browsed down, devoured even to a greater extent than in the Alps. Nothing can equal this destructive fury, unless it be the marvellous recuperative power of these forests when protected from cattle and the hand of man.

The economic circumstances in which our forests are placed are as varied as the elements of production. But what is most important of all, is the necessity of having sufficient material for continuous regular working. If this does not exist, the only way to obtain it is by hoarding up savings for generations. On the other hand, the wants of the country in respect of timber are increasing with rapid strides: they are no longer met except with the greatest difficulty, even after increased imports. We have to go for our deals to all the northern countries of Europe as well as to Switzerland, Germany and Austria, and this in daily increasing proportion, the quantity imported in 1869 being four times that imported in 1836, only a third of a century ago. The deal timber obtained from exploitations at home is probably equal to only half the quantity imported. We purchase oak on the Baltic and the German Ocean, in Central Europe and in North America. This oak is inferior to what we produce, and France, relatively to her extent, is still the best endowed oak country in the world. But large trees of this species have now become scarce with us. At one time we sold such trees to England, which now sells us teak. Insufficient existing resources and the necessity of saving up for the future, such is, in a word, the economical condition of a certain number of our forests.

Some idea may thus be gained as to the difficulties of all kinds to be encountered in the organisation of our forests. The art of regulating the treatment and working of a forest is as difficult as it is important. Leaving all to chance, ignorance, and routine can only produce deplorable results. Happily the task is rendered easy by the progress recently made in the theory as well as in practice.

The necessity of treating the forests of the broad-leaved species belonging to the State as high forest is now-a-days admitted on all sides, and the conversion of a great number of its copses with standards has already been decreed. What remains is to effect them properly. The reboisement of mountains, decided upon in theory in 1860, has also since begun to be put into practice. These two parts of our task, like the rest generally, require long years to accomplish ; but one step made in advance makes the next easy and one progress leads to another. Let each generation, let even each forester, perform faithfully his duty of leaving his forests in a better state than that in which he received it, and very soon in respect of forests as, it could happen in so many other respects, France will have nothing to envy the rest of the world.

BOOK FIRST

REGIME AND EXPLOITABILITY.

DEFINITIONS.

By the term FOREST ORGANISATION we will designate the art of regulating the treatment and working of forests. For each forest this art determines, in the first place, the REGIME, the METHOD OF TREATMENT and the EXPLOITABILITY to adopt in order to obtain from it produce in the closest conformity possible with the interests of the owner ; and, in the next place, it regulates the distribution and extent of the ANNUAL CUTTINGS so as to ensure a SUSTAINED YIELD.

The word REGIME we will employ to express in a general manner the system of culture applied to a forest ; it will be synonymous with METHOD OF CULTURE, OF WORKING or OF EXPLOITATION. It is in this sense that we may say, in speaking of a forest, that it is subjected to the REGIME OF HIGH FOREST or to that OF COPPICE.

The distinction between these two REGIMES is founded on the manner in which reproduction is obtained. If reproduction is effected by leaving the forest entirely to itself, or by the natural or artificial sowing of the ground, the forest is, according to our nomenclature, said to be under the REGIME OF HIGH FOREST. On the other hand, if restocking is the result chiefly of reproduction from the stools of trees cut, the REGIME OF COPPICE is said to prevail. In the former case the new stock is composed of seedlings, while in the latter it consists principally of shoots from the stool.

Forests under the first of the two Régimes are worked either by SELECTION or according to the NATURAL METHOD WITH THINNINGS Formerly a third method was also in vogue, viz., that known under the denomination of TIRE ET AIRE, in which the most unbroken regularity was observed in making the exploitations.

The silver fir and the spruce are in France the only species to which the Selection Method can at times be applied with advantage. But it is often impossible to adopt any other method in the treatment of the various coniferous species of our great mountain tracts.

Forests subjected to the Coppice Régime are worked as SIMPLE COPPICE or as COMPOUND COPPICE, COPPICE WITH STANDARDS, COPPICE UNDER HIGH FOREST, or HIGH FOREST OVER COPPICE, the four last denominations denoting one and the same METHOD OF TREATMENT.

We thus see that forests subjected to one and the same REGIME may be grown or worked according to various METHODS OF TREATMENT. In our terminology a tree, a forest, timber or wood will be said to be EXPLOITABLE or to have attained its EXPLOITABILITY, when it has acquired its maximum usefulness. The age of its exploitability may vary between very wide limits, according to the nature of the produce it can furnish at different stages of its growth, and the kind of utility which the owner desires to obtain from it.

The maximum utility which it is possible to obtain from a tree or forest may be regarded from different points of view. For the State and for imperishable proprietors in general, the maximum corresponds with the production of those descriptions of wood and timber which are most in demand and are the most capable of satisfying the multifarious wants of society. For a private individual, the maximum utility is attained when the forest is so constituted that it yields him the largest possible income compared with the capital value of the estate. In the first of these cases, it is the production of the most useful articles of consumption that determines the kind of Exploitability; in the second case, it is the money returns or the production of what is most of all comformable with the private interests of the owner, without regard at all to the quantity or the quality of the produce obtained.

These considerations, and others as well, which will be developed in the succeeding chapters, lead to the distinction of EXPLOITABILITY into two principal generic classes, viz., (i) the EXPLOITABILITY depending on the public good, according to which the end in view is to obtain from the forest all it can yield that is useful to the country at large, without considering at all the amount of the money returns or of the capital invested in the soil and standing crop ; and (ii) the EXPLOITABILITY which aims exclusively at securing the highest possible percentage of profits on the capital invested.

The first kind of EXPLOITABILITY we will term ECONOMIC. It may be either QUANTITATIVE or QUALITATIVE or NATIONAL, according to circumstances. We will call it QUANTITATIVE, when the object in view is simply to obtain the maximum quantity of produce in a given time ; QUALITATIVE OR RELATIVE TO THE MOST USEFUL PRODUCTION, when the forest is required to furnish the most useful descriptions of wood and timber in demand, independently of any other consideration ; NATIONAL when it is proposed to combine, within the measure of the possible, the maximum of usefulness with the most considerable production of material. The second generic kind of EXPLOITABILITY we will designate COMMERCIAL EXPLOITABILITY or EXPLOITABILITY RELATIVE TO THE LARGEST INCOME.

From what precedes it follows that the choice of the kind of Exploitability to be adopted in any given case depends entirely on the object sought by the owner in growing his forest.

By the term ROTATION we will denote the number of years fixed for the successive exploitation and regeneration of all the crops in a forest. The length of the rotation to be adopted in any case depends on the Exploitability and Régime chosen. In fixing it, account has also to be taken of the physical conditions of growth obtaining in the forest under consideration, viz., soil, climate, and species. And as in any forest these conditions are very different for its different component masses, it becomes expedient, in order to make the most of the forest as a whole, to consider each of these large masses separately, and, when that is possible, to treat it as an integral forest in itself.

Each such mass, when treated as an independent forest, we will designate a WORKING CIRCLE. A copse † in which one twenty-fifth

† The reader will observe that both the words "Copse" and "Coppice" occur in this translation ; but he will notice that they are not employed indifferently one for the other. The distinction maintained between them throughout this work is as follows:—

A copse (always a concrete noun)—a forest or collection of trees composed chiefly of shoots from the stool.

To copse—to fell any forest or collection of trees in such a manner that the new crop shall be composed chiefly of shoots from the stools of the stock felled.

Coppice (always an abstract noun)—the system or Régime in which reproduction is obtained chiefly from stool regrowth (Trans.)

of the area is worked annually, forms only a single Working Circle, if it is divided into twenty-five annual coupes; *but it may be split up into two separate groups of twenty-five annual coupes each, in which case it would comprise two Working Circles. Further on we shall explain how to operate in order to form Working Circles.

The quantity of produce that can be extracted year after year from any Working Circle or forest throughout a whole Rotation or part of a Rotation, represents the ANNUAL YIELD, or simply YIELD of that Working Circle or forest. It is usually expressed in cubical contents or by an area ; thus we say that such and such a Working Circle of high forest returns a yield of 16,000 cubic feet (of wood and timber understood) or that in such and such a Working Circle of copse the yield is 15 acres 3 roods, 17 poles, meaning that the stock on that area is exploited every year.

In high forests worked according to the Natural Method the Rotation is usually long and even very long. It generally ranges from 150 to 200 years for the oak, and from 120 to 130 years for the beech, Scots' pine and the silver and spruce firs. Now as it is impossible to order at once in advance, for the whole duration of such long terms, the succession and nature of the exploitations to be made in any given forest, it is an invariable rule in organising high forests to divide the Rotation into a certain number of equal portions, which we will term PERIODS. In connection with this division of the Rotation, the area itself of the Working Circle is split up into an equal number of portions, each of which is worked in succession during the corresponding period of the rotation. These divisions of the Working Circle we will call PERIODIC BLOCKS. This two-fold division being effected, according to rules to be laid down in a future chapter, the next thing to do is to prescribe, *for the term of one Period only*, the nature, order and extent of the exploitations to be carried out simultaneously in each of these Periodic Blocks.

It thus follows that the quantity of wood and timber to be felled each year is obtained from exploitations differing from one another in character, but which naturally fall into two well-defined categories :—

* Coupe—area in which a cutting is made. (Translator.)

(*a.*) Regeneration Fellings.
(*b.*) Improvement Cuttings.[1]

As a matter of principle, the yield of the Regeneration Fellings in high forests is based on cubical contents, that is to say, it is the figure represented by the total estimated out-turn of these cuttings for a whole Period, divided by the number of years in the Period.

The Improvement Cuttings in high forests generally consist of Weedings and Thinnings. By reason of their very nature and of the object sought in making them, the yield of weedings is too uncertain as well as unimportant to be taken into account. Thinnings, on the other hand, can not be usefully executed unless made in a regular manner, and repeated periodically in the same crop at well defined intervals of time determined beforehand. This can only be done by basing the yield on area. Lastly, if, in the same Working Circle, it becomes necessary to make other exploitations than Regeneration and Improvement Cuttings properly so called—*e. g.*, the removal of scattered trees, or topping off of overhanging crowns—these may be included under Improvement Cuttings, only their yield must be expressed in cubical contents, by an area or in number of trees, according to the nature of the cuttings themselves and the produce derived from them.

In all these cases, the object in view, so far as the distribution of the produce is concerned, ought to be to let the yield or the average annual out-turn vary as little as possible from Period to Period. We now understand the meaning of the phrase ASSURING A SUSTAINED YIELD.

In the foregoing paragraphs we have defined Forest Organisation by noting the essential conditions which all Organisation Projects should fulfil. We have followed this up by defining and explaining in a summary manner the value and bearing of these conditions, while bringing out the intimate connection that exists between

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(1) Regeneration Fellings—the fellings or series of fellings made in an exploitable piece of forest such that the stock that is to take the place of the one thereby exploited, shall come up as the direct result of the fellings themselves.

Improvement Cuttings—cuttings made solely with the object of improving the growth of existing stock that has not yet become exploitable.

For full explanations of the meaning of these terms see FERNANDEZ and SMYTHIES' "TRANSLATION OF BAGNERIS'S MANUAL OF SYLVICULTURE" (Translator.)

them. These definitions and summary details form, so to speak, the Programme of our Course of Forest Organisation. We will now proceed to study and develop the fundamental principles on which all Organisation Projects should rest; after which we will indicate the various steps to follow in drawing up such Projects, and offer practical suggestions for carrying out their prescriptions, so far as they can be usefully given in a book.

CHAPTER I.

CHOICE OF REGIME.

In choosing the Régime for a forest, we determine the method of working it that suits best the special conditions of growth obtaining therein and the interests of its owner. The principal points for consideration in making this choice range themselves into two groups, the one having reference to cultural, the other to economic requirements. The former takes cognisance of the influence of the Régime on the forest, *i. e.*, enquires in what way and to what extent it affects the species, the soil and the meteorology ; the latter class relates to the produce itself, considered from the point of view of its utility, the income derived therefrom and the ratio of that income to the capital producing it.

SECTION I.

CULTURAL REQUIREMENTS.

The Régime of High Forest, essentially favorable to long-lived species, is alone applicable to the conifers, which do not grow from the stool. It is also the only Régime that suits well the beech. Nevertheless the oak, and even the beech, worked as coppice woods, maintain themselves for an indefinite period of time under favorable conditions of soil and climate. Under any circumstances, the suitability of the one or the other Régime is clearly indicated by facts that may be observed in the forest itself. The influence exercised on the reproduction of the various species by the Régime that may be in force is at once seen in the actual results obtained. The study of such facts is of great assistance in choosing the Régime to apply in any case, and they may almost always be taken as a certain guide, so far as the future well-being of the species is concerned.

The action of forests on the soil below is referable to two principal causes, cover and improved composition. Cover, the result itself on the one hand of the foliage overhead and on the other of the dead and fallen leaves, maintains the soil moist and loose. Improved composition, due to the organic detritus mixed with the original soil, modifies the condition of the latter in the most favourable manner for vegetation, while enriching it with the most useful elements of plant food. In high forests, the cover is always complete, and the improvement of the soil is at its maximum. In copses, on the contrary, the cover disappears periodically at short intervals and is a long time before it is completely reformed, sometimes for the entire half of the Rotation. The result is that improvement of the soil, slight in any case, ceases partially and even wholly after each coppice exploitation.

Again, the aerial organs of nutrition of plants—branches, buds and leaves—are, for a considerable number of years, only slightly developed in a young copse, which cannot therefore form all the wood that the soil is capable of producing. It is then easy to understand why the sum of production is less in copses than in high forests, at least when the latter are managed according to the rules of sylviculture. This is a well established fact, and if there are exceptions to it, they are more apparent than real. Objectors may, for instance, question whether in a rich and moist soil High Forest would yield more than Coppice, which Régime has been known in such soils to produce up to 120 and 140 cubic feet per acre per annum. We may, however, reply that that quantity consists chiefly of the soft woods, whereas in High Forest the hard woods would form by far the largest proportion of the yield. In all such comparisons made to demonstrate the superiority of the Coppice Régime over that of High Forest, or at least its equality, similar stumbling blocks occur.1

(1) In the Forest block of Saint Gobain-Coucy, the Coucy-le-Chateau portion is in the condition of High Forest ; that of Saint Gobain in the state of Coppice. In the former tract the crops, consisting of beech chiefly and oak, contain at the age of 120 years, before being thinned, a standing stock of from 8200 to 9500 cubic feet per acre. Adding to this the wood previously cut out, which amounts to 2050 cubic feet at the least, we see that the average annual production per acre is nearly 95 cubic feet. In the Saint Gobain tract, the soil being as good if not better, the copse, containing scarcely any reserves at all and consisting of hornbeam, ash, birches and the softwoods in abundance, yields on an average per acre, at the age of 35 years, 3060 stacked cubic feet and 400 fagots representing 270 stacked cubic feet more. The mean annual production is therefore only about 95 stacked cubic feet per acre, and this too composed to a large extent of inferior species.

We have of course for individual forests only incomplete observations; nevertheless, these are, as far as they go, in perfect accord with our general conclusion. But this relation of particulars to universals holds good in all branches of human knowledge, and it is precisely because of the universal experience of Foresters in all exploitations of Coppice and of High Forest, and as a consequence of the comparison of the respective outturns yielded by scores and hundreds of forests, that we are permitted to affirm the superiority of the High Forest over the Coppice Régime in respect of yield of material.

In moist and fertile soil the difference between the relative merits of the two Régimes may be slight, but in dry and poor soil it is practically unlimited, since the Coppice Régime, in certain kinds of soils, suffices to cause the ruin of the forest, by leaving the bare sand to the mercy of ling bushes. Hence for each forest, it is the effects left by the Régime heretofore in force that alone offer a sure guide in estimating the influence of Régime on the soil and outturn of produce. And here the main point to attend to is the condition of the soil; as regards the produce, it is more frequently its nature and quality than its quantity which usually requires to be considered.

The influence of Régime on the meteorological conditions of a forest is occasionally well marked. The effects of heat and cold, of light, drought and winds, and of all the other determinant factors of climate are different, and are not felt in the same degree in high forests as in copses. Here again it is the various effects of the Régime followed, such as frost-bite, faults and defects in the timber, injury caused by winds, &c., which must be observed and studied; for it might be expedient to know what such effects actually are in the forest such as the Régime hitherto in force has left it, in order to be able to tell what modifications would result on the introduction of another Régime.

From a cultural point of view, the general effect of the Coppice Régime is mostly the same every where, whether the Coppice is Simple or Compound. This Régime can never divest itself of its essential defects, viz., uncovering the soil and favouring the inferior at the expense of the more valuable species. These defects might be minimised by preserving a plentiful stock of standards, but in revenge, such standards run the risk of serious injury each time they are isolated by the periodical exploitation of the underwood.

To recapitulate, reasons derived from a consideration of cultural requirements are at times of themselves strong enough to necessitate the adoption of the High Forest Régime. This is first of all the case in conifer forests, and next in those of broad-leaved species in which the soil is unfertile and extremes of climate prevail. But more often such reasons recommend the adoption of the one or the other Régime indifferently, and can only be considered in connection with the economic requirements to be satisfied ; and in that case they should govern chiefly the method of treatment. The choice of Régime is seldom left to us, but we are constantly called upon to apply it, once it is made. It is, therefore, very important to know the advantages and disadvantages attaching to each Régime in any given forest, so as to be able to turn the first to account aud minimse the second when we step in to carry out the prescriptions of the Organisation Project. A study of the Régimes and their results is thus extremely useful, whether we have to draw up an Organisation Project or only to carry it out as executive members of the Forest Hierarchy.

SECTION II.

Economic Requirements.

The subject of this section, like the one we have just quitted, may possess more importance for one class of forests than for another, but its absolute importance is always great and of the first order. It is generally a consideration of these requirements that finally determines, in any given case, the choice of the Régime and the age for exploitation.

§ 1. *Utility of the produce.*

The utility of the produce obtained in each case varies with the nature, condition, and properties of the wood composing it. So far as their nature is concerned, ligneous products are not simply either firewood or timber. In each of these two great classes, especially the latter, there must necessarily be included sub-classes founded on difference of size. Thus we have large timber fit for all great works, split wood, boards and scantlings, large and small rafters, wood for the wheelwright, and last of all simple poles. Now in high forests of broad-leaved species the outturn of timber forms two-thirds and never less than a half of the total yield, the proportion of large timber alone being about one-third of that total. Thus with High Forest worked on long Rotations it is possible to obtain yearly and per acre, under only average conditions of fertility, twenty-eight cubic feet of timber, all oak and beech, of large dimensions.[1] The high forests of Blois and of Bellèime yield this figure under such conditions. We see here the chief and peculiar merit of the High Forest Régime.

As Simple Coppice yields, at the very best, only small timber, no better than firewood in respect of age and size, we may be allowed to ignore it completely in the present discussion. Coppice with Standards is capable of furnishing timber of all sizes, small, medium and large. The total quantity may be very different according to the various forests; but it is always smaller than that yielded by High Forest, in which Régime the production of such timber is sought from every square inch of the soil. If we consider only large timber, the comparison is still more unfavorable for the Coppice Régime, for a considerable number of the standards, with crowns isolated above the underwood, are subject to premature decay. A copse with standards, situated on soil of average quality, would certainly be considered as yielding extremely good results, if it produced 5 cubic feet of large timber per acre per annum.

Actually our copses are, at the present day, very poor in large trees, and neither their great extent nor the active growth of isolated trees is sufficient to compensate for the extreme paucity of the standards. Moreover, this evil is beyond all present remedy where the material, out of which a plentiful reserve could be formed, is wanting.

With respect to its condition, wood, being an organised substance, is either sound and well-shaped or decayed and mis-shapen. Of little or no moment in the case of firewood, the condition of the

(1) By timber of large dimensions we mean only trees measuring at least 27″ in diameter.

ligneous tissue acquires considerable importance when we come to deal with timber. Now, quantity for quantity, the proportion of sound and well-shaped timber is much larger in high forests than in copses with standards. The standards, rising above the underwood, often have their boles irregularly twisted or affected with hollows in the interior, and with holes and knots in which decomposition has made more or less progress. The crowns, struck continually by the wind and weakened by the periodical development of epicorms[1] below, lose some of their branches, which, in breaking off, allow water to permeate into the trunk, thereby producing decomposition. The butt-end of the trees will also be found to be full of defects arising from various causes. The result is that in our copses with standards it is often necessary to examine a number of trees before we can discover a single oak with a girth of 7¼ feet at the base, that is sound and of regular form and which possesses a bole at least 20 feet long.

Thus owing to the rarity of large trees and their defective and unsound condition, it is exceptional in our forests to meet with oaks fit for employment in large works.

The purposes for which wood of all kinds, and oak especially, is used by the builder and the artificer are as various as the different qualities of the timber itself. Oaks that grow isolated, with an ample crown bathed on every side in light, form thick annual rings of wood ; their timber is thus close-grained, tough and durable, and peculiarly suitable for house-beams and for ship-building. Oaks that grow in canopied forest, possess thereby a long bole and thin annual rings ; the wood is soft, is easy to work, contracts little and does not warp ; it is thus specially adapted for planking and staves of casks. It follows then that under the same conditions of soil and climate, coppice standards and high forest trees will yield timber of essentially different qualities. That of the former, extremely valuable as it is for the purposes of the builder, must be looked upon more as *pièces de choix*, which being employed for special purposes, are not therefore required in any large quantity, while that of the latter, being much sought after by the artificer, is to be preferred

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(1) From *epi*, upon, and *kormos*, a stem.

Epicormic branches develop themselves on the boles of trees, generally those which have been isolated after having grown for some time in close leaf-canopy. To avoid inconvenient repetition of the word "branch" we will employ the single term "epicorm." (Translator.)

for the ordinary industries, which consume enormous quantities of timber. A consideration of the defects and good qualities of the timber produced is, as a rule, insufficient to determine in any given case the choice of the Régime to adopt, and only influences the manner of its application ; for the end to be kept in view is to obtain by means of each Régime wood possessing the good qualities peculiar to it, while minimising the bad qualities by adopting a suitable method of treatment.

§ 2. *Income.*

The next subject for examination, after the utility of the wood produced, is its money value ; it is on this chiefly that the income derived from a forest depends. We have seen that the yield of high forests is larger than that of copses, and, more than this, that the produce of the former, at least a great proportion of it, possesses a distinctive character and commands a higher money value. Thus, for instance, the firewood derived from a copse is worth about 25 shillings per 100 cubic feet, while the timber of a high forest can fetch 75, 100, and up to 125 shillings and even more per 100 cubic feet. Hence it follows that the income yielded by a high forest is, area for area, larger than that obtained from a copse.[1] But what is required in proposing the Régime to apply to any given forest, is to compare the income derived from it under the Régime hitherto in force with the income that may be expected under another Régime. For this comparison the facts available are of an extremely varied nature.

The income yielded by copses with standards, which of course produce timber suited for the purposes of the builder and the artificer is, as a rule, intermediate between that of simple copses and that of high forests. It is very different according to the number and size of the standards. But it is seldom that these forests return as much as £32 per acre for the whole term of a Rotation of 30 years.

Whatever other circumstances may be, for the purpose of a fair comparison we must always take gross income, irrespective of ex-

(1) A high forest must be in a bad state to yield less than 32 shillings per acre per annum, whereas there are few copses that return as much as 16 shillings under the same circumstances. (Author.)

The copses of the Central Provinces, consisting for the most part of open scrub in which the inferior and at present unmarketable species predominate, do not yield even 1 shilling per acre per annum under the most favorable circumstauces (Translator.)

penditure. For after all that is the revenue properly so called, in other words, the money returns derived from the forest considered as an instrument of production.

§ 3. *Profits.*

Profits, which are a measure of the net income or of the ratio of income to the capital producing it, are quite distinct from gross income. This last may be considerable, yet the percentage of profits may be very small, a circumstance which always occurs when the capitalised value of the standing material in a forest is very high. We thus see why in high forests, where the stock is so large, the percentage of profits is, as a rule, lower than in copses. Indeed copses are often so managed as to yield a fixed percentage, 4 per cent. for instance, whereas in high forests where the trees are not exploited until they are quite mature, the profits may be as low as 2 per cent. and even less.

This is easily explained by means of an illustration. Suppose a forest of 250 a cres worked on a rotation of 150 years, and composed of a well graduated series of crops from 1 to 150 years old. It will yield annually the mature timber standing on $1\frac{2}{3}$ acres, the value of which may exceed £320. This, with the outturn of the thinnings made over the rest of the forest, will furnish an income, say, of about £400 per annum. But the various crops aged from 1 to 149 years represent together a considerable sum of money, which, added to the value of the land itself, may give a capital value of, say, £20,000, so that the profits will only be 2 per cent. The climate, soil and species being still identical, the same area, if constituted as a copse with standards worked on a rotation of 25 years, may yield, from 10 acres exploited annually, an income of £160, while the capitalised value of the whole standing crop and the land may be only £ 4000. The resulting profits would thus be 4 per cent.

This want of correspondence between income and profits is due to the fact that the income and the capital value of the forest do not increase in the same ratio. For them to do so would be contrary to the very nature of the things in question. In order that profits may be maintained at a constant figure of 3 or 4 per cent during all the time required to produce large timber, it would be necessary for the selling rates of timber to increase with increase of size in a ratio exceeding all the bounds of possibility. It could only be realized then, when the last large trees were on the point of disappearing naturally. Thus it is not a continuous rise of prices in direct proportion to girth that we ought to look to for the means of assuring the production of large timber and the preservation of high forests.

On the contrary, the dearer large timber is, the higher is the value of the growing stock, and this is the very thing that invites speculation on the part of timber merchants, whose business, which consists in purchasing, exploiting and reselling, enables them to secure the ordinary profits of trade, viz., 12 to 15 per cent. Thus we see that rise of prices only provokes speculation and the consequent destruction of high forests, and it must be remembered that the production of large timber is, as a rule, naturally a slow process.

A consideration of profits alone may, and often does, suffice to determine the Régime to apply in any particular case. It does not always lead to the adoption of Simple Coppice, but rather to that of Coppice with Standards, the object being the production of builders' and artificers' timber of average dimensions. In every case without exception, the right way to proceed in considering the subject of profits is to compare income with expenditure. Too often people adhere to the established custom of the country or district in treating their forests. Forgetting that prices have changed with the times and that the rates for builders' and artificers' timber have risen considerably, they unfortunately give no thought to the production of such timber when choosing the Régime for their forests, or rather in the way they apply that Régime.

To summarise what proceeds, economic considerations are of an entirely general character; they are based directly on the interests of the proprietor, which interests have no concern with those of the forest itself. Thus every proprietor who aims at obtaining the most useful produce, will, as a rule, work his forest according to the High Forest Régime. All those whose essential object is the largest money returns possible, have interests of another order which will equally lead them to maintain the High Forest Régime or imitate it as closely as circumstances will allow. On the other hand, those owners of forests, who desire principally to derive the highest profits from their property, will adopt Simple Coppice whenever it is practicable.

We believe that the following practical rule contains the essence of the general conclusions arrived at on the subject of choice of Régime: "In any given forest, there is reason to change the Régime, if cultural considerations require it, or if the system heretofore pursued does not permit of the owner's obtaining results conformable with his interests." If the forest grows day by day thinner and blanks tend to grow larger as a result of the Régime in force, the Régime must be changed. If the system pursued can only yield firewood, whereas it is to the advantage of the proprietor to the obtain builders' and artificers' timber, there is equally no room for hesitation.

The Régime once settled, the Method of Treatment to apply is determined in accordance with the same considerations. On this head, in the Coppice Régime, there is scarcely any choice except between Simple Coppice and Coppice with Standards. Now an accurate knowledge of cultural facts and, more than all, the ever increasing value of builders' and artificers' timber, enforce the universal adoption of the latter method of treatment; besides this, the inevitabe transformation of a simple copse is an easy matter. In the High Forest Régime the choice rests chiefly between the Selection System and the Natural Method. The former, as we shall see later on, suits certain species and is required in certain situations. The facts that render its adoption necessary, are to be observed on the ground, and must be carefully noted by the Aménagiste. Besides this, the substitution of the Natural for the Selection Method is above all things only a question of time.

CHAPTER II.

CHOICE OF EXPLOITABILITY.

SECTION I.

PRINCIPAL KINDS OF EXPLOITABILITY.

From one and the same forest very different results are obtained according to the age at which the timber is felled. This age, which may vary between very wide limits, sometimes even between 20 and 200 years, determines the interval of time, at the end of which the exploitations, after successively passing through the rest of the forest, come back to the point whence they started. There is nothing analogous to this either in agriculture or the manufactures. Thus a question of an entirely special character presents itself to us here : to resolve it, we must go back to the fundamental principles of forest economy.

All owners of forest property find it to their advantage to exploit their timber when it has attained its maximum utility. Whether we speak of a single tree or a canopied collection of trees, the timber is now said to be EXPLOITABLE, and the peculiar conditions it offers constitute what we will call its EXPLOITABILITY. This state of the timber, which always corresponds to its maximum usefulness, depends above all on the nature of the services required of it.

The utility properly so called, *i. e.*, the technical utility, of wood varies with the species yielding it and with its properties, and increases in direct proportion to its size. A given quantity of timber is, as a rule, all the more useful for being composed of trees of large girth. The principal reason for this is that it can thereby serve a greater variety of purposes, and can in consequence be employed in the manufactures, which need it most of all, and which would therefore pay more for it than other timber using trades. We thus see how, without being exactly proportional to their respective degrees of utility, the prices of the various classes of woods, according to species, size and quality, indicate which of them are most in demand, are most useful to the persons using them. On the other hand, it is evident that the sum total of utility of the produce of a forest is the combined result of the quantity yielded and the utility of each separate category according to its nature. Hence if it is desired to derive from a forest the highest sum total of utility of which it is capable, we must endeavour to obtain from it the most valuable woods in the greatest quantity possible.

For those proprietors who do not themselves use the wood, but sell it, the price of this wood is a measure of its utility for them. The money value of the wood is of course the income obtained from the forest, and is the product of the quantity and the selling rate of each description of wood; thus income is proportional to the quantity of the various kinds of produce and the price of unit of quantity. Now since the most useful woods are also the dearest, it follows that a forest that yields the highest sum total of utility, yields also the largest income.

For those individuals who are in a position to speculate with the funds at their disposal, and in so speculating, to sell or to purchase forests, for them forests constitute simply an investment, like any other business, for their money. For them a forest is the more profitable, the larger the income it yields relatively to its capitalised value. This relative income is directly proportional to percentage of profits; and hence they regard forests chiefly from the stand-point of profits.

Thus the owner of a forest may seek to obtain either the most useful produce, or the largest income, or lastly the highest profits on capital invested. But, as we have just seen, the first two objects are compatible with one another; they are both realized at the same age and under the same circumstances. Hence we have two generic classes of Exploitability. The one corresponds to the maximum usefulness of the timber produced, and has for its essential object the supply of the country at large; the other corresponds to the highest rate of profits and its essential character is only to benefit the producer. The first regards solely the public good, the second the interest of the individual owner or owners. It is for this reason that we will style the first ECONOMIC EXPLOITABILITY, the second COMMERCIAL EXPLOITABILITY.

As the standing crop grows on, the quantity and usefulness of the wood produced increase, but each in a different ratio. It behoves us then to study each separately. Sometimes we may desire to obtain only either the maximum quantity of material or the maximum degree of usefulness, as would happen if one of the two varied very little or not at all. Hence, following the practice of writers on forestry, we have 1stly. QUANTITATIVE EXPLOITABILITY, which aims solely at producing the largest quantity within a given time ; 2ndly. QUALITATIVE EXPLOITABILITY or the Exploitability relative to the degree of usefulness of a given quantity of produce ; and 3rdly. the Exploitability combining the characteristics of the two preceeding, which we will term NATIONAL EXPLOITABILITY, and which has for its object the production of the largest quantity of the most useful produce. These are only three specific kinds of Economic Exploitability. Under the other head there is only the single specific kind which we have designated Commercial Exploitability, and which has reference to the profits accruing on capital invested. It is by the aid of this Exploitability that the selling price of forests is estimated.

As an exceptional case forests are required to perform for mankind other offices than that of producing wood, as, for instance, the preservation of the soil, protection against avalanches, shelter from high or dry winds, &c. Under these circumstances, the maximum benefit derivable from a forest is realized only when the trees have attained their maximum growth, in other words, the limit itself of their life, or, to say the least, the beginning of decay. The generic name we will give to the kind of Exploitability which procures us these indirect services will be PROTECTIVE EXPLOITABILITY.

It is easy to conceive that there can be other kinds of Exploitability depending on the object with which a forest may be managed, such as the production of resin, pastures, &c. But these are questions that present themselves only under exceptional circumstances and their solution is as a rule obvious or at least easy.

§ 1. *Quantitative Exploitability.*

In a canopied collection of trees the quantity of wood produced each year does not vary in the same manner as it does in the individual trees themselves. In the former case, the annual increment represents one year's production of the whole wooded surface. Since the number of the trees diminishes as the crop grows older, the average annual rate of growth at any given age is at once obtained by dividing by the number of years in question the sum of the contents of the standing timber and of the trees already removed. In this manner it has been ascertained that the mean rate of growth, or the ratio of the cubical contents to the age of the forest at any time varies with the age itself of the forest according to a certain fixed law. This mean annual growth reaches its maximum at an advanced age, which is nevertheless considerably below that of maturity. The moment that age is reached, the forest has attained its Quantitative Exploitability. This age varies according to soil and climate, differs considerably for the various species of trees, and is not the same in a high forest as in a copse, except that under either Régime it is approximately midway between the birth and decay of the forest. If the age at which the maximum rate of growth is reached is very different for the different species, the pine and the silver fir for instance, the degree in which the rate of growth itself varies, is also very different; from being well marked from year to year it may become scarcely appreciable. This fact can often be noticed by attentively observing the state of the forest and of the soil, but to establish it thoroughly requires actual experiments.

In the case of an individual tree, the annual rate of growth goes on increasing during a considerable portion of its life; it then remains constant up to an extremely advanced age, and if it decreases at all, it does so to an inappreciable degree just before decay sets in. The above fact is explained by the manner in which the organs of growth are developed, for a long time increasing progressively, then remaining more or less constant. The result is that the mean annual rate of growth of the tree generally goes on increasing until death supervenes, so that its maximum is reached only with the end of life. Nevertheless no conclusions can be drawn from these facts as to the sum of production of the soil, for the area occupied by the tree goes on increasing like its rate of growth, and this not according to any fixed law. Hence no rule can be laid down with regard to the age at which single trees ought to be cut so as to obtain the maximum produce from the soil in the least possible time. It is for this reason that, in foresters' parlance, we say that there is no Quantitative Exploitability for single trees.

§ 2. *Qualitative Exploitability.*

It is well known that the degree of usefulness of timber increases as a rule with its size. It hence follows that the usefulness of a tree, for every cubic foot of wood it contains, is highest when the tree has acquired the largest dimensions it is capable of attaining without beginning to decay, that is to say, only when it is thoroughly mature. Thus the age at which the conditions of Qualitative Exploitability are realized is the same as that of complete maturity.

The trees forming any crop reach this stage one by one, never simultaneously. Individual trees of the large forest species possess remarkably different degrees of longevity. While one silver fir is mature at 150 years, its immediate neighbour may not become so until it is 250 years old. Of two oaks, growing side by side, one decays perhaps at the age of 180 years, while the other is quite sound at 300 years. Hence we could not exploit all the trees of a crop according to their individual maturity, unless we were prepared to fell them one by one at wide intervals of time. But to do so would be to expose oneself to some capital disadvantages. It is opposed to the requirements of a great number of species, and the question of the condition or the quantity of the produce becomes thereby subordinated to that of constantly maintaining the leaf-canopy.

It is thus apparent that Qualitative Exploitability is not one that we could realize throughout the whole extent of a crop of trees of the same age.

§ 3. *National Exploitability.*

To obtain the most useful yield of material from a perfectly uniform crop, it would be sufficient to fell it only at complete maturity.

Before the trees begin to decay or the death of some among them produces blanks, it is clear that the crop, as it stands, contains in its large timber the highest sum of utility it can ever possess.

But on the other hand the bulk of the produce is necessarily always composed of a large proportion of firewood, even if the only source thereof is the toppings. Besides this, the age at which the mean rate of growth is highest, has already passed away, often years upon years ago. The question therefore presents itself, "Does it thence follow that we lose in quantity more than what we gain by the enhanced usefulness of the large timber after a certain definite age has been reached ?"

To answer this question it will be enough to enquire in what manner the quantity and the degree of usefulness of the produce vary from the time that the individuals composing the crop in question have become *high forest trees*, that is to say, have attained their full length of bole. As long as the leaf-canopy is complete and the trees are all vigorous and healthy, the annual sum of production scarcely diminishes ; indeed we can expect no other result, and the fact is easy of proof. As long as the trees gain in diameter while still remaining sound, their usefulness is continually increasing. This fact becomes obvious and striking if we compare the various purposes for which large and moderate sized timber respectively are employed. Indeed a comparison of receipts for equal periods of time will show that the money returns go on steadily increasing until the stage of maturity is reached, and thus proves that the sum of utility has also greatly increased in the meantime.[1] It hence follows that the conditions of National Exploitability are not realized except at the age of maturity. By felling forest crops when they have reached that age, we obtain, as far as that is possible, the most useful and considerable yield of material as well as the largest money returns.

Those forests of which the component species, the soil, or the Régime in force do not permit of the production of any but firewood, yield the highest sum of utility at the age which corresponds to that of Quantitative Exploitability. But such cases are very rare or are capable of being modified with advantage. On the other hand, those forests which furnish us with the most valuable timber both as regards quality and size, also contain numbers of trees that have still, at the maturity of the collective crop, a great many years to

(1) A high forest, mature say at 200 years and possessing at that age a convertible value of £ 670 per acre, is not worth £ 500 per acre at 150 years, and still less £ 335 at 100 years. (Author.)

grow on before they attain their highest degree of usefulness. It often happens that these trees can be spared when the crop containing them is exploited. In this manner we can follow up and add to the results of National Exploitability, by keeping such trees standing in an isolated state and not felling them except in accordance with the requirements of Qualitative Exploitability, that is to say, only as each of these choice specimens of timber becomes individually mature.

Thus the three specific kinds of Exploitability treated of hitherto all agree in having the public good for a common object.

§ 4. *Commercial Exploitability.*

Commercial Exploitability is based on the ratio of income to the expenditure producing it. This is by no means a simple ratio. In any given portion of a forest, the successive exploitations made therein are naturally not annual, but periodical; the consequence is that from the very first appearance of the standing crop, the values, or sums of money sunk in it, go on increasing, like any other kind of capital, at compound interest. If then periodic exploitation, at intervals of n years, yields receipts $= R$, the rate of interest i, which the original value C of the land with its stools or seedlings must be supposed to be put out at, is found from the equation

$$C\left\{(1+i)^n-1\right\}=R.$$

If we wish to find the rate of interest on capital invested, yielded by a forest worked on a fixed rotation, we must employ this equation to determine it. Thus the comparison of income with capital expenditure is always a question of figures.

Actually a wood that is quite young has no convertible value. Very soon it acquires such a value, at least as firewood, and this value, towards the age of 20 or 30 years, reaches all of a sudden a figure that is high compared to what it was only a few years previously. From this point onwards the value in question goes on increasing, but this in strict accordance, 1stly., with the natural laws of tree growth, which always remain pretty uniform, and 2ndly., with selling rates, which as a rule rise slowly with increasing age. The consequence is that the value of the crop on the land, in other words, the periodic receipts, cease to keep pace with the rapid accumulation of compound interest. Commercial Exploitability is thus always reached at an early age; and the higher the rate of interest required from the forest property is, the earlier will be this age.

In the case of solitary trees, as for instance coppice standards, the relation between capital and income is still more complex. For here of course the area required by any such tree is an unknown and variable quantity; and not only does the spread of the crown change as it develops, but the isolated condition itself of the tree is the main effective cause of the resulting rapid increase in girth and value. Thus, not having a sufficient number of terms to find this unknown, we are perforce limited to comparing the receipts that can be obtained at various ages. If the money value v of the standing crop rises to V in n years, the rate r at which this increase has taken place is found from the equation.

$$v\,(1+r)^n = V.$$

Used with judgment and due attention to error, this formula will give correct results. The rate r is not of course the rate of interest on capital, but that at which the receipts actually realisable have increased during n years. From the moment the young shoot is isolated by the exploitation of the surrounding copse, that rate becomes of necessity higher than the ordinary rate of interest yielded by forest property, for otherwise there would be no advantage in reserving the shoot. It is only when the former rate falls to the same figure as the other, that the object sought in maintaining the standard is fully attained and the standard becomes exploitable.

It is an ascertained fact that isolated trees increase more rapidly in size than trees growing in leaf-canopy. The standards of a copse are moreover selected from among the most promising individuals of the copse and belong to the valuable species, the price of the timber of which may rise considerably in proportion to diameter. As a consequence of this twofold increase of size and price, the resulting receipts are occasionally for a very long period in excess of the increase calculated at compound interest. It thus happens, and oftener than we imagine, that the Commercial Exploitability of isolated trees is not attained until the age of 100 years, if the customary rate of interest demanded from forest property is 3 per cent. per annum. To obtain this rate of interest we need only be sure that the value of the tree doubles itself every twenty years.[1]

SECTION II.

EXPLOITABILITY FOR THE PRIVATE OWNER.

Each class of proprietor has an Exploitability specially suited to its own requirements. What is applicable to one class of proprietor may be generically different from what is suited to another; or even if the respective Exploitabilities are generically the same, they may still differ with respect to the extent and the importance of the various results to be obtained in each individual case.

In the France of to-day there remain only three classes of proprietors, differing essentially in their nature; they are the STATE, the MUNICIPALITIES, and the PRIVATE INDIVIDUAL.

The PRIVATE INDIVIDUAL possesses at most a transitory existence. He is a stranger to the general good and is above all a speculator. A being of today, who survives but the tenth part of the life of the large forest trees, he cannot hope to gain any advantage himself from those he may preserve. Under the most favorable circumtances, such trees, if the object with which they are preserved is to be attained, must be left standing for at least twenty five years. How often does it not happen that present need or the legal division of inheritances, so fatal to the maintenance of forest property as such, or lastly the desire of immediate enjoyment, offer an insurmountable obstacle to the trees being spared for even so short a period? And if the further development of trees that have already reached a certain size is exposed to so many risks from private ownership, what shall we say of the growth of an oak or a silver fir from its first appearance as a seedling to the time when it is ripe for the axe? The obvious conclusion is that the PRIVATE INDIVIDUAL and the FAMILY, such as it is constituted by the law of France, is altogether unsuited for producing large timber.[2]

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(1) A sum of money put out at compound interest at the rate of 3 per cent per annum doubles itself every 23½ years. (Author.)

(2) These remarks apply with still greater force to India, where the law of equal division of inheritances has been in existence from time immemorial, and the blind improvidence natural to a low state of civilisation renders the private individual still more unfitted as a producer of large timber. (Trans.)

An infinitesimal, almost imperceptible fraction of society, the private person is unable to regard the interests of the public at large with the same importance as his own individual interests. If in the various branches of human industry both classes of interests are satisfied simultaneously and by the same line of action, the case is entirely different in the production of timber. The public interest requires wood at low prices, wood that is produced for nothing and costs scarcely any thing to preserve standing; the interest of the private owner of forest property is on the contrary to have wood selling high. It would not pay him to grow large trees unless the relative prices of large timber were very high, a result that can only be attained by keeping down production at as low a figure as possible. To expect a sufficient supply of large timber from private forests is thus a pure contradiction in terms.

Endowed with industrial activity, and an aptitude for commerce, and constantly spurred onwards by the stimulus of his own interests the private individual is always by nature speculative. He goes to those branches of production in which the returns on capital outlay are high; he considers carefully the safety of each investment and the realization of large profits. Time is an element which is his to dispose of to an extremely limited extent; in revenge, the vigilance and care required in carrying out money transactions are bis in a special manner. Industrious to a degree, he can give unflagging attention to any work he has in hand, even if that be the production of wood, but in return he requires quick, direct and large returns. Forest property pays him only if it yields him a fairly high percentage of profits. We thus see that rate of profits, which regulates the distribution of the wealth of the world, whatever the amount of this may be, is for the private individual the very basis on which he works his forests.

Only one point is open to discussion on this subject, viz. as to what extent it is justifiable for the various owners of private forests to look for high profits; whether, in other words, they should grow only small wood or timber of moderate size. And here indeed the advantage lies on the side of this latter class of produce, thanks to the high prices it commands. But as regards large timber, the production of which necessarily yields low profits, the private individual is for ever precluded from growing it. In France, at least, this point is never contested.

SECTION III.

EXPLOITABILITY FOR THE STATE.

The STATE is the highest form of expression of human society. A great State must be looked upon as imperishable like society itself taken universally. Having only a moral existence, it has no aptitude for speculation.

Imperishable or, to say the least, lasting for an indefinite period of time, the State is in a position to rear high forests and look forward with certainty to the enjoyment of the produce thereof. It possesses or can possess that indispensable *esprit de suite,* which is the sole guarantee for the attainment of results that can only be completed step by step in one or two centuries. For it is reserved the enjoyment of the highest forms of advantage that can be derived from the possession of forest property—a large income expanding of itself with time and the increasing scarcity of builders' and artificers' timber; easy treatment with assured results through the agency of a great Department; development of the general wealth of the country by means of raw products employed in every kind of industry; turning to the best account unfertile wastes; protection of steep slopes; favourable modification of climatic influences; natural ornament for the country. Howsoever we regard the forests that are required to satisfy the wants of the country, we see in their possession nothing but advantages accruing to the State.

Wanting in true industrial activity, the State cannot speculate with its forests; any such enterprises undertaken by it can meet with only a small measure of success. It is said that for the same reason it is a bad producer. This is true if we take only the ordinary forms of production, for which labour is a necessary condition. But it is not so in the case of wood. What a forest wants above everything else is protection and conservation. The amount of labour required is almost limited to regulating the felling of the produce. For a forest to be well administered the production and development of the stock must be obtained and controlled according to our wants as the direct result of the exploitations themselves. Thus the State, for the very reason that it is unfit for commercial undertakings, for agriculture and the manufactures, but is nevertheless all powerful and effective for protection, the State, we say, is an excellent owner of forest property. For a standing proof of this we have only to look at its forests, which are better conserved, possess a higher capital value, return larger receipts and yield finer and more useful products than those of all other classes of proprietors.

As the representative of society, the State finds in this very office its essential reason for possessing forests and the rule itself for working them. In order to produce in sufficient quantity the large timber which it requires, society has none but itself to depend upon. We find by chance well wooded tracts in some wild, unpopulated countries, but obviously no thought is given there to reproduction: the forests are worked and disappear as soon as they are made accessible, and if they offer valuable resources, these are at the best only temporary, limited and uncertain.[1] Now if no one inside it or outside it is capable of producing the large timber required by society, this function naturally devolves on the State. And it is to this single function that the rôle of the State shonld be limited, for it would be useless for it to possess forests that it may compete with other proprietors in producing timber of moderate or small dimensious as well as firewood; of such produce it would always obtain as much as could ever be wanted, if it aimed exclusively at growing large trees. In the last place, it is clear that although the duty of producing large timber appertains in a peculiar manner to the State, yet it need discharge it only so far as it is able; but the measure of its ability in this respect is certainly not reached until the state forests, in a country insufficiently provided with timber, are treated so as to yield the highest sum of utility.

It has been objected that the interests of the Public Treasury are not satisfied when the forests yield the highest sum of utility. Yet it is in this very case, and in no other, that the National Exchequer obtains the largest revenue from its forests, the highest price for the produce of its cuttiugs, the sale of which, to speak truly, is only the means employed by the State in order to distribute throughout the country and the world, the various classes of wood and timber yielded. Another objection raised is that the interest on outlay is very low, and that, however little the State may be adapted for

(1) If society can, strictly speaking, rely at all times upon the private proprietor for its supply of firewood, it can only depend on itself to provide timber for generations yet to come, and the duty of the Forest Department ought to be to look after chiefly the production of timber. (De Bonald, in Report of Parliamentary Committee presented to the National Assembly 25th November 1872.) (Author.)

speculative enterprise, it is certain that it could invest its money at a higher rate. But the authors of this objection are guilty of overlooking the indirect receipts accruing to the Exchequer, and these are affected in no doubtful manner by the cheapness of large timber. Let these be never so inconsiderable, yet when they are combined with the direct receipts derived from the sale of the large timber of the State Forests (and here we are concerned only with large timber) do not they suffice to double or treble this latter revenue and, at the same time, the corresponding rate of interest ?

The necessity of the partial and limited intervention of the State in the production of wood is a very remarkable economical fact. It is a result of the mixed character of forest property, which is at once an instrument of production and a natural product, although each of these in a very different degree, according to the time necessary for production.[1]

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(1) The importance of the function of the State in its position as an owner of forests varies greatly according to the State in question. Let us consider in this respect the special case of France.

The home production of this country in respect of wood is not equal to the demand. Timber of large dimensions is obtained in such small quantity that already we import more than we produce. This means of supply is an expensive one and the consequence is that the price of timber is so immoderately high that consumption is kept below what it might be with a large production at home. But, more than this, we have no guarantee that even the present supply will not eventually fail. The demand for timber is increasing with rapid strides not only in France but in all other industrial countries, which run us very close in the markets of the world. The timber resources abroad, will they last long ? Nothing, we answer, is less probable.

Does France possess the necessary elements to assure for herself a permanent supply in the future? No country is for this purpose better endowed by nature than she is. She has cultivable lands in ample sufficiency ; other lands distributed throughout her whole extent which are unfitted for agriculture but peculiarly suited for forest growth. She has forests in the full sense of the term covering several millions of acres ; numerous woods of smaller extent growing on, which have not yet been destroyed, the precious remains of forests belonging formerly to Religious Houses, now in the possession of Communes. Lastly she has 2,500,000, acres more of woodland, her supreme resource, spared hitherto to the State ; and with all these advantages, the most admirable variety of climate, soil and species.

But it would be vain to hide from ourselves the fact that our forest resources have been rapidly declining since the last century. This decline is to be traced not so much to the superficial extent of the forests as almost solely to the factors of production as regards large timber. Holdings in *mortmain*, the nature of which was so favorable from a forest point of view, have disappeared with the exception of those portions which passed over into the possession of the Communes. The State woodlands have lost their most valuable portions, thanks to repeated alienations carried out in spite of the provisions of the Constituent Assembly and the law of 23rd August 1790, which declared these forests to be inalienable. Lastly woods and trees in full growth have been ruthlessly destroyed to meet modern wants, such as the construction of railways, &c. Thus the duty of the State to hold forests acquires now in France a character of extreme urgency.

In France the rôle of the State is clearly defined in the Edict promulgated for the carrying out of the Forest Code. Section 68 of that Edict in fact lays down that "Orgainsation Projects shall have for their main object a Large Yield of Material and the rearing of High Forest Trees." It is impossible to prescribe more clearly and forcibly Economic Exploitability with its two component elements.

Besides, what does it matter, so far as the present subject is concerned, in what manner the receipts are obtained, as long as the country is well supplied with wood and with every other source of wealth ? The rate of interest on outlay yielded by high forests, the amount of the revenue they furnish, the rent of the land which bears them, all these are facts that cannot be avoided but are only of second rate importance. They vary with existing requirements and only reach too high a figure for the State when the wood supply ceases to keep up with the demand. Here then it is, in the satisfaction of the wants of the country, that we find the true gauge by which to measure the revenue, rate of interest and rent yielded by the high forests of the State. But in this matter our concern is entirely with a distant future, which conceals from near-sighted persons the importance of growing high forests. In preserving such forests, we work for the benefit of a future generation, while by destroying it we serve the interests of the present generation. Yet successive generations of men are bound together by the ties of a necessary solidarity, which gives them a continuous existence ; and we cannot ruin posterity without impoverishing ourselves. However it be, the conservation of forests devolves on the State much more as a duty than as a source of profit.

SECTION IV.

Exploitability suited for Municipalities.

The Commune or Municipality possesses the same character of imperishability as the State, perhaps so even in a higher degree. It is incapable of mercantile industry and of sustained activity. Lastly it forms an organic component of the State, of which it is an integral part both in respect of its land and its population.

In past times the Communes consumed themselves the entire produce of their forests. The number of those which do so still is dimishing every day, and, thanks to the progressive opening out of means of communication, it will ultimately retain only those Communes which occupy the great mountain tracts, and which can scarcely sell and never purchase wood outside their own limits. Like the State, and for the same reasons, such Communes must in their own interests, try to obtain the largest quantity of produce, and that too of the most useful descriptions according to the peculiar wants of each. Cases of this kind are now, however, quite exceptional.

The majority of Communes now sell their wood, at least the timber portion of it, or make it over to the inhabitants by levying a tax on them approximating to the value of the wood delivered. The expenditure and wants of the Communes have increased since the last century; hence income has already become, or tends to become the chief object in the management of their forests. Thus the interest of the Commune is to obtain the largest revenue possible.

The only kind of Exploitability that can secure the object desired is that which seeks the good of the country at large; for it is in the forest itself, and not outside it by means of purchase or investments of money, that it is possible to increase the income of a Commune. A Commune possesses only by accident any woodland situated beyond its own limits, and besides this the purchase of a forest by a Commune is a most rare phenomenon. Moveable property belonging to Communes disappears rapidly; thus forest property constitutes for them an excellent investment, and as a rule the very best of all. In the first place, it is perfectly secure, an indispensable condition where the owner is imperishable; in the second place, it continually increases in value; in the third place, it requires, so to say, no care at all; and fourthly and lastly, it can yield compound interest accumulated during an indefinite period. What better Saving's Bank could be conceived than this? The apparent rate of interest of course becomes low after 100 or 150 years; but most certainly no banker could guarantee as much for so long aperiod. A high forest in fact furnishes every 15 or 20 years the produce of thinnings, while returning ultimately the original capital increased fortyfold.

Thus far only as appearances go; the reality goes much beyond this. The value of money must continue to fall owing to the abundance of the precious metals. A certain individual, for example, has been in receipt of a fixed income for the last forty years, but he now obtains only two thirds of the articles which he was formerly able to procure for the same sum of money. In the case of a forest, on the contrary, the money value of the large trees is continually rising, since they are day by day becoming scarcer while the demand for them is increasing in proportion. Certain Communes possessing high forests have seen the revenues derived from them double itself within the last 30 years. Thus the effective rate of interest they have obtained on the capital sunk in their forests is not two but four per cent.[1]

Indeed forest property is for Communes an unrivalled source of income when the right conditions of Exploitability are realised. For what Communes, if we exclude revenue derived from municipal taxation, are the richest, if not those which possess real forests, like the greater number of the Communes of the North-Eastern portion of France? He who runs may read this fact in the Vosges and on the plateau of the Jura; the condition of the roads, of the fountains, of the schools and of the churches discloses it at every step. The Communes of the plain country could be just as well off, if their forests, instead of consisting of simple copse or containing but few large trees, were so constituted as to yield the most useful produce; but as a rule these forests are far removed from so desirable a state, for Communes are needy bodies. Indeed this last characterestic is at the present day so general among the Communes, that it appears to be one of their necessary attributes. And so it happens that although it is their interest to obtain the most useful produce in the largest quantity possible, still their neediness only allows them to labour towards this end without ever attaining to it.

The guardianship exercised by the State in taking up the management of communal forests, has no other object than the protection and the interests of the Commune itself. There is nothing in our laws which affords ground for any other supposition. Section 68 of the Forest Edict is textually excluded from the Sections which apply to communal woods. But its own proper interests are alone sufficient to impose upon the Commune the duty of preserving its

(1) In the communal forest of the town of Remiremont, consisting of silver fir, the annual yield of which, 15,600 cubic feet in all, is sold standing, the revenue in 1833 was £ 800 and in 1869 £ 2000. Since the latter year the receipts have still further increased. (Author.)

forests in the state in which they actually are; those interests also prove, now more than ever, that the management of these forests ought to seek as far as possible to realize the conditions of Economic Exploitability.

The rules which define the manner in, and the extent to, which the Communes may utilise their own forests are laid down in Sections 69, 70, 72, 137 and 140 of the Forest Edict. Section 65 of the Forest Code, applicable by virtue of Section 112 to Communes as well as to individuals possessing rights of user, rules that the quantity of produce that may be removed can always be regulated in accordance with the condition and yield of the forest, and that in case of any contention being raised, reference is to be made to the Prefectoral Council.

The other sections relate to facts of a special nature. But taking them as a whole, we find that the right of appropriating the produce of their own forests is a usufruct of a special kind, regulated as far as possible by custom, and subject to reservations and restrictions, and which usufruct it is desirable to limit to the trees that are exploitable, whether so by reason of their maturity or because they have attained the most useful marketable size. This last restriction is made compulsory in respect of coppice standards.

SECTION V.

Application of the Various Kinds of Exploitability.

We have thus seen that the Exploitability suited to any given forest, grove or tree depends entirely on the character of the proprietor. In forests that are required to yield chiefly ligneous products, the private individual will find it to his advantage to work in accordance with the rules of Commercial Exploitability, the State according to those of Economic Exploitability, and the Commune as much as possible in this latter direction. It is only in the matter of details in applying any kind of Exploitability that account has to be taken of the special character of each forest, block of trees of the same age, wood worked on the Selection System, simple copse or copse with standards.

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To realize the object of Commercial Exploitability, we must exploit forest and individual tree at the age at which the rate of interest on the capital value is at its maximum. In the case of individual trees it is obvious that they must be as numerous as possible, since the resulting income is ofcourse directly proportional to their number.

The conditions of Compound Exploitability are never fully satisfied except in high-forest crops consisting of trees of the same age. But this being so, it is sufficient to fell the standing crops at complete maturity in order to obtain from them the highest sum of utility.

In a forest worked on the Selection System the larger trees are found only here and there in the midst of younger ones. Each of the former, felled at maturity, yields the most useful produce the forest can ever furnish. But owing to the rate of growth being an indeterminate quantity, it is impossible to estimate the loss of production resulting from the maintenance of the tree above the younger individuals of the same species, the free development of which it impedes. In the case then of forests worked by Selection we must be satisfied with Qualitative Exploitability, which is all that we need require, as quantity of produce must give way to utility.

From a forest in the state of simple copse it would be vain to expect the largest quantity and the most useful kinds of produce that the soil can yield ; but we may endeavour to obtain as much of such produce as this class of forest can furnish. Now the mean rate of production of the soil in a copse goes on increasing up to an age beyond that at which we could maintain the standing crop, if we are to regenerate it by means of regrowth from the stool. Hence we must exploit such copses as late as possible, consistent with security of regeneration, in order to obtain the largest quantity of material possible under the circumstances of the case.

In a forest under treatment as a copse with standards, the underwood must be exploited under the same conditions as a simple copse and this for the reasons already explained in the foregoing paragraph. With respect to the standards, which are intended to yield timber, they must be felled only one by one as they become mature, in order that they may furnish the most useful classes of timber. No attention at all is to be paid to the loss of growth which the underwood suffers from the cover of the crowns overhead, as it sinks into insignificance before the enhanced utility of the produce of the standards, which are, by their very nature, infinitely more valuable. Thus the copse below is cut as late as possible, and the standards that are preserved for the production of timber, one by one at the age of the Qualitative Exploitability of each. But we cannot evidently work in the direction of National Exploitability except by increasing the number of the standards.

In our opinion it would be useless to call attention here to exceptional and special cases; in every such case, the question of the Exploitability to adopt can be determined with certainty by the aid of the general principles we have laid down. Thus it is easy to understand that every proprietor may have, under certain circumstances, to maintain a protective fringe or even large block of trees. It is obvious that in a forest of the Cluster Pine (Pinus Pinaster), in which the process of tapping for resin is in full operation, the crop must be so thinned that each tree may be quite separate from its neighbours, without standing too far apart from them, and that it is only by a careful balancing of profit and loss that we can determine the age at which the stock should be renewed.

It is now easy to see that the ideas of Régime and Exploitability are too intimately connected together to be fully considered apart. The application af the one or the other ought to secure the same end, viz. the production, by treating any given forest in the right way, of what suits best the interests of its proprietor. Hence in organising a forest the Régime, the Method of Treatment and the kind of Exploitability to apply to it or, as it sometimes happens, to its various parts separately, must be considered and determined conjointly.

SECOND BOOK

OPERATIONS COMMON TO ALL FOREST ORGANISATION.

The various kinds of work required in the organisation of every forest fall under two broad classes, viz.—(I) OUTDOOR OPERATIONS and (II) the ORGANISATION REPORT AND PROJECT.

The former class always of necessity begins with the examination of the forest, while the latter, in like manner, opens with the report of this examination. Now a forest of any extent offers at first sight a confused collection of trees; it is impossible to take in the whole of it in one view. To become thoroughly acquainted with it, we must separate it into its various component parts, divide and analyse it, then group together the data thus obtained and digest and form them into one whole by the opposite process of synthesis. This work consists in the division of the forest into COMPARTMENTS, followed by a detailed examination and description of them, and in the drawing up of the GENERAL DESCRIPTIVE REPORT of the forest.

That being done, next comes the formation of the Working Circles, then the determination of the Rotation or age at which the forest is to be exploited.

Such are the preliminary steps in the organisation of every forest.

CHAPTER I.

COMPARTMENTS.

The division of a forest into COMPARTMENTS is the very foundation stone on which is built up the inventory of the forest, and must precede every other operation. That inventory must take in every one of the component parts of the forest, and describe its condition and special character. The produce one may expect from the forest may be extremely varied, according to the species, and the quantity, qualities, and dimensions of the wood when exploited, and to the time for exploitation, which may be near or remote. Thus in order to ascertain what produce we can obtain from a forest which, by reason of its very nature, must cover a wide extent of country, it is indispensable first of all to draw up an inventory of it.

§ 1. *Boundary Map.*

In order to be able to divide a forest into compartments, it is necessary to have in the hand a plan, or at least an approximately accurate sketch of the forest: there is no other way of obtaining a thorough knowledge of the ground. The first thing to do is thus to procure such a plan, which we will call the BOUNDARY PLAN. It ought to give not only the boundary of the whole forest, but also that of the principal large masses composing it, or, better still, of its various cantons or beats known under popular local names. The Plan ought thus to have figured on it all great internal natural lines, such as watercourses, valleys, crests, or ridges, as well as the chief artificial lines, like roads, lanes and important paths.

It is expedient that this Plan should be drawn on a medium scale, so as to give sufficient details, while still allowing the whole of one or several cantons to be easily taken in at a glance. The scale of 4 inches to 1 mile, in which $\frac{1}{2}$ inch on the map is equal to one furlong on the ground, is very convenient.[1] With the aid of the Boundary Plan the relative positions of different points, the lengths of the natural and artificial lines and the approximate area of any portion can be ascertained at once. The Plan is extremely useful at every instant, and one may say, at every step made in the forest. It is the true guide of the Aménagiste—not, however, because it serves chiefly to enable him to find his way about, but really because it directs his work and gives, in his mind, a locality to every fact that he observes on the ground. But it is after all only a guide. It is therefore enough if it is only approximately correct, there is no necessity for it to be rigorously accurate.

The Boundary Plan may be obtained on application to the Central Forest Office, if it possesses a map of the forest in question, that can be copied, enlarged or reduced. In the absence of such a map, one may be compiled from the village plans, if they are sufficiently accurate, which is seldom the case. As a last resource, a rapid survey of the boundaries and principal lines may be made. This last is often the best course to follow when the forest taken in hand is of limited extent, in which case this preliminary survey would be sufficient for the construction of the map that has to accompany the Organisation Project.

§ 2. *Division into Compartments.*

Having the Boundary Plan the Aménagiste may now proceed at once to examine the forest and form the Compartments.

A COMPARTMENT is a portion of forest that is homogeneous throughout its extent in respect of the great factors of production, viz. CLIMATE, SOIL and STANDING STOCK. The climate of a given forest may be different in its different parts according to elevation, aspect, shelter or exposure and, in a word, according to all the various elements which together constitute the situation of a place. Soils differ from one another by their composition itself, which may be

(1) The scale suggested by the Author is $\frac{1}{20,000}$, in which 1 centimetre on the map represents 200 metres on the ground The scale adopted in the Translation is $\frac{1}{15840}$ and is thus rather larger than the former, but is perhaps more convenient for our purpose. (Translator.)

clayey, silicious, marly, rich or poor, or by their looseness or compactness, their depth, moisture, covering of dead leaves and vegetable mould, &c. Climate and soil constitute the constant factors of production, for naturally they cannot be modified except to a limited extent.

The chief elements of difference in the standing stock of a forest are species, age and density. But the promise held out by the stock and the state of its growth also constitute points of difference. Again although, speaking generally, the causes of difference are those enunciated above, yet existing differences may also be directly due to anterior circumstances special to the compartment in question. The standing crop is thus an essentially variable factor of production, for its condition is necessarily ever changing with its age, and that too without any limit whatsoever, since one day at last the stock itself is to be worked out and to disappear and be replaced by a new one.

The essential reason for the division of a forest into compartments, from each of the three points of view of climate, soil and standing stock, is that the dissimilar portions of one and the same forest require different cultural treatments or different rotations, and it is precisely these very two points—*cultural treatment* and *rotation*—that the Aménagiste is required to determine. It would be impossible for him to fix and prescribe clearly the treatment of, and time for, exploiting each of these dissimilar portions of the forest, unless he studied them separately. By bearing this rule well in mind, we are enabled to judge what amount of difference justifies the separation of one piece of forest from another and their formation into separate compartments. Mere shades of difference do not afford sufficient grounds for making a separate compartment of any particular portion: we must have marked and notable differences. But in that case the cause or the effects of the differences observed are at once apparent either in the configuration and condition of the soil, in the nature and relative proportions of the species, or in the shape and size of the trees. The task of appreciating these differences is thus reduced to the question of ascertaining whether a certain given difference requires a different kind of treatment or a different time for felling the standing material. This question only experience and a true sense of the Aménagiste's art can resolve.

The division of a forest into compartments serves various ends. In the first place it enables the Aménagiste to make himself throughly acquainted with the forest. Secondly, it is useful to him in drawing up an inventory of the forest. Thanks to this division, he can calculate or estimate the resources it offers as regards the various qualities and descriptions of wood. Lastly and chiefly, without it he could not determine the treatment adapted to, and the time suited for, working out each of these portions of the forest, that is to say, he could not draw up the Organisation Project itself.

The way to set about dividing a forest into compartments is not without some importance. It is necessary first of all to make a general reconnaissance of the forest. You walk about through it and round it; you examine the boundaries and the boundary marks; you study the relief of the ground, the hydrography and the character of the surrounding country. This reconnaissance gives a general idea of the forest itself and its surroundings; it affords some general notions regarding the prevailing climate, soil and species, the condition and distribution of the standing material, and the situation of the forest with respect to the neighbouring estates, to export lines, centres of population and the district considered as a whole. Moreover it is by means of this reconnaissance that we obtain general starting points or land marks, which furnish the necessary terms of comparison in the subsequent detailed examination of the forest.

These general notions once obtained, we proceed to the formation of the compartments. To that end we station ourselves at some known point, on the boundary, for instance, or at an angle or at the point where a road enters the forest. Then guiding ourselves with the aid of the Boundary Plan, we move along some fixed line (the boundary or the road, in the instances we have selected), while observing the standing crop and the ground, until some marked change in one or both strikes the eye. At this point we turn to the right or left as the case may be, following the line along which the observed difference between the two contiguous portions of the forest (one to the right, the other to the left) is continued. Care must be taken to keep our eyes chiefly on the portion which we started with by examining, viz., the one the boundaries of which we are trying to fix. Going on thus, winding along this line, which is indicated to us by the age, density, component species and condition of the standing crop, and by the relief of the ground, and always keeping that portion constantly to the right or to the left of us, as the case may be, we arrive at last, after having made a complete circuit, at the point from which we started. If, while making this circuit, we have taken the precaution to blaze the trees or fix flags or signals at short intervals, the compartment is marked out on the ground. There is nothing more left to do than to clear a narrow provisional line along this perimeter, which may also be at once laid down on the boundary map.

Next we must traverse the interior of the compartment in order to be sure that it is homogeneous throughout, or, in the contrary case, to note the dissimilar portions of which it is composed, and which it may be necessary to form into separate compartments if they differ to a sufficient extent for that purpose. In the latter case, when the sight is unimpeded for any distance, it is generally sufficient to cut the compartment in two by a transverse line or path.

In hilly and mountainous country it would often be extremely fatiguing and, it may be, useless to make a circuit round each compartment. In that case, on steep slopes it is enough to make horizontal traverses one above the other, closing the quadrilateral with lines of steepest descent, with gullies or other good boundary lines.

Frequently we come across gradual transitions which may be very embarrassing. Thus a slope with a northern aspect may gradually end by looking south-east; or the density of the standing crop may decrease by very slow gradations until from completely canopied forest we get amongst a few scattered trees; or again the age of the stock may decrease continuously, so that we may by imperceptible degrees pass from full grown high forest to a crop of poles. Under such circumstances where are we to draw the line between two contiguous compartments? Is it to be exactly midway between the two ends of this embarrassing piece of forest? Certainly not. This line must pass through that point at which the crop has changed sufficiently to require a different treatment and a different date for its exploitation from that first examined. This is an infallible rule to follow; but its application, whenever the necessity for it arises, requires the exercise of no little judgment. In any case, the essential point to keep in view in forming the compartments is to be sure that they mainly follow the natural lines of the ground.

However it be, it is not a matter of indifference how large or how small the compartments are. It is clear that if each of the divisions is to be homogeneous throughout and bounded by natural lines, they cannot all have the same area. Still it is necessary to remain within certain limits. If the compartments are too small, they become too numerous, and the result of this may be confusion in the prescriptions of the Organisation Project; at the best difficulties in carrying out these prescriptions can never fail to occur. It is desirable to have a whole annual cutting within the limits of a single compartment, and experience shows that the area of a compartment ought never to be under 13 acres at the least, even at the sacrifice of homogeneity. Hence if we have at first marked out any compartment that is too small, it is easy to judge afterwards with which one of those surrounding it, it ought to be incorporated, considering it as a mere dot or patch on a uniform ground. Those officers who have afterwards to execute the Organisation Project, being necessarily foresters by profession, will be easily able to modify their cultural operations as required, whenever they meet with such patches.

If the compartments are too large, it is impossible to determine the treatment of the various standing crops and to prescribe the order of the exploitations in a sure and precise manner. The series of successive operations in one and the same compartment soon becomes complicated, a circumstance which is a fruitful source of disorder. Hence the necessity of so arranging, that no compartment may be subjected to a single class of operations for more than a few years at a time. Without this, the homogeneity of a large compartment would probably soon be destroyed. On this point, experience has shown that no compartment should exceed 125 acres. If a larger area of homogeneous forest is found, it is always easy to split it up into two or more compartments.

The division of a forest into compartments requires chiefly a good deal of walking about round it and through it. The Aménagiste should avoid tiring himself, so as always to have his eyes open and his head clear, in order that no fact may escape his observation. The work does not call for any involved process of reasoning, for the characteristic features which separate one compartment from another are facts that immediately strike the sense of sight. But to reconnoitre them thoroughly, he has often to move about a great deal. On level ground he must satisfy himself with respect to their situation and relative positions. In hilly or mountainous country he may have to station himself on some high distant points and even on the slope across the valley below him, if he wishes to form an accurate idea of the configuration of the ground. This work, apart from the object necessitating it, is full of instruction for him and gives breadth to his views.

§ 3. *Survey of the Compartments.*

The compartments once formed, it remains to ascertain their area, situation and form by means of a regular survey. This survey must be accurate; not that without a thoroughly accurate survey we could not determine the right treatment to apply or the yield of the forest, whether that be based on cubical contents or area; but with only an approximately correct survey, it would be impossible to estimate all the resources of the forest and draw up a true and complete inventory of it.

A general series of levels may be taken with advantage, as they may prove useful in perfecting the organisation of the forest, especially if the surface of the country is even. With the configuration of the ground delineated on the map, it is easy to choose lines for roads. Such a map may be turned to account even in laying out the various paths to be cleared, which also can serve as export lines.[1]

The above are the only survey operations that may be required in organising a forest. When the area of the forest is considerable,

(1) The laying out or straightening of roads forming a complete network connecting all the various portions of a forest with the principal trade routes, is a work quite distinct from the organisation itself of the forest. It is expedient, when that is possible, to allow both these works to go on hand in hand and in direct connection with one another. Well-designed and well-constructed roads adorn as well as enrich a forest. If they are laid out simultaneously with the organisation of the forest, they simplify the formation of the compartments and serve as a sort of frame-work for the latter, so that a complete harmony is at once established between the network of export lines and the series of compartments.

But although it is desirable to devise a system of export roads while the outdoor work of the organisation is going on, it is seldom possible to lay out or even design the complete network at once, except at the risk of making some useless ones, and others that do not accord with the Organisation Project. It is, therefore, enough if only those roads are laid out while the organisation is going on, the necessity of which is clear and undeniable. Whatever be done, whatever amount of foresight exercised, the future will always necessitate modifications in the network of roads as in the prescriptions of the organisation itself.

the only way to construct an exact map of the forest in one piece is to make a triangulation, but such a map is not absolutely indispensable. Again, although the demarcation of a forest in accordance with existing law may be of the greatest utility when the boundaries are liable to be encroached upon, still for the purpose of the Aménagiste it is enough if they are known and clear to the eye.

CHAPTER II.

DETAILED DESCRIPTION OF THE COMPARTMENTS.

After the formation of the compartments comes their examination, and simultaneously with this the detailed description of each, which is noted down at once in a book. The object of this operation is to ascertain the condition of each compartment, and, as far as that is possible, the causes that have produced this condition, so that from the data thus obtained, the Aménagiste may be able to form a correct judgment regarding the future promise held out by the standing crop and the treatment that suits it best. Hence the expediency of describing separately the climate, soil and standing stock.

In connection with the present subject we are concerned with only the local climatic conditions of any particular compartment. To describe it fully, it is sufficient to note the situation, and, where the necessity exists, the aspect.

As regards elevation we are here seldom concerned with the idea of height in its absolute sense, but always and to a very great extent, with relative height as compared with the surrounding ground. Thus the upper portion of a slope possesses a very different situation from that of the lower portion of the same slope. Again the elevation being the same, the situations may nevertheless be entirely different, if one place is on the top of a ridge and the other forms the bottom of a valley.

In noting aspect, the slope or gradient, which is the measure of its influence and a cause of variation in its effects, should also be given. In most cases it is easy to describe the slope by means of a single word. In order to do this clearly and so as to express degrees of comparison, the following conventional gradations may be adopted.

(i) Gentle slopes, those whose gradients are comprised between $\%$ and 1/6, say between 0 and 16 in 100,
(ii) Rather steep ...1/6 ... 1/3............. 16 ... 33.......
(iii) Steep ....1/3 ... 2/3............. 33 ... 66.........
(iv) Very steep ......2/3 ... 1/1.............. 66 ... 100.........
(v) Scarps, whose gradients exceed 100 in 100 or 45,° and which men cannot climb except on all fours.

The dendrometer, which every Forest Officer in France carries in his sac, is a very convenient instrument for observing the gradients of slopes in hilly country.

Sheltering rising ground in the vicinity is always desirable and is frequently of very great importance. If in describing the situation of a compartment, the existence of such rising ground cannot be expressed or implied, then it ought to be specially mentioned. The height of the rising ground should be stated, as well as the point of the compass towards which it lies and the effects of its influence on the compartment in question. No hard and fast rule can be laid down as to the method of noting the existence of such sheltering ground and of describing it. Ability to recognise it when it exists, and to appreciate its influence, requires no small amount of general, as well as local, experience. There are occasions when it is necessary to note the absence itself of such shelter and the effects of this absence. The presence of streams and tanks and large sheets of water may also affect the climate of a compartment either favorably by rendering it moist, or unfavorably by aggravating the effects of frost.

In order to gain a knowledge of the soil, we must examine the state of its surface, its composition and its principal physical properties. With regard to its surface, the soil may be quite bare or covered with a layer of leaves, carpeted over with moss or grass, or overgrown with bushes; it may be loose or caked, rocky or consisting of earthy particles, &c. By the term composition of the soil we refer to the proportion of the principal elements which form it. It is expedient to determine it absolutely, at least in a few compartments taken as types, by means of acids and the methods of levigation and quantitave analysis. The presence in large quantities of humus and vegetable mould affects very considerably the nature and condition of the soil. Their proportion is roughly estimated with the eye. In the last place, the nature of the subsoil exercises a very marked influence on the forest growth, and may vary from compartment to compartment. The rock below may also manifest its influence on the topsoil above it by modifying its physical characters, according as its stratification is horizontal or inclined, or according as it is compact or permeable, entire in sheet masses or broken up. The physical characters of the topsoil, the chief of which are stiffness or looseness, hygroscopicity and depth, always exert a proponderating action on the forest growth.

The state of division (looseness) of the soil, which is a product of the nature and size of the particles composing it, goes on increasing from stiff plastic clay that is impermeable both to air and water, to loose sand and stones and agglomerations of rocks and boulders. As regards hygroscopicity we have soils that are boggy, wet, moist or dry. These classes of soils can often be recognised by the characteristic species which grow on them; but the humidity of the climate and of the soil are to a certain extent complementary one of the other.

Of all the characters of the soil, depth is generally that which varies most from compartment to compartment, and is also the most important. Thanks to it, the other characters perform their rôle more effectively, the roots of the trees spread out and take a strong hold of the ground, the moisture of the soil is better preserved and an excessive rainfall is more easily carried away into the depths of the earth. Depth of soil is at once manifested by the form of the trees; in shallow soil the boles are short and the crowns low, with the branches stunted and crooked, while in deep soil the boles are tall and the branches of the crown straight and long. A soil possessing a depth of 20in may be termed deep. Depth and the other characters of the soil may be observed in ditches, trenches, quarries and cuttings, which open to the view a section of the topsoil traversed by the roots of the trees.

For any compartment in particular the soil is described in a few words, and mostly by the use of comparative terms. The underlying geological formation is not mentioned, unless it is different from that of the preceding compartments. But it is expedient to estimate the fertility of the soil by employing the terms *very good, good, mediocre, bad, very bad.*

For indeed the fertility of a soil is not in any sense an absolute quality; it depends on the species of tree with reference to which it may happen to be considered. Thus a soil that is mediocre for the beech may be good for the Scots' Pine and bad for other species; again a dry and shallow soil would be good, say, for the beech but mediocre for the oak. Thus the fertility of a soil must be judged chiefly by reference to the manner of growth of the species concerned, which betrays it at once. It must receive a further qualification, since it varies not only with the nature and the condition itself of the soil, but also with its surroundings, viz. the atmosphere, geological formation, adjoining soils, and standing crops. This qualification, so to say, sums up the estimate formed after full consideration, of of the two constant factors of production, or, more accurately, of the productive forces of the locality itself.

It is the description of the standing crop which requires to be most complete of all. And here there may be a great many points to attend to, viz.

Descriptive technical name.
Density.
Component species.
Age or ages (if different.)
Origin.
History.
State of growth.
Approximate estimate of promise held out.
The most suitable treatment.

The descriptive technical name of the crop expresses in a characteristic manner what it is, whether a thicket, saplings, &c., or whether it is in the condition of a copse with standards, or a high forest worked by Selection or simply an irregular mass of forest. This name should give in a single word a general idea of the whole stock considered in the mass; and it is only when blanks dotted with scattered trees occur, in which there is no trace of any regular order or uniformity, existing or recently destroyed, that this fact has to be specially mentioned.

The density of a crop, viewed as a canopied collection of trees, is described by stating whether the leaf canopy is complete or not, close or open, discontinuous or only with an opening here and there, and this to what extent and in what manner. It may, for instance, be of greatly varying density and even interspersed with complete blanks.

With respect to the species of trees, only the principal and auxiliary [1] ones need be mentioned, and, if necessary, their relative proportions should be given, but this always in the most brief and simple manner possible. Nay it is often sufficient simply to state that an associated species is abundant or rare. Numerical ratios usually afford but inadequate information; this is always the case for instance when any species is represented by lanky, unhealthy or irregularly distributed individuals, or when the presence of the species is useful only in varying proportions according to the soil and aspect. As regards secondary or accessory species, only those should be mentioned which are characteristic of any special fact observed; the birch and aspen, for instance, if confined to certain compartments alone; or again the species comprised under the collective name of brushwood or the soft woods, if they are abundant only exceptionally here and there. If there is more than one stage of growth, as in a copse with standards, each should be described separately.

(1.) The various species of trees in a forest naturally group themselves into 3 well defined classes according to their relative importance in the organisation of that forest; we will denote them severally by the specific terms PRINCIPAL, AUXILIARY and COMPLEMENTARY.

Among the species present there is one (or it may be more), which from the superior value of the produce it yields and the general suitability of prevailing conditions for its favorable growth, necessarily stands out as the central pivot round which the whole Organisation Project turns. The Régime and the Rotation adopted are determined entirely by the requirements of that one species, which thus constitutes the PRINCIPAL species of the forest in question. As parenthetically observed higher up, there may be in the same forest several principal species, the Régime and chiefly the Rotation being judiciously manipulated to suit them all more or less equally.

Of the remaining species, well distributed throughout the forest or capable of being generally introduced there, one or more form the natural associates of the principal species, the growth of which they promote and improve, while, thanks to different requirements, they usefully occupy space both in the soil and in the leaf canopy, which the former could not but leave unutilised. These we have designated the AUXILIARY species.

All the other species, which are neither principal nor auxiliary, we have included in one comprehensive class under the name of COMPLEMENTARY species. These are either too slightly distributed, or do not attain a sufficiently large size in the forest in question, or yield produce of too little value, to influence in any way the choice of the Régime or the Rotation to adopt. (Translator.)

With respect to age, if the crop is composed of two or more distinct stages of growth, the respective ages of these various stages should be given, otherwise only the single figure expressing the general age of the crop. In a copse with standards, it is often sufficient, as regards the standards, simply to state that a certain class of reserves is predominant. If the age of the crop varies from tree to tree, as would happen in a high forest worked by Selection, the main point to determine is at what age it would be expedient to fell the crop considered as a whole. This we will call the *dominant age.* It does not always depend on the age of the majority of the trees, but here again on rapidity of growth and the relative situation of the trees.

At times it is necessary to note the origin of the crop. It may be traceable to seedlings or to stool shoots, or even to a mixture in certain proportions of both. It may be the result of the system of *tire et aire,* or of natural restocking or of artificial reboisement, &c. The history of each crop would be full of the most valuable instruction. As a rule it can seldom be traced any distance back. But it is expedient in a great many cases to mention what operations were last carried out in the compartment described. Occasionally also traces or evidence still remembered may be found of offences and serious damage committed, for instance, of removal of scattered and valuable trees, of loppings that have ruined a growing stock, of offences by graziers or by others repeatedly stripping trees of their leaves.

The state of growth of the standing stock may be described in one or two words: the growth is either *active* or *slow, sustained* or *languid,* &c.

The future promise held out by the stock, *i. e.* the probable period of time during which it will continue in good condition, requires a special reference, when its age and state of growth do not afford sufficient information on this head. In the last place, it is advisable to indicate in the Field-Book the operations that may be usefully executed in any given compartment before many years are over. This note, made with regard solely and absolutely to the treatment of the compartment in question, apart from all considerations connected with the adjoining crops, refreshes the memory when the in-door work of the Organisation Project begins, and enables the Aménagiste to prescribe with confidence the combined treatment of all the compartments of the forest taken as a whole. Its utility ends there and it must be omitted altogether from the Organisation Report.

Such are the points to be examined and noted. But, as a rule, there is peculiar to each crop some special characteristic, some important fact, that is more or less obvious, which must be observed and noted. Now it is one thing, then another. Experience, and the acquired sense of the forester's art, which has sometimes been termed his second sight, can alone enable him to recognise it. If it has been passed unnoticed, if it is not clearly brought out, if it is not faithfully interpreted in describing the compartments, that description may be lengthy, drawn up with care, specious, but for all that inadequate and deceptive.

To examine a compartment thoroughly after having obtained a knowledge of its boundaries and taken his bearings, the Aménagiste may proceed as follows :—(i) Place on the boundary of the compartment a guard who is to move along this line, while he himself moves paralled to him inside the compartment at a distance of 30, 40 or 50 yards off; so that while the guard completes a circuit outside, he himself also completes a circuit inside. As the Aménagiste has to stop frequently to observe, the guard must obviously stop too until the former moves on again. The Aménagiste must be in no hurry, but walk on slowly, taking in a general view rather than observing details, and he must avoid stopping to jot down notes, which act only distracts the attention and falsifies the appreciation of facts ; (ii) the circuit finished, he must formulate and clothe in words the ideas taken in ; (iii) then walk through the middle of the compartment from end to end, say through its greatest length, in order to assure himself that the compartment is homogeneous throughout, and above all to test or correct his first judgment. [1] (iv) That done, he must sit down and write straight off the description required, and then, (v) rest for a while before beginning to examine another necessarily different compartment. This description fatigues the mind as it demands sustained attention. It has no analogy whatsoever with the formation of the compartments, in which work the only thing to do

(1.) By marching along parallel lines, the Aménagiste does not gain so complete a knowledge of the ground and the stock, and indeed is likely to lose his way in the middle of the compartment.

is to look out for differences sufficient to separate one compartment from another; on the contrary, its aim is the very opposite, viz, to bring together the principal features observed and portray the general characteristics of each compartment.

§ 1. *Divisions and Sub-divisions.*

The crops of compartments adjoining one another occasionally present only transitory differences, as regards, for instance, age, density or species. These differences may sometimes be such as to justify keeping the compartments separate with a view to their immediate treatment, but without being opposed to their simultaneous exploitation. Once that is effected and the new generation has occupied the ground, these compartments will have become similar to one another, and may then be lumped up into a single compartment, granting always that the aggregate area is not too large for that purpose. While waiting for this to take place, the compartments may be maintained on the footing of SUB-DIVISIONS in order to facilitate the work of the Aménagiste in prescribing the treatment, and that of the Executive Officer in carrying out the prescriptions of the former. The single group of sub-divisions we will term DIVISION, which may therefore be defined as a portion of forest comprising one or several different crops, destined to be regenerated simultaneously and capable after that of forming a homogeneous whole.

The system of sub-divisions has once been much employed. At the present day it has been all but discarded; Forest Organisation seems now a more simple affair. But because that system is cumbrous, it would be a mistake to give it up altogether, for cases occur, in which the establishment of sub-divisions has its use, and without it the Organisation Project would be imperfect and incomplete. However it be, the fundamental condition that every division, seeing that it is to be permanent, ought to satisfy is homogeneity of the constant factors of production, viz., climate and soil. So also every Organisation Project to be perfect must be based on natural divisions of the forest.

CHAPTER III.

GENERAL STATISTICAL REPORT.

The simple inventory of the forest is not enough to enable one to draw up the complete Organisation Project. It of course shows what descriptions of produce can be furnished by the forest; it gives the quantity and the qualities of the different kinds of wood and timber it is capable of producing; it even affords data for finding out when its various portions could be exploited. But for our purpose it is indispensable to know besides:—(i) the wants and special interests of the proprietor, the extent to which he can seek to satisfy them and the means he has at his disposal in order to obtain that result; and (ii) the economic conditions in which the forest is placed, and the state and form in which its produce is employed and brought into consumption.

An examination of the whole body of facts connected with production forms the necessary point of departure for all forest organisation. This examination we have termed the GENERAL STATISTICAL REPORT of the forest. Its object is to ascertain what descriptions of produce and what results the Organisation Project should seek to obtain. This Report necessarily deals with facts relating to three orders of perfectly distinct ideas:—(i) *Administrative Circumstances*, that is to say the facts on which are founded the rights of proprietorship and the circumstances under which these rights are exercised; (ii) *Physical Circumstances, i. e.*, the existing factors themselves of production, a knowledge of which furnishes a general picture of the forest; and (iii) *Economic Circumstances* or, if you will, the relation between the wants of the surrounding country in wood and timber and the interests of the proprietor.

§ 1. *Administrative Circumstances.*

The chief points of information to give under this head are as follow:—

The name of the forest and its geographical, political and administrative situation.

The name of the proprietor and the nature of the rights of proprietorship. This right may be absolute or limited. Occasionally the right of property in forests is subjected to the most singular legal or conventional restrictions.

Area of the estate and the state of its boundaries. The facts relating to its demarcation, to the erection of boundary marks, to disputed portions, to its settlement map should be stated, and even discussed here, if necessary.

Origin of the property and its history, as far as that can be traced back. This historical record includes two most important classes of facts, viz., prescriptive rights and former treatment.

Actual condition of the estate, whether wooded or not throughout its whole area. Adjoining estates which surround it, whether fields or forests, towns or villages.

Other kinds of produce besides wood often possess considerable importance, for instance, grazing, game, and minor produce. This is the place to describe the circumstances under which they are obtained and the relation they bear to the ligneous produce. Besides the preceding, there may be a great variety of special facts to record. Moreover information must always be given respecting the administration of the estate and the means employed for protecting it, two points of very great interest. Thus it should be stated what officers are charged to administer it, and the character of the task entrusted to them may be dwelt upon. Details should be given concerning the nature and extent of the offences committed or the dangers to be feared, such as fires, damage caused by game, &c. The strength of the protective establishment entertained should be given, followed by a statement as to what degree of efficiency we ought to expect therefrom and the modifications that may be called for.

The taxes and contributions levied on the forest and other expenses incurred on account thereof also require a short reference, followed by estimates or proposals of various kinds.

Frequently the administrative circumstances of a forest are exceedingly simple and may be summed up in a few words on the constitution of the property, its history and management. The facts to record in that case are obvious and well-known ones. But sometimes, on the contrary, the questions to be considered are of quite a special character, such as undivided property, heavy prescriptive rights, civil suits, public servitudes, want of an outlet, and other facts of the first importance, which cannot be mastered without laborious study, and which at times even require an immediate solution before the work of organising the forest can be taken in hand.

The simple suggestions which precede suffice to indicate the lines to follow in describing the administrative circumstances of any given forest.

§ 2. *Physical Circumstances.*

The general study of the climate, the soil and the component crops of a forest is by no means simply a résumé of the detailed description of the compartments. It is rather the synthesis of that analysis, so formed as to give a clear idea, unencumbered with diffuse details, of the forest considered as a whole. Thus this study gives a picture of the forest sketched out in broad lines so as to bring out in bold relief its general condition.

In describing the climate, the first thing to note is the situation of the forest, *i. e.*, whether it lies on level, undulating or hilly ground, whether it forms a portion of one or several river basins, at what height above the sea, or above and below the surrounding country it is. The names of plains, hills, mountains, rivers, &c., should be expressed, whenever possible. After this the climate is qualified, from the point of view of temperature, by one of the five terms of the scale adopted for France. It is *hot, mild, temperate, cold or very cold* according to the species found indigenous in the locality and

Thus, for instance, it seldom happens that when those differences are at all pronounced, different rotations are not necessary. The work of separation being now complete, each portion thus arrived at forms a separate Working Circle.

All the various crops composing a Working Circle ought to require one and the same Rotation. The length of the rotation depends on the climate, soil and species. These vary more or less from compartment to compartment, so that, strictly speaking, the rotation would be different for each compartment. But it is clear that unless these differences are marked, it would be absurd to consider them to be opposed to the inclusion of the compartments in question in the same Working Circle. No one can fix within ten years the exact exploitable age of high forests of our large species or within one or two years that of our copses. Hence it is only when differences of 30, 40 or 50 years in the case of high forests, and of from 5 to 10 years in the case of copses present themselves between two several compartments, that it is necessary to place these in different Working Circles. Such differences cannot be discovered until after the Working Circles have been formed; but facts that help to discover them must be noted, as for instance, the girth of the trees at known ages.

A proper Gradation of Ages in a Working Circle is necessary in order that the series of annual exploitations may go on continuously without any hitch and that all the standing timber may be felled at the right time. This gradation can never be dispensed with, but in order to be able to extract more or less equal quantities of exploitable wood every year it is enough if we have certain principal broadly defined age-classes represented in sufficient proportions. Thus we must have in each Working Circle *old high forest, high forest, high poles, low poles* and *thickets*, or, in more general terms, at least these three great classes, viz., *old, middle aged* and *young crops.* After what we have just said, it is obvious that if the old crops, instead of covering one-third of the whole area, occupies only one-sixth, they are in insufficient quantity.

It is often very difficult to satisfy this condition of the gradation of ages. Thus it may happen that a certain age-class is insufficiently represented in the forest or is too irregularly distributed to be included in each of the natural Working Circles.

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There is no way of getting out of this difficulty but by maintaining, as far as possible, as Working Circles the old cantons or working units of the forest, and, still further, by running the boundary lines of the Working Circle right through the large age-groups, so as to distribute them equally between the several Working Circles. The effect of this may be to give the Working Circles very unequal areas. In this respect, the shorter the rotations are, the easier is the work of forming convenient Working Circles, for then the difference between the youngest and oldest age-groups must naturally be slight. It is desirable to have the age-groups in a Working Circle succeed each other in more or less regular order, to admit of the observance of the Rules for laying out coupes. For this purpose the Working Circle ought to be in one piece or, at the least, its different portions ought not to be mixed up with those of another Working Circle. In the second place, it is expedient that the crops composing any one age-class should be situated all together or, at the outside, form not more than two separate groups.

The boundaries to choose for Working Circles should be natural lines such as ridges in hilly country and, to say the least, roads on level ground; for it is evident that a Working Circle should form a homogeneous whole and a real working-centre. All arbitrary lines cut through the forest would be entirely out of place.

All foresters agree in admitting that a Working Circle ought to be neither very large nor very small. If small, the number of the Circles in a single forest becomes very large and, as a consequence, the various exploitations become numerous and scattered. The result is complication and disorder, comparatively high general working charges, more extensive injury to the crops adjoining the coupes, and occasionally extreme risks from the breaking up of the leaf canopy. A forest of silver fir may be ruined by being split up into too many Working Circles. If the Working Circle is large, it must contain a great many compartments. The result of this is that its organisation becomes more difficult; cost of carriage and working reaches a high figure owing to the great distance of the dwellings of a large proportion of the labourers employed and of the wood-working factories, and to the over-crowding of some of the export roads; the produce of the exploitations is liable to be left long encumbering the coupe; and lastly the, coupes being large, regeneration becomes difficult. Some hundreds of acres devoid of any shelter or some thousands of tons of wood worked out all in one locality cannot but be accompanied with great risk. So much said, nothing is more variable than the area to give to Working Circles and no limit can be suggested in this respect. Nevertheless Working Circles of high forest containing from 1250 to 2500 acres and those of copse covering from 375 to 750 acres are free from the defects noted above. The difference between the relative extent of a Working Circle of high forest and one of copse is due to the fact that, acre for acre, the annual cutting goes over more ground in a copse than in a high forest. Moreover the produce of the former, less important, as it is, not only on account of its lower value but also of its nature and quality, does not command such large and ready sale as high forest produce.

In forming his Working Circles, the Aménagiste must be guided by his Boundary Plan and the data he has collected together in forming and describing his compartments. He must begin by noting the great natural divisions formed by ridges, rivers, main roads, or cultivation. Such divisions are ordinarily few in number. Then considering each of these great divisions separately, he can easily judge what portions require a special method of treatment or a particular rotation. Next he must take up each of these smaller portions one by one, and observe how the crops of the principal age-classes are grouped together or distributed. He will thus end by defining one or more of his Working Circles. But if he is obliged to make some special arrangement in order to obtain a convenient distribution of the age-classes in each of these Working Circles, he has besides to form a correct estimate of the promise held out by the different crops, to consider in what various ways he can make the most of them and to combine all the resources at his disposal in such a manner as to minimise the disadvantages of a defective gradation or distribution of the age-classes. On this subject no rules can be laid down: it is entirely a question of professional *savoir faire.*

CHAPTER V.

DETERMINATION OF THE ROTATION OR AGE OF EXPLOITABILITY.

The first thing to determine in organising a forest is the age of exploitability or the rotation to adopt. On this depends not only the size and sum total of the timber produced but also the quantity to be removed in the annual exploitations.

A Rotation properly so called is applicable only to a canopied collection of trees. As regards solitary trees or the individuals of a canopied collection of trees considered singly, the age at which they become exploitable, varies from tree to tree according to the special growth and surroundings of each; for them, therefore, what we would have to determine is not the age at which they would become severally exploitable, but simply the condition or the size of the exploitable individual taken generally.

SECTION I.

Age at which Quantitative Exploitability is realized.

The end of Quantitative Exploitability is of course the production of the largest amount of material. Here we are concerned not with the total quantity of produce accumulated at any time in a forest but with the quantity obtainable within a given time, in other words, the average sum of production of the soil. This, we have already shown, does not exist for individual trees but only for a canopied collection of trees considered as an organic whole. Hence if it were possible to watch the progressive development of such a collection of trees from the very moment that it came into existence, the question of finding out the mean annual production would be simple enough. For in that case, to ascertain the mean annual production at any time we would have only to measure the cubical contents of the standing wood, add thereto the contents of the trees that have disappeared whether from natural causes or by the hand of man, and divide the total thus obtained by the number of years expressing the given age. The quotient is the mean annual production of the soil at that age. The age at which this mean is highest would be that of the Quantitative Exploitability of the forest. But to carry out a complete series of experiments of this nature would require perhaps a hundred years, and the Aménagiste could not obviously afford to wait so long. It is of course a good thing to undertake them whenever the history of the forests or portions of forests concerned is accurately known.[1] But it is not every forest that offers such convenient data, and the general solution of the problem has still to be provided for. The Aménagiste must ascertain somehow or other the mean annual production of the forest he has to organise. We, therefore, give another method for obtaining this mean.

Instead of watching the progressive development from year to year of the same crop, we look out for crops growing under identical conditions but of different ages. Such crops can of course always be found and they enable us to obtain at once all the data we require. We have thus only to ascertain for each crop its age, the contents of the standing material and the quantity of produce to be thinned out before it reaches the age-class next above its own. We thus obtain for any given crop the total cubical contents per unit of area, say per acre; and this divided by the number of years which expresses the age, gives us the mean annual production at that age, and, as before, the age which corresponds to the highest mean is that of Quantitative Exploitability. For example, the mean annual production is, say, 100 cubic feet at 20, 175 cubic feet at 40, 210 cubic feet at 60, 220 cubic feet at 80, and 215 cubic feet at 100 years; then the rotation which corresponds to the Quantitative Exploitability of the forest in question would be about 80 years.

In selecting the trial crops referred to in the preceding paragraph, we must be careful that they are as complete as possible, since they are supposed to represent the maximum production of the soil at the respective ages. Besides this, in point of fertility, they should represent the average conditions obtaining in the

(1) This is prescribed in Forest Department Circular No. 145.

Working Circle that has to be organised, for we have to consider not this or that particular portion of the Working Circle but the whole of it as an organic unit. The age of the youngest of the trial crops need not be less than that at which the stock becomes marketable, and it matters little how great the difference is between the respective ages of any two of these crops; but one condition they must all fulfil, they should be dense enough to require being thinned. In the first place, unless they be so, they cannot be considered to be as complete as possible; and in the next place, once the cubical contents of the standing wood in each has been estimated, we can at once proceed to thin and measure up the quantity thinned out. The produce yielded by a crop in thinnings is a quantity that must be known in order to enable one to deal with the older trial crops.

After the thinning in any given crop has been made, the number of the trees remaining should be counted. The next older crop should contain, before being thinned, the same number of trees more or less, for it is evident that it is only by comparing the number of trees standing at different ages that we can be sure that the crops have been suitably selected and that each crop is an exact counterpart of the immediately younger one modified by time. The degree of fertility of the soil in the several crops has to be the same, and there is nothing to indicate this except equality of the number of the trees in any two consecutive crops, the younger one taken after, the older before, being thinned, it being granted that each of these crops is as full as it can be. The reason of this is clear, for it is obvious that the number of trees standing in any full crop is inversely proportional to the fertility of the soil.

A complete series of such experiments can rarely be made in the same Working Circle, since for this purpose it would have to contain in itself every one of the trial crops required, all of them as full as possible and representing the different stages of the same ideal crop. Now there are even species (like the silver fir, for instance, which was formerly everywhere treated on the Selection System) that form only in exceptional cases crops composed of trees of the same age. Another difficulty is that it is only recently that regular thinning operations have been adopted as an integral and necessary part of the treatment of forests, the consequence being that in existing crops of any age they have been made only since the last 20 or 30 years. Hence such crops are not in the condition in which they might have been, had they been thinned regularly from an earlier age as soon as thinnings became necessary. Moreover the degree of severity of a thinning is not without its influence on the total production of the soil, the extent of this influence being still but little known.

But if a complete series of experiments can rarely be made, partial experiments of this kind are frequently possible and furnish general data of great importance. Thus nothing is easier than to find out the cubical contents of a uniform crop together with its age. And as the quantity of the produce yielded by the thinnings already made is on record, a small arithmetical calculation gives approximately the mean annual production since the appearance of the crop. By this means we have been able to ascertain that the Quantitative Exploitability of high forests of our large species generally is reached towards the end of the first century and is the longer delayed, the slower these forests thin themselves under the action of natural forces alone. Again we have copses exploited at all ages between 20 and 40 years, and there are even many in different localities which have been left standing with a view to conversion into high forest and which are now from 40 to 80 years old. These copses show that the mean annual production of a simple copse goes on increasing beyond the age at which it ought to be exploited to obtain an abundant regrowth from the stool; and, more than this, that the Quantitative Exploitability of copses is attained only towards their fiftieth year, a little earlier or a little later, according to the component species and the prevailing classes of soil.

It is even possible to tell by certain peculiarities or physical signs whether a given crop has become quantitatively exploitable. At this period it has passed the stage during which growth in height is rapid, and it has acquired nearly all its natural length of bole; it has become completely fertile, and, growth in height being practically at a stand still, the forest has begun to thin itself naturally.

Thinnings made by the hand of man precipitate this result; but the point on which their importance chiefly rests is that they obtain from the forest and render available for consumption a larger quantity of produce, and this too at an earlier age, than if the forest were allowed to thin itself by the natural struggle for existence between the trees composing it, as they expand their crowns. Moreover the produce of thinning operations is more considerable during the first half of the life of the crop operated upon than during the other half. The consequence is that they affect our calculations as soon as the middle age of the crop has been reached, and they do this, if not as a constant quantity divided by an increasing number corresponding to the advancing age of the crop, at least as a quantity increasing less rapidly than the age. Taken into account, this produce has the effect of diminishing the mean annual rate of growth during the years that succeed the most productive thinnings, as compared with the mean annual rate of growth during the immediately preceding years, and it thus hastens or even suffices of itself to bring about the maximum mean annual production sought.[1]

The explanation of this is simple. It is an established fact that differences in the annual sum of production in any complete crop, from being well-marked during the first years, become slight later on; and it is equally well known that thinnings scarcely, if at

(1) We will illustrate by figures the meaning of this paragraph.

Suppose a full-cropped acre aged 90 years to have just been thinned, the stock left standing measuring 5040 c. ft. and the total outturn of all thinnings made hitherto being 2520 c. ft.; then the average annual production per acre at 90 years $= \dfrac{5040+2520}{90} = 840$ c. ft.

Similarly suppose the crop at 120 years just before being thinned to contain 6720 c. ft.; then.

Average annual production per acre at 120 years $= \dfrac{6720+2520}{120} = 770$ c. ft.

Thus although we have assumed the annual production to be constant, the produce of the thinnings of itself suffices to reduce the average annual production in the space of only 25 years from 840 to 770 cubic feet. If we continued the series, the average annual production, supposing T to be a constant, would be represented by the general expression

$$P+\frac{T}{n}$$

where P = annual production, T = total produce of thinnings. and n = age of crop. But actually T is naturally not a constant and hence the thinnings cannot affect our calculations "as a constant divided by an increasing number corresponding to the advancing age of the crop." It is easy to show that they must affect our calculations "as a quantity increasing less rapidly than the age"; for if this quantity increased at least as rapidly as the age, then

$$\frac{T}{n} \propto n$$

$$\text{or } T \propto n^2$$

i. e. T would have to increase in an absurdly impossible ratio (Translator.)

all, affect the annual sum of production, for the judiciously thinned crop, thanks to the full room for unimpeded development thus afforded to the conserved trees, makes as much growth as the unthinned crop would have done. Hence the yield of the thinnings is so much over and above what could be obtained from the same crop, if no thinnings at all were made.

To resume in general terms what precedes, we may say that experiments relating to the mean annual production of forests show that the extreme limits between which this mean attains its maximum are, on the one hand, the young high-forest stage or the age of complete fertility and, on the other, the natural opening out of the leaf-canopy when the trees have reached complete maturity and the soil begins to deteriorate by the reason of incomplete cover overhead.

SECTION II.

Age of Qualitative Exploitability.

A tree presents its highest sum of utility for unit of volume when it has reached the largest dimensions it can acquire while still remaining sound. For whatever it is, whether oak, silver fir or any other species, its timber is then adapted for the most varied purposes and is, as a rule, bouud to be used in such a manner as to satisfy the most important wants. Now it is impossible to foretell what precise use will be made of timber that is to be felled many years hence, or what other wants may not by that time arise, that will require the same wood. Hence the only sure way to produce the most useful descriptions of timber is to grow trees of the largest dimensions possible and that chiefly because they will thus be suited for the greatest nnmber of purposes possible.

The wastage in working up timber being less in the case of large logs, it follows that, volume for volume, large timber in the log contains more utilisable material than pieces of smaller size. This remark applies with less or greater force according to the species concerned; for instance, it is much more important that oak and pine, which contain comparatively a considerable proportion of sap-wood, should be obtained of larger size than silver fir or beech in the employment of which no difference is made between the heart and sapwoods. Again large logs can be cut up into more useful scantlings; thus they may be first cut up into quarters before undergoing further conversion, or they may be sawn up into broad scantlings which are in great demand for certain purposes. This advantage becomes most striking in the case of species valuable for certain special characters, notably so in that of the oak, the ash &c. To resume in a few words what precedes, we may say that the largest logs are destined to supply the most important wants and this more fully both as respects quantity and quality than smaller pieces.

The heartwood of trees does not improve with age; on the contrary it deteriorates by gradually losing some portion of its component elements, and even begins to decompose, as is proved by the various alterations of colour which old wood undergoes. If it is a desirable thing to obtain large trees, it would be no less undesirable to let them deteriorate standing. Now experience shows that the deterioration of standing timber does not begin except with the decay of the tree, so that instead of waiting until that stage supervenes, we must fell all trees as soon as they are mature.

This latter stage, which precedes the beginning of decay, can be recognised by a visible loss of vigour; the annual shoots remain very short, the foliage becomes spare and of a dull green. The stage of decay on the other hand, shows itself by the loss of important organs; some of the principal branches in the top of the crown die, and in consequence the foliage of the tree is entirely wanting in places. For each species the mature tree and the tree in full decay are recognised by special physical signs. The mature oak possesses only a few scattered leaves which turn yellow early in autumn and begin to fall from the top downwards; entering the stage of decay, it becomes stagheaded. The mature silver fir possesses a tabular crown completely flattened at the top, and the lower branches are but scantily furnished with leaves; when decay sets in, the crown loses its shape and, from having been circular, its outline becomes irregular. Sometimes premature decay occurs. It is either accidental and special to the tree affected, or general throughout a forest. When accidental, it may be due to a broken branch, for instance, or to any other extraneous cause. To recognise it, it is necessary to examine the crown, the bole and the butt-end, including the visible spread of the principal roots. If the decay affects trees in a general manner throughout the forest, it may be traced to the character of the soil, which may, for example, be deficient in lime or rest upon an impermeable sub-soil. Such decay consists in the decomposition of the heart of the tree at an early age. Actual experience obtained in working a forest can alone show whether the trees in it are affected or not in this manner.

The conditions of Qualitative Exploitability can be practically realized only in the case of trees that are felled one by one, like the standards of a compound copse and the trees in a forest worked by Selection, whenever the object in view is to obtain the highest sum of utility from each individual tree. In this case, the total production of the soil is not taken into account, either because it is of no consequence, or because it cannot be estimated. Indeed the loss of material that may result from the maintenance of trees that overtop others is slight, when such trees stand far apart; for they too produce wood and this wood is more useful by reason either of its superior size or because it often belongs to more valuable species than the overtopped trees.

The age of maturity is very variable according to the species concerned. It is rather late for the oak, the silver fir and the larch, and early for the beech, the spruce fir and the Scots' pine. In any case, without an examination of each individual tree and the possession of professional experience, it is impossible for any one to say whether a given tree is in full growth, or is mature, or has begun to decay.

SECTION III.

Rotation corresponding to National Exploitability.

The only way to obtain from the soil the full amount of production of which it is capable, and above all to employ every square inch of it in the production of timber of large dimensions, is to rear canopied forest. Hence in order to realize the highest sum of utility possible, we must grow our trees in leaf-canopy and better still in canopied forest composed of trees of the same age, as far as that is allowed by the nature and habit of the various associated species. Now such a forest does not furnish the most useful produce it can yield until it is quite mature, whereas it returns the highest sum total of production of which it is capable at a much earlier age. In order to obtain the highest average yield possible of produce, that is at the same time the most useful the forest can produce, are we to exploit it at an age intermediate between the two ? Certainly not. It is at the age of maturity itself that we must exploit it, just as we do wheat, fruits and other produce of the soil in general.

We know that the average sum of production of the soil of a canopied forest decreases but little so long as the forest is full and composed of vigorous and healthy trees. Let us now enquire in what way the usefulness of this production increases with the age of the forest. The variety of purposes to which any piece of timber is applied, depends principally on its size. Timber dealers hence divide the various descriptions of wood in the market into size-classes, depending chiefly on diameter. The highest class of course commands the highest prices, for no piece of wood is placed in that class, unless it is suited for employment in the most important industries. It is impossible to estimate directly the value which wood commands in any single one of these industries, since that depends not only on the use made of the wood in that particular industry, but also on the relative quantities of such wood consumed by them severally, so that this value is subject to great fluctuations according to time and place. Hence the most logical classification of woods must be founded on the price of unity of volume. As long as the selling rate of any class of wood has a general and steady tendency to rise, we may be sure that it is required by certain industries, which are willing to outbid all others in order to obtain it. That industry will pay more for it, which is most in want of it. From what precedes, it is thus clear that the utility of wood goes on increasing continuously with its size until it reaches the first class of commerce.

The same result is obtained if we compare the receipts realized at different ages. The value of the standing timber on a given area, from its first appearance to the time the trees attain the first class size of commerce, does not increase in exact proportion to its age, but more rapidly. For instance, if the total value of the crop at the latter age, say in this case 160 years, is £2000, and at the age of 120 years £ 1500, then at the age of 80 years, it would be very far from fetching £1000. Thus an increase of marketable value is a test that its utility has also increased. It follows then that whether we wish to obtain the highest sum of utility or the largest receipts, we have never any reason to exploit a forest before its timber has attained the first class-size of commerce. The age at which this occurs is the lowest limit for a rotation that realises the conditions of Natitional Exploitability.

We must except from these remarks those forests, of which the soil is not good enough to enable the trees to attain the required size. It is obvious that in no case ought the rotation to exceed the age of maturity, but since the thicker a log is, the more useful it is, it follows that the first-class size of commerce is necessarily as nearly as possible that, which that species generally attains before beginning to decay. It thus happens that, as a rule, the maturity of a canopied forest is reached soon after the age at which first-class marketable size is attained, and just before that at which it begins to decay. The interval between these two ages is more or less long, depending on the species and forests concerned. In any case, the moment when decay begins is the superior limit for the rotation corresponding to National Exploitability.

It is thus easy to determine this rotation with perfect certainty within a very few years of the real figure. By keeping as near as possible to the age of the maturity of the crops concerned, there is no danger of making a mistake.

The maturity of a canopied-forest, like that of a solitary tree, is also manifested by a marked loss of vigour of growth. The leaf-canopy becomes lighter than during the period of sustained vigour; seedlings of the principal species now make their appearance, if they did not exist before; or, if they did exist before, they now begin to push forward. But these signs, although generally similar for all forests, present certain characteristic differences according to the species of trees composing any particular forest.

The two limits of age between which the National Exploitability of a forest is comprised, *viz.*, that at which the standing timber acquires first-class dimensions from a commercial point of view, and that at which decay sets in, always offer two definite starting points by means of which to determine the rotation. If we work from the lower limit, we must ascertain by careful ring-countings on felled trees the age at which the minimum diameter required is attained. When there is choice in the matter, the trees selected for these experimental ring-countings should be such as have grown in canopied high forest under the average conditions of fertility special to the Working-Circle concerned; those that present any exceptional characters should be rejected. The highest figure obtained from the ring-countings should be fixed for the rotation, since it is better to be above the minimum diameter required than to run the risk of having to exploit the trees before they have acquired that diameter But in practice, as a rule, the best trees found for these experimental ring-countings do not quite satisfy all the points required of them; for example, old crops, if they are present, may not be growing under the average conditions of fertility, or may not have yet acquired the desired dimensions; or they may be entirely wanting in the Working Circle. If we were obliged to work with trees of larger girth than the minimum required, it would be easy to determine, on a section of the trunk, the age at which they reached this minimum. But if such trees have grown in an isolated state, as they often do, what are we to conclude as to the dimensions that would be acquired at a given age? And if large trees are absolutely wanting, a circumstance of not unfrequent occurence, what is there to do but to fix the rotation by analogy?

However it be, it is obvious that individual judgment must always, and to a considerable extent, come into play in the determination of the rotation to adopt. The greatest risk we run is, no doubt, that of arriving at too low a figure for the rotation. The effect of this would of course be that we would cut too fast the trees that have already attained the exploitable girth, and thus in a short time have no exploitable trees left to cut.

SECTION IV.

Determination of the Age of Commercial Exploitability.

The object aimed at in subjecting a forest to the conditions of Commercial Exploitability is to obtain the largest income from the total sum in cash represented by the value of the forest. This sum is treated exactly like moveable capital, and is expected to yield the highest rate of interest possible. But the income derived from wooded land is necessarily periodic; any particular portion of it yields no money return except once after a more or less long series of years. The income derived from and the capital sunk in the forest do not increase in the same ratio as the years go on. The question to resolve is, therefore, the determination of the age at which the forest should be exploited in order to obtain from it the largest income compared with the capital invested.

This problem is capable of a single general solution, and also presents some very important special cases. The general solution is applicable to woods composed of trees of the same age, such as simple copses and all perfectly uniform canopied masses of trees. The most important particular cases are those presented by the standards of a compound copse and forests worked by Selection.

§ 1. *Rotation applicable to a Wood composed of Trees of Uniform Age.*

Given a compartment of average fertility—if not a compartment, say a coupe or even an acre of forest; the problem before us is simply to determine the age at which the crop standing on this area ought to be cut. This will also be the age for exploiting the other coupes or portions of the Working Circle, that are placed in the same conditions of production. Thus this age is itself the rotation sought. The procedure to follow depends on the following proposition:—

The revenue derived from the exploitation of a uniform canopied forest is necessarily periodic, and increases for every year that the forest is allowed to stand. The revenue for each year represents the amount of interest on a certain definite capital, calculated at the customary rate of interest expected from investments in forest property. The capital corresponding to each year's revenue, therefore, increases from year to year like the revenue; and hence the most profitable revenue, i. e. the age of Commercial Exploitability, corresponds to the largest resulting capital.

In order to find the age at which a given forest composed of trees of the same age becomes commercially exploitable, we must first of all determine the various figures of the respective receipts obtainable at regular periods for a series of years; then by a simple sum of arithmetic capitalise these figures. The highest capitalised value gives us the required solution. Suppose, for instance, that the periodic receipts determined experimentally are as follow :—

At 20	years	£ 16
„ 25	„	£ 24
„ 30	„	£ 37
„ 35	„	£ 48
„ 40	„	£ 58

The capital corresponding to each of these figures can be obtained from the formula,

$$C = \frac{R}{(1+i)^n - 1}$$

Where C = the capitalised value sought.
R = the revenue to be capitalised.
and n = the no. of years at the end of which the revenue is periodically obtained.
i = the interest on £ 1.

Take in the present instance 4 per cent as the rate of interest ;
Then $i = 0.04$
and C, *i. e.* the capital capable of yielding every twenty years an income of £ 16

$$= \frac{16}{(1+0.04)^{20} - 1} = \quad £\ 13\text{–}8\text{—}11$$

In the same manner, C at 25 years	=	„ 14–8— 2
... 30 ...	=	„ 16–9—10
... 35 ...	=	„ 16–5—10
... 40 ...	=	„ 15–5— 2

The highest capitalised value here, *viz.*, £ 16-10-0, is obtained at the end of the 30th year, which is tantamount to saying that the age of Commercial Exploitability for the forest in question is 30 years.

If the customary rate of interest for forest investments was 3 per cent we would have the following figures for the capitalised values :—

At 20	years	£ 19—15—0
„ 25	„	„ 21—18—9
„ 30	„	„ 25—18—2
„ 35	„	„ 26— 9—2
„ 40	„	„ 25—12—7

Here then the maximum capital would be realized at the age of 35 years.

Even *à priori* it appears obvious, that to the highest capitalised value capable of yielding a periodic income in perpetuity corresponds the largest income derivable from the capital actually sunk in the forest, and the highest rate of profits. We may nevertheless proceed to prove this proposition, a task by no means difficult. The value of any property whatsoever depends on the income it yields and the customary rate of interest required on their money by persons investing in such property. The value of a field that can be let for £160 per annum, free of all charges, is £160 $\times \frac{100}{4}$ = £4000, if the customary rate of interest in the locality in connection with land under cultivation is 4 per cent. On the other hand, if the customary rate of interest is only 2 per cent, the value of the field is £ 8000. Similarly the value C of a wooded estate, which yields every n years a periodic net income R, is given by the formula as shown above: viz:—

$$C = \frac{R}{(1+i)^n - 1.}$$

Now each of the respective periodic receipts derived by exploiting the forest at different ages is represented by a certain capitalised value. Of the various capitalised values thus obtained, one must be higher than all the rest. That value is the true value itself of the estate after the wood has been exploited, that is to say, of the land with its stools and seedlings; for the land as such would yield to any one the same proportion of income compared to capital invested, since he has only to exploit at the right age. And indeed the estate is bought or sold at that very price, calculated, as it is, by capitalising at the customary rate of interest the income which any one could derive from it; this customary rate is itself a proof of the fact.

But this value is always the market value of the estate at whatever age, judiciously or injudiciously chosen, the owner exploits the standing crop. If any other figure than that corresponding to the highest capitalised value is obtained as income from that forest, it follows that the capital represented by the value of the forest is made to work at a lower rate of interest than that customary in the locality, in other words, at a loss.

We thus see that if we wish to obtain from a forest the largest possible income as compared with the sum sunk therein, we

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must exploit it at the age at which the capitalised value of the receipts is highest. It is the only way to make the investment pay the utmost it can, in other words, yield the local customary rate of profits expected by owners of forests. That rate is really the highest at which money invested in forest property can be made to work. If we exploited before the age in question, the capital value of the land would be excessive compared with the resulting receipts; if we delayed beyond that age, then there would be so much time lost without any compensating financial result.

It is important to know that the lower the rate of profits is, the later will the forest concerned become commercially exploitable. The example given above shows this clearly. Conversely, the more rapidly the periodic receipts increase, the further must the exploitation of the forest be postponed in order to secure a given rate of profits. The reason is that as the amount of compound interest increases in steady progression, the receipts from the forest must also increase in like manner to keep pace with the former. Now the receipts from a forest, from being at first *nil*, increases afterwards with large strides, and this often during a considerable time; but the manner in which it increases is entirely different from that in which compound interest accumulates, steadily and without any limit. Thus it is always a little after the receipts from a forest cease to increase as rapidly as before, that it becomes commercially exploitable.

The procedure to follow in determining the rotation of a forest subject to the conditions of Commercial Exploitabitily is sure and easy. Tables have been constructed giving the value of the expression $\frac{1}{(1+i)^n-1}$ for different values of i and n. Such a Table is that marked III in M. Nanquette's *Cours d'Exploitation.*[1] The only thing left to do is thus to multiply the number taken in any given case from that Table by 3, 4 or 5 several figures, representing the periodic receipts of as many years, and noting the largest product thus obtained. This procedure is much more important than people imagine.. As a rule, forests are cut too early, without their owner being at all aware of the fact. Such proprietors, by recognising their error and exploiting at the right age, would never fail to increase their forest income, sometimes even by as much as 25 or 33 per cent. In actual practice, the determination of the rotation corresponding to Commercial

(1) This Table is reproduced in an Appendix, which see. (*Translator.*)

Exploitability presents certaiu difficulties, which ought to be known in order to be overcome or avoided. As regards the periodic income realisable at any given age, say, for instance, at 25 years, that sum is none other than the value of the standing crop at that age. To determine it by actual experiment, the crop chosen for the purpose should be complete, and placed under average conditions of fertility; without the first condition, the results obtained could not represent the whole sum of production possible, and without the second they could not be applicable to the whole Working Circle generally. All this is a question of appreciation and judgment, which is by no means very difficult to resolve. But often and, we may say, in the majority of cases, crops above the age fixed by the Rotation heretofore adopted, are entirely wanting, and yet we must have them to obtain all the necessary terms of comparison. Under such circumstances there is no alternative but to seek out analogons types amongst the surrounding crops, for it is impossible to picture to oneself, with any degree of accuracy, the future state of a crop, by simply noting its present condition, and arguing from it what the state of the crop will be so many years hence.

We have seen above that the age of Commercial Exploitability varies with the customary rate of profits demanded from investments in forest property. But forests constitute, by their very nature, great properties, which do not go into the everyday market like smaller things. They have, therefore, no well established market value. Hence the determination of the customary rate of profits from forest property is as difficult as it is importaut. The best way to obtain it is generally to take as a starting point the customary rate of profits demanded from investments in cultivated land—farms, for instance, a class of property which has a great analogy to forests. That rate is well known. The next step is to enquire whether investments in forests in the particular locality in question are expeeted to pay a little more or a little less than cultivation; this fixes approximately the rate songht, which is the corner stone of all subsequent calcnlations. Although, with such precautions, we may not be able to determine exactly the age of Commercial Exploitability, yet this much we can certainly do, viz., find out whether it would be expedient to lengthen or shorten the present rotation.

§ 2. *Age of the Commercial Exploitability of Coppice Standards.*

The question to resolve here is to ascertain, for each species in the forest, at what age it would be most profitable to exploit the standards. In the first place, it is obvious that this age must be some multiple of the Rotation adopted for the underwood; and, in the second place, it is no less obvious that the age determined for a single tree will also apply to all other trees of the same species placed under similar conditions of growth.

In order to ascertain after what age the value of a standard ceases to increase at the customary rate of profits obtained from investments in forest property, it is sufficient to compare the amount realisable at each age, on the one hand by felling the tree, and on the other hand by preserving it. By exploiting the tree, its price could be placed out at compound interest at the customary rate, and with the same degree of security as if the tree were standing, while, in addition, a new growth would be coming up on the site of the exploited tree. On the other hand, by preserving it, the tree would acquire an additional value with increased size, which additional value could be calculated, thanks to its older neighbours. As long as that value exceeds the loss of compound interest and new growth gained in the other case, it is profitable to preseve the tree.[1]

(1) Take, for example, the case of an oak standard of average growth, the rotation being 25 years and the customary rate of returns on investments in forest property 3 per cent. Suppose its value at different ages to be as follows.—

As a standard of			25	years.........	1s.
,,	,,	,,	50	,, ...	5s.
,,	,,	,,	75	,, ...	20s.
,,	,,	,,	100	,, ...	60s.
,,	,,	,,	125	,, ...	120s.
,,	,,	,,	150	,, ...	200s.

Suppose the standard of 25 years to be preserved for one rotation; the increased value would be 4 shillings. On the other hand, suppose it to be cut; to draw a comparison, we must balance against the 4 shillings in the first case the total compound interest on 1s. at 3 per cent for 25 years, viz: 1s. 1¼d. + the value of the shoots from the stool of the felled standard, say 2s, total = 3s. 1¼d. Thus there would be a net gain of 10¾d. by preserving the standard of 25 years until it was 50 years old.

In the same manner, as regards the standard of 50 years, we would have on the two sides respectively 15s., and 5s. 5¾d. (compound interest) + say 4s. (value of the regrowth) = 9s. 5¾d. Thus there would also be a gain in preserving the standard of 50 years till its 75th year amounting to 5s. 6¼d.

Similarly by preserving the standard of 75 years for another 25 years, the net gain would be 40s. — (21s. 10½d. + say 6s.) = 12s. 1½d.

But by preserving the standard for 25 years more, that is to say until its 125th year, there would be a net loss equal to (65s. 7¾d. + 8s.)—60s. = 13s. 7¾d.

Thus the oak standards in the forest in question must be cut at the end of the 4th generation *i. e.* at the age of a hundred years, supposing always that present prices continue unchanged.

In practice certain real difficulties are encountered. The first consists in the determination of the progressive value of an average or type tree. This progressive value is the basis of all subsequent calculations. The selecting of the type-tree requires a great deal of *savoir faire,* since there are no two trees that grow alike, especially in an isolated state, and no rule can be laid down to enable one to know that a certain tree 75 years old is the exact counterpart of what a tree, now 50 years old, will become 25 years later.

In the next place, when marking the trees to fall, it is necessary not only to know the age of the various trees from which a selection can be made, but also and chiefly their state of growth. If the veteran of 4 generations or rotations is making poor growth, it cannot acquire that additional value which would constitute a reason for preserving it for another rotation; it must therefore fall. But inversely, if the veteran of 5 generations has a full and ample crown, it is certain to acquire, in the course of another rotation, a value superior to the mean value of veterans of 5 generations, and it may therefore be found profitable to preserve it. It is no inconsiderable advantage to have in a compound coppice coupe a few large trees; they at once raise the value of the whole coupe. Such trees attract eager purchasers, who would otherwise not have come forward, and thus help in disposing of the small wood.[1]

The loss resulting from the cover of the standards need not cause any great concern, when they belong to valuable species possessing a light cover, like the oak, the ash, the service tree, and even the aspen. Near the foot of an isolated oak standard it is a common thing to find some young growth coming up. But such is not the case under a beech or hornbeam tree. The injurious effects of cover diminish as its height increases. In any case the loss sustained by the underwood can be estimated with the eye, by taking out the difference between the quantity that has actually grown under cover in any given case, and what might have grown up had the cover been absent.

The impossibility of foreseeing how the prices of wood and timber will fluctuate in the future is of little consequence here,

(1) To understand the force of this assertion, the reader must remember that in France the produce of an entire coupe is sold standing wholesale. Hence the purchaser must buy the whole quantity or none at all. *(Translator.)*

and the continued rise in the market value of builders' and artificers' wood which is likely to take place, is a sufficient reason for entirely leaving out of account the effects of cover. We may even limit ourselves, in the majority of cases, to comparing the value at different ages of the trunk only, of formed trees, paying no attention whatever to the contents of the small crowns. The calculation thus simplified would still give sufficiently correct results.

§ 3. *Age of Commercial Exploitability of the Timber of a Forest worked by Selection.*

The growth of the trees in a forest worked by Selection is irregular and unequal and often differs to an extreme degree from one tree to another. While one individual has a diameter 8″ at the base at the age of 50 years, another, although measuring no more, may be 100 years old; in other words, there is no definite proportion of any kind between size and age. But as the very first condition of all is to keep the leaf-canopy continuous, the exploitations ought not, speaking in a general sense, to touch any trees but what are already fertile, nor, in a particular sense, any trees but those surmounting a young growth capable of taking their place. This gives us the lowest limit of age at which the forest becomes commercially exploitable. To remain below it would be simply the ruin of the forest and if proprietors, goaded on by a speculative fury, are often led to destroy their forests, it is not with the idea of treating the latter as forest property but as an entirely different class of investment.

Now the trees of a high forest worked by Selection, when they have reached the age of fertility, stand, as a rule, well apart, thanks to the removal of their original immediate neighbours. From this time, therefore, their annual increments can be measured. These increments all tend towards a common mean, if not throughout the whole Working Circle, at least for entire compartments taken in groups. Suppose, for example, that silver fir trees gain a radial increment of 1/10 inch per annum. Granted so much, we can tell how many years it would take for a certain tree to attain a given size or acquire a given market value.

A tree now 16″ in diameter and worth say £1 would, in 20 years, measure 20″ in diameter and be worth £2-8-0. In 20 years more the diameter would be 24″ and the price nearly £5, or double that 20 years previously.

Such data as the above enable us to institute the same kind of comparison between values at different ages, as was pointed out higher up in the case of coppice standards. But we must be very careful that much more is left here to individual judgment than in the latter case, both as regards the determination of the basis of calculation and the application of the method to trees greatly differing in the manner of their growth.

CHAPTER VI.

ORDER TO OBSERVE IN THE EXPLOITATIONS.

Once the exploitable age of a Working Circle has been determined, we know at once what descriptions of produce we may expect to obtain from it. We are then in a position to direct the exploitations in such a manner, as never to cut anything that is not exploitable, a condition that is in reality the very first that every Organisation Project ought to satisfy. But the order in which the various crops should be successively removed is a matter of no little importance. The order in which the compartments ought severally to be taken up, is first of all indicated by the age and promise of the standing stock. But, on the other hand, the location of the coupes is subject to certain special rules, the observance of which is always useful and sometimes obligatory. It thus happens that in order to conform to these rules, it is often found necessary to modify the successive order of the cuttings, which a consideration of the age alone of the crops would require.

The Rules for locating coupes belong to the province of Sylviculture, in works on which art they will be found enunciated and discussed. They have been drawn up in as simple and general a form as possible. The objects to be secured by observing them and the results consequent on their being neglected are clearly defined in such works. These Rules are not, however, entirely cultural in their scope, and belong equally to the subject of Forest Organisation, in which art they occupy an important place. We have already had occasion to refer to them in treating of the formation of compartments and the constitution of Working Circles. And we shall be confronted by them at every new step we make in the theoretical study of Forest Organisation, as well as in the daily practical work of the Aménagiste. We have seen that the limits of age, between which a forest may be profitably exploited, sometimes include within them an interval of a great many years. We can, in a certain measure, exploit early or late, without ceasing to obtain from it the same class of produce as, although it may be of slightly inferior quality to, what we might have obtained by removing the standing material precisely at the right time. A high forest which is required to furnish the highest sum of utility it can yield, may be exploited at any moment between the time when its trees have just attained the first class dimensions of commerce and the age at which they begin to decay. A simple copse worked as a commercial investment may be exploited a few years early or late, according to the fluctuations of the market, or in consequence of accidental circumstances, or even on account of the necessity of having to observe the Rules for locating coupes. We may, therefore, always satisfy all the conditions of the Exploitability adopted and at the same time conform sufficiently closely to the Rules for locating coupes. Besides, each of these Rules may have in certain cases its own special influence in regulating the order of the exploitations.

The First Rule relates primarily to the successive order of the cuttings to be made, and only secondarily to their form. It directs that all coupes shall be laid out on the ground in the successive order in which they are exploited, and be given the most regular form possible. Now nothing could be more simple and natural than to have the cuttings following each other on the ground in unbroken succession, in the order of their respective dates. Such regularity not only secures most important cultural advantages, but without it the other Rules for locating coupes could not be observed. It ensures the exercise of effective control and supervision over the felling operations, which are then concentrated over a manageable area, at the same time that its effect is, by necessarily keeping the woodcutter at a distance, to protect the growing crops. It is the best guarantee we can have that every crop is given the full time it requires for its complete development, since the exploitations cannot return to or near any point until they have successively passed through the whole of the rest of the Working Circle. The necessity of this Rule becomes glaringly obvious in those forests where it has been neglected. The worst disadvantages inherent in the Selection System follow from its unavoidable neglect of this Rule. The origin of the confusion prevailing in our plain forests and of the bad condition in which they are found, is to be traced to the same cause. In those forests, in former times, the old crops went on decaying in certain secluded corners, lost in the midst of the most varied crops. Even at the present day, ill-stocked areas, incapable of any improvement whatsoever, and scattered here and there in the midst of other compartments, are sometimes allowed to stand on, while, owing to the absence of exploitable timber, young and valuable crops are destroyed. In copses the necessity of the First Rule for locating cuttings is so obvious that it is enforced without question before every other Rule, the only exception being when its observance would lead to the felling of timber still far removed from its exploitability.

If, as if often the case, the distribution of the various age-groups does not permit of the observance of the First Rule from one end of the forest to the other, we can still do without such extreme regularity. We need be able to exploit successively in this manner only a whole natural block or a large group of crops, in order to secure all the advantages resulting from an observance of the First Rule. If after this, the felling operations have to go with a bound to some more or less distant point, we sacrifice none of these advantages, provided there again we meet with a similar block or group of compartments admitting of uniformly successive exploitation. Indeed it is rarely that we have to pass from one block to an adjoining one without a break in the succession of the cuttings, and, as a rule, it is much more important in arranging the succession of the cuttings from one block to another, to be guided by the condition of the crops than by their age. It is thus, by taking collective groups of crops or compartments, or, as a rule, cantons, separately one by one, that the First Rule for locating coupes should be applied; in other words, the regularity in the succession of the annual coupes on the ground need not be absolute, but may vary within certain limits according to the forests concerned. On the other hand, when in any block the ages of the various crops are so different, that the First Rule for locating coupes cannot be observed except by neglecting all considerations of Exploitability, that Rule must yield the place to such considerations. The only exception is when the very existence and maintenance of the forest depends on its observance. In the generality of cases, it is enough if we endeavour to secure as much regularity as possible, while attending strictly to the requisite conditions of Exploitability. At the next exploitation either the desired regularity can be fully secured, or a further step made towards its attainment. However it be, we can never hope to obtain an absolute regularity, for during the long lives of forest crops many unforeseen circumstances may always arise to disturb the prescribed regularity. It would therefore be the height of folly to strive to realize an impossibility and sacrifice for uncertain results the growth of valuable products.

The deductions we have drawn with respect to the First Rule for locating coupes, the most important one of all, apply also more or less to the rest. The Second Rule directs that the exploitations shall be distributed in such a manner, that the produce obtained may not have to be carried through coupes recently exploited. The removal of wood, and especially the transport of large logs, requires considerable room in the very midst of the forest. That operation is a fruitful source of injury, often irreparable, amongst coppice regrowth, and, generally speaking, in all young standing timber. The Second Rule for locating coupes thus prescribes the means for avoiding such mischief. In organising a forest, it should be applied compartment by compartment, so that the compartments farthest from roads may be exploited first, as also all elevated portions of steep slopes, the timber from which has to be slipped down, or dragged through the crops lower down. As regards the manner of applying this Rule, each canton or zone of forest situated along a single slope should be considered separately, since it is naturally independent of every other. To speak more generally, this Rule need be applied only by separate groups of compartments, each group being served by the same road or export line.

In copses there is never any crop old enough to allow of carts or timber passing through it without injury. Each coupe of copse must, therefore, possess at least one export road that does not pass through any other coupe. Hence the necessity of extending such coupes right down to a road, so that each road may serve a number of coupes, situated on either side of it; hence also the expediency of cutting bridle paths which also answer the purpose of export lines.

The Third Rule for locating coupes requires that they should succeed each other in the direction contrary to that of dangerous winds. Thus while the First Rule compels the Aménagiste to make his cuttings succeed each other on the ground in the order of their age, the Third Rule prescribes the direction in which they should so follow each other. The winds here referred to are such as are dangerous, either by their violence, or by the steady manner in which they blow, or by the moisture which they bring. The chief object, which this Rule is designed to secure, is to afford the necessary shelter to reserved trees left standing far apart in High Forest Regeneration Coupes by the exploitation of those surrounding them. But even the, so to say, ramparts formed by lofty canopied high forest, are not, once they are breached by the exploitations, proof against injury from winds, unless the latter have no access to them. If, therefore, dangerous winds blow from the South-West, this rampart must be opened by the exploitations only on the North-East side. If such winds come rushing down a valley, the coupes should follow each other from below upwards.

The Third Rule may thus compel the Aménagiste to modify the succession of the cuttings that he may have adopted in any group of compartments before considering it, and the modification may go so far as to completely reverse the order of the successive exploitations first determined upon. Indeed it is easy to conceive that the circumstances of the case may be such that without so reversing the order originally chosen, it would be impossible to satisfy, at one and the same time, the requirements of both the First and Third Rules, while still satisfying the conditions of the Exploitability adopted.

The Third Rule for locating coupes is of universal application both in hill and mountain, and in plain forests. It is not only useful for the preservation of standing forest, but it also favours reproduction and growth in many ways. Shelter, often a necessity, almost always of great utility, exercises its action a considerable distance off. In level country this action is felt over a belt of ground, the width of which is 20 times the height of the sheltering object. Thus a mass of canopied forest 80 feet high protects from the wind the adjoining land over a breadth of 1,600 feet. The beneficial effects of shelter are as great as the injury caused by cover over a narrow strip of a few yards is slight; as a rule, while the former are always clearly perceptible, the latter is not noticed at all. This was not the place to insist on that fact, were it not for the necessity of proving beyond dispute the general utility of shelter in Forest Conservation. This utility is more or less great in simple copses according to their situation; it is very great as regards the standards of compound copses. In high forests the presence of shelter is a necessity for the Regeneration Coupes; in conifer forests it is the first condition for successful reproduction both because it prevents the reserved trees from being blown down and because it favours the sowing of the ground and the protection of the soil. At high elevations the necessity of shelter is so great that it renders the consideration of all other requisite conditions entirely secondary; there the presence of constant shelter becomes necessary to the very existence of the forest, and this circumstance may necssitate the adoption of the Selection System, when the configuration of the ground alone does not afford the required shelter.

Thus the observance of the Third Rule for locating coupes is obligatory under the most various circumstances. In applying it, each independent, naturally sheltered portion of the Working Circle should be considered separately. It is rarely necessary to take up the whole of the Working Circle *en bloc*, in such a manner as to be unable to stop the exploitations at some one spot in order to resume them at another. But it must be observed that the continued neglect of this Rule can only be repaired with the utmost difficulty. Indeed it might happen that the only way to effect it would be to take up the coupes in the reverse order at the next series of exploitations, a circumstance which the succession of the age classes on the ground would nearly always render impossible.

The Fourth and Fifth Rules for locating coupes refer solely to hill forests. The former directs that all exploitations on sloping ground shall begin at the bottom and work successively upwards. The reason of this is, that in hilly country the effects of the wind on forests become more dangerous as the elevation increases on the same slope. By cutting from the bottom upwards, the portions of the forest under regeneration are protected by the standing canopied mass above it, while they at the same time receive the seed shed by the latter. According to this Rule a group of compartments forming a continuous belt on the same slope must be worked from the bottom upwards. The Rule in question is excellent, provided the gradient of the slope is not too steep. On slopes so steep that wood cut on the upper portion could not be removed except by having it dragged or slipped through the portions below, the young growth in these latter must inevitably be destroyed, or at least suffer considerable injury. This happens on all slopes which we have qualified as steep *i. e.* which exceed 1 in 3. In that case the Fourth Rule has to give way to the Second and the exploitations must begin at the top with certain precautionary restrictions to be now described.

When the slope runs up to a considerable height, it is seldom that it is not divided off into terraces, each terrace containing a road or path running more or less horizontally, or offering capabilities for the construction of such road or path. Each such terrace thus forms an independent, compact mass of forest as regards the removal of the standing timber. The Organisation Project should, therefore, fix the exploitation of the successive terraces according to their relative position, beginning with the lowest in accordance with the Fourth Rule; but for each taken separately, the observance of the Second Rule may require the exploitations to work from the top downwards.

In any case, an excellent plan, when the slope is wooded right up to the top, is to maintain intact a belt of forest at the highest point, broad enough to resist the force of the strongest winds, while the lower portions are being exploited. In elevated situations, such protective belts can only be worked by Selection. When the climate is not very rigorous, they may be completely cleared last of all.

The Fifth Rule for locating coupes requires them to be long and narrow, and to present their least dimension for the wind to impinge upon. It is only an extension of the Third Rule. It may be usefully observed in copses, but its chief *raison d'être* is in hilly or mountainous country. But it is connected more with the laying out of the annual cuttings, which is an operation to be left to the discretion of the executive officer, than with the general prescriptions of the Organisation Project. However useful the object of this Rule may be, it is necessary, in spite of it, to avoid giving the compartments or cuttings on a slope too great a length in the direction of the slope, especially when that is very steep. Otherwise all work would become very costly and even the Organisation Project might be detrimentally affected thereby. It is better, under such circumstances, to divide the slope off by one or two lines running transversely to the direction of the slope and forming, whenever possible, practicable export roads.

We thus see in how various and complex a manner the Rules for locating coupes enter into the organisation of a forest. Often the conditions they impose are satisfied without any intention or consciousness on the part of the Aménagiste, but not unfrequently they are, in like manner, altogether neglected. A special study of the various parts of an Organisation Project, moreover, shows how intimately those conditions enter into the economy of a forest.

BOOK III.

THE WORKING SCHEME IN THE ORGANISATION OF HIGH FORESTS.

GENERAL NOTIONS.

HAVING decided what Régime, Method of Treatment, and Rotation or Age of Exploitability to adopt for an entire forest, or for each of the several large masses which compose it, the next step is to prescribe the series of exploitations that must be made in each compartment, to fix their serial succession for the whole of each Working Circle, and to ascertain the annual yield. This work constitutes what we will call the WORKING SCHEME; it is the very pith of the Organisation Project, and is the law which is to govern the foresters charged with the execution of that Project.

The Working Scheme is generally drawn up in tabular form embodying in one or two statements the prescriptions relative to the exploitations, so that any one may take in the whole series at a glance. The particular form differs according to the method of treatment to which the Working Circle is subjected, since the nature and succession of the cuttings, as also the manner of determining and expressing the yield, necessarily vary with the method of treatment.

High forests worked by the Natural Method yield extremely variable products according to the age and dimensions of the wood cut. The timber removed in the Regeneration Fellings comprises, what we will term, the PRINCIPAL PRODUCE of the Working Circle. The Improvement Cuttings, which are made while the forest is growing up, yield produce of minor importance, which we will designate the ACCESSORY[1] PRODUCE of the Working Circle.

In foresters' parlance, we thus include under the name of PRINCIPAL PRODUCE the timber obtained from the series of Reproduction or Regeneration Fellings, and usually also windfalls and dead standing trees; while the ACCESSORY PRODUCE comprises all the wood cut in the thinnings and weedings, or, speaking in general terms, in the Improvement Cuttings.

In high forests worked by the Natural Method, the yield of principal produce is expressed in cubic measurement. With equal areas exploited annually, the quantity of material obtained would often differ very considerably from year to year, while it would besides be impossible to predict, within several years, the date of the appearance and establishment of the new generation of seedlings, for the favourable development of which the number of the reserved trees acting as nurses must vary from point to point, according to the quantity of light required. Every attempt hitherto made to fix the yield of high forests by area has ended in unsatisfactory and, often, even disastrous results. On the other hand, it is expedient to base the yield of the accessory produce of a Working Circle on area, and not on cubical contents. The advantages attaching to this procedure are many; it is more simple, it is the surest means of securing the return everywhere of the thinning operations at the right time; it is the only way of preserving for these operations their essential character of Improvement Cuttings, since it leaves to the executive officer complete liberty of action as to the quantity to exploit, his only pre-occupation being how best to improve the growth of the forest.

The Working Scheme must satisfy several essential conditions. In the first place, it must, as far as is practicable, be so drawn up that each compartment may reach its turn for regeneration more or less near the age fixed for the exploitability of the forest. It must,

1.) This class of produce, accessory both from the Sylviculturist's and Aménagiste's points of view, must not be confounded with the class of produce termed also *accessoire* in official language. This latter word is used for produce, whether ligneous or otherwise, derived from communal forests, and which are not liable to the Government charge of 5 per cent. for cost of administration. In the state forests such produce is termed minor produce.

moreover, distribute the annual exploitations of principal produce according to the requirements of the Rules for locating coupes.

Again, it is very important that the annual outturn should be sufficiently equal during the whole rotation. This condition of a sustained yield may be realized in high forests worked by the Natural Method, by exploiting during equal periods either equal quantities of produce or simply equivalent areas ,*i.e.*, areas of equal productive power. Here we observe the point of departure for the two different methods employed in the drawing up the Working Scheme for such forests, which constitute as many different methods of Forest Organisation. One of these, comprising several modes of procedure, we will call the VOLUMETRIC METHOD, the other we will term the METHOD OF EQUIVALENT AREAS. We shall examine each method separately; but before proceeding to do so, it is necessary to define clearly the practical value of the fundamental idea that essentially underlies them both, namely, the realisation of a sustained yield.

CHAPTER I.

A SUSTAINED YIELD.

IN high forests, the yield of which is based on volume, it would seem possible to realise the condition of a sustained yield by dividing the total quantity of the timber to be felled during the course of an entire rotation by the number of years in the rotation. But this quantity would include not only the actual contents of the standing timber, but also the total annual increment of each crop up to the time of its exploitation. Now it is impossible to estimate with any degree of exactness the future increment of crops, that are still to grow on for a long series of years, up to the time they reach their turn for exploitation. It is for this reason that it is a point of doctrine in forest organisation to divide the rotation for high forests into a certain number of periods, and to estimate successively beforehand the yield of the given forest during the currency of each of them. To this end, the exploitations to be made during the course of the rotation are arranged in their order of succession and grouped together according to the periods into which they fall, in such a manner as to obtain as nearly as possible equal quantities of produce in equal periods of time. This distribution of the annual exploitations may be effected either according to volume or to area, and it is in this that lies the distinctive character of the two methods of forest organisation. The next step is to determine the annual quota of the produce to be exploited during the first period. The same process is repeated at the commencement of each of the following periods of the current rotation, and, if on passing from one period to the next, the calculated yield of the forest is found to be appreciably the same as it was for the First Period, it is clear that the yield is a sustained one; conversely, if the conditions necessary for assuring a sustained yield have been correctly determined and established, the annual yield of the forest cannot vary, or, at the worst, it will differ but little from period to period.

To assure a sustained yield and to estimate at the beginning of each period the annual yield during that period are thus two perfectly distinct operations in the organisation of a high forest. The first, which is the more important of the two, consists, we have said, in the proper distribution of the exploitations between the periods of the rotation. Now in whatever way the distribution is made, it stands to reason *à priori* that it is impossible to succeed at once in perfectly equalizing the total quota of produce for each period. The problem of assuring a sustained yield is thus not only a difficult one, but also one, of which we can obtain only an approximate solution. It even often happens that it is impossbile to assure a sustained yield without having to exploit a certain number of the crops either too late or too early. It thus becomes a question of importance to ascertain, from the very beginning, how far it is the interest of the proprietor of a given forest to secure a sustained yield and thus have the annual or periodic quota of produce equal.

The limits between which the yield of a forest may vary, while still remaining sufficiently uniform to be considered sustained, depend on the condition and situation of the forest, and, above all, on the character of the proprietor.

If the proprietor is a private individual, his main object will be to obtain the largest pecuniary profits from his property. As a rule, he will not pay any attention to the equalization of the annual or periodic quota of produce, and will admit no other principle but that of the satisfaction of his own personal wants and the increase of his wealth. He will exploit and sell on a large scale when the demand is high, and will diminish or entirely suspend his exploitations when the market is dull and prices low.

Nevertheless, if he possessed a real forest, which would ordinarily form no small part of his wealth, he could not afford to neglect all considerations of a sustained yield by suspending his exploitations, unless he was in a position to obtain from some source other than his forest the annual income which he required. Such a happy combination of circumstances is, however, the exception and not the rule, and the necessity of having a sustained yield is only too often felt by him in its fullest force, the result being premature exploitations at the sacrifice of capital and income in the future.

If the owner is a Public Foundation or a Commune or Muincipality, it is necessary to determine the capacity of its forest, and assure the yield being sustained as accurately as possible. It is obvious that the Commune is an imperishable collection of individuals, every generation of which has an equal right to enjoy the income derived from the communal property, either by receiving its own share of the produce, or by selling it in order to cover the annual budget expenditure. The same is the case with Public Foundations. But Communes and Public Foundations both partake of the same character as the State as regards their constitution, while they resemble the private individual in that they are subject to constantly pressing needs, since their resources are, as a rule, limited, and are often represented wholly by the produce of their forests. Every year their budget expenditure is based upon the quantity and value of this produce. It thus becomes important to correctly determine in advance the annual quota of such produce, which must on that account vary as little as possible from year to year. Besides this, it is indispensable to preserve and to save up resources in ordinary years in order to provide against future unexpected contingencies. The law itself has provided for this by ruling that one quarter of the forest of every such proprietor shall be reserved in view of extraordinary wants. Very often the condition of assuring a sustained yield, which places an effective check on immoderate cuttings, becomes an essential guarantee for the preservation of a communal forest. It is for this reason that the Royal Edict putting into force the Forest Code, while refraining from laying Communes under the obligation of organising their woods with a view to increased production and the rearing of high forests, has at least fenced round the exploitation of their forests with wise restrictions. To respect these restrictions is of the highest importance.

Lastly, in the case of forests belonging to the State, the question of assuring a sustained yield may be subordinated to the treatment which the crops stand in need of. There can be no dispute that the duty of the State is to bring into existence the largest quantity possible of produce required for the daily wants of the population, as well as to guarantee an adequate supply of timber for large civil and naval public works. The state forests ought, therefore, to be subjected to that Régime and Exploitability, which, taking into account the constituent species and the special conditions of vegetation, shall guarantee the production of the most useful material. It is moreover evident that as the wants of the State and of Society, which is co-extensive with it, are ever changing, the state forests ought to be able to satisfy for all time, within the limits of the possible, the multifarious wants of the nation. It thus follows, firstly, that these forests ought to be so worked that the exploitations are annual and the quantity of produce the same from year to year; and secondly, that in treating and working those amongst them which are composed of the more valuable species, there ought always to be a certain number of reserved trees fit for exploitation at any moment. The object of maintaining this Reserved Fund of standing timber is to provide against unexpected demands, like those of the navy and the army in time of war.

Such are the principles on which must be based the determination of the quota of the annual cuttings in state forests, principles the application of which would be easy, if all these forests were regular and composed of the better species, and if each one was subjected to the Régime, Method of Treatment, and Rotation that suited the most valuable of those species. But many of them are irregular and composed chiefly of inferior species, or are exploited at an age and according to a method of treatment which do not obtain from them the highest sum of usefulness that they could yield. Hence, it is necessary first of all to improve the actual constitution of these forests, and to bring them little by little into a better condition.

To effect the transformation or improvement of a forest, there is often no alternative but to neglect for some time the condition of a sustained yield, in order to carry out in a successful manner the cultural operations. Still this neglect of one of the fundamental principles of forest economy may prove in the end to be more apparent than real; for, if, instead of considering the particular forest by itself, we take into account the production of all those situated round the same centre of consumption, we shall often find an equilibrium established on the whole by compensations between restricted cuttings on the one side and abnormally large cuttings on the other. Often also, in organising any given forest, it is possible to combine the exploitations in its various component Working Circles in such a manner, as to have the general yield of the whole forest appreciably the same from period to period. Let us in the last place add that the continuous improvement of our export lines and roads allows of a more equal distribution of forest produce throughout the country, and of its easy export from one district to another, so that the supply at once responds to the demand.

To summarise what precedes, we see that it is necessary, in organising high forests, to endeavour to combine the exploitations in such a manner, as to obtain sufficiently equal quantities of produce in equal periods of the rotation. Nevertheless, if in any given forest there is no exploitable timber at all to be found, it is certainly better to wait till the older portions of the standing stock are completely mature, than to fell them when they are, as it were, on the eve of acquiring all their finest qualities. If, on the contrary, old timber is abundant, while the age-class next below it is insufficiently represented, it is expedient to distribute the exploitation of this old material, already exploitable though it be, over the first two periods of the rotation, in order to reserve for the next generation the supply of large timber which it will require, and to allow the younger crops sufficient time to reach maturity.

The reason is obvious, for the production of large timber is the chief *raison d'être* of state forests, since all other descriptions of ligneous produce can be obtained from communal and private woodlands as well. The main duty of the Forest Department is thus to economize as much as possible what timber is still left in the state forests, and to be careful not to abandon to the axe vigorous well-formed and flourishing trees before they have attained exploitable dimensions. This recommendation of ours refers chiefly to our two principal species, the oak and the silver fir, which in our climate yield timber of a quality far above the average. Our state forests, such as they have come down to us, can furnish only a small proportion of the large timber required by the country, and we are reduced to go the foreigner for a considerable portion of our supply of timber suited for the cabinet-maker and the cooper. The wants of the former are supplied from the countries round the Baltic, those of the latter from the countries on the Adriatic. Now we know on unimpeachable authority that the forests in the neighbourhood of those two seas are becoming impoverished and exhausted, and at no distant date, perhaps in less than a half a century, this source of supply will completely cease to exist. It is necessary, therefore, now more than ever, to apply ourselves with all the means at our disposal to the production of large timber, even if to attain that result we had for the present to forego a portion of our forest revenue and to neglect for a time, comparatively short after all, the condition of a sustained yield in our high forests.[1]

(1.) The forest of Fontainebleau offers to the observer at the very gates of Paris a sight full of instruction. Out of a total area of 42,500 acres about 2,500 acres are under full-grown high forest, 5,000 acres under pole crops from 50 to 90 years old, and 32,500 acres under copse and young pine plantations, while more than 2,500 acres consist of the bare rock. Thus out of a total productive area of 40,000 acres, only 2,500 acres contain old timber. These chiefly cover the fine cantons that are reserved in the interests of the artist. But had there been no special reason for conserving these high forest crops, it would have been not less expedient, in the interests of the forester, not to touch them except with the most sparing hand. It would be advisable to spread their exploitation over as long a period as would suffice to allow the next lower age-class over some considerable area to reach a large size. For what would happen if, to secure a sustained yield, a quantity equal to the mean annual production of the forest were taken out every year? In less than 10 years every vestige of the full-grown high forest would have disappeared. In another ten years the pole crops would have suffered the same fate, and by the end of the present century the memory itself of the large timber now standing would have passed away with the generation that had seen it all felled. In those days perhaps people would refuse to believe that the sandy soil there could produce tall high forest, and for time without end this forest would be devoted to utter ruin. The most rigid economy is now the one indispensible guarantee for the future prosperity of this fine forest, and the question of a sustained yield must be subordinated to that of the proper exploitability and the requisite rest.

But it must not be thence inferred that there are cases, in which the condition of a sustained yield may be entirely disregarded, and to such extent as to suspend the exploitations for a time, or even only to reduce them to the lowest figure possible. To understand this, a moment's reflection is enough. Suppose, for example, that at Fontainebleau the income, reduced to £4,000, is barely sufficient to cover cost of supervision and maintenance, and yields no immediate profit to the State Treasury, or that the produce extracted is too inconsiderable to supply the town inside the forest with wood for the most ordinary purposes, such as cooking, &c. Such a state of things could not continue for any length of time. Very soon there would be a reaction, and a too parsimonious organisation would be partially or wholly set aside. Besides this such excessive rigour is quite useless. There is no forest, however poor it may be, but contains some crops that hold out little promise, and which can be cut, without detriment to the forest, so as to yield a sufficient supply of secondary produce. Thus the condition of a sustained yield is always to a certain extent imposed on the Aménagiste, and some means always offer themselves by which it may be satisfied. Only to judge the right extent and to recognise the true means require on the part of the Aménagiste an unfailing power of appreciation and a thorough knowledge of facts.

CHAPTER II.

THE VOLUMETRIC METHOD OF ORGANISATION.

SECTION I.

DESCRIPTION OF THE METHOD.

THE various volumetric methods of forest organisation are based on the division of the rotation and the quantity of produce into equal and corresponding portions. Among these methods we will describe that of Hartig, from which all the rest have been derived and which gives a good general idea of them all. To estimate the total quantity of produce that the forest can furnish, it is indispensable to know beforehand when each of the crops composing a Working Circle will be fit to cut. The Aménagiste is thus obliged to make a forecast of the various ages at which the different crops should be exploited. The rotation having been determined and the order of the successive annual exploitations fixed provisionally, this forecast naturally follows as the next step. Dividing the rotation into a certain number of equal periods, the Aménagiste must make a trial distribution of the various compartments amongst these periods taking care to follow, the order indicated by the age of the crops and the Rules for locating coupes. This distribution takes the form of a tabular statement, divided into as many compartments as there are periods in the rotation, and which we will call the TRIAL WORKING SCHEME. He must then estimate the quantity of produce which each compartment of the forest is likely to yield during the course of the different periods. A separate estimate must be made for the principal and the accessory produce, for the first by supposing that each compartment will be regenerated towards the middle of the period to which its exploitation is assigned, for the second by adding together the quantity of material that is likely to fall in each compartment in the thinning and other improvement operations during the several Periods of the Rotation.

This done, the Aménagiste must next sum up the total quantity of produce that would be obtained in each of the various Periods. But as these sum totals can never, save by a very exceptional chance, be equal to one another, he must set about equalizing the quantities to fall in each Period by transfers from one compartment of the Trial Working Scheme to another, taking care that he does not thereby anticipate or put off till too late the exploitation of the crops so transferred. The first distribution of the compartments amongst the various Periods of the Rotation being thus altered, the result is a second Tabular Statement which we will term the FINAL WORKING SCHEME, or simply The Working Scheme.

Then by dividing the total quantity of produce to be exploited during the First Period by the number of years in that Period, he obtains the annual yield, i. e. the number of cubic feet to be removed each year from the whole Working Circle both in the Regeneration Fellings and the Improvement Cuttings.

SECTION II.

APPLICATION OF THE VOLUMETRIC METHOD.

The preceding analysis of the Volumetric Method shows that it requires two principal operations:—(i), the quantitative valuation of all the timber to be exploited in each compartment, both in the Regeneration Fellings and Improvement Cuttings during each of the Periods of the Rotation; (ii), the equal distribution of this produce amongst the various Periods.

We have stated above that before beginning any of these operations the compartments must be provisionally grouped together according to the Periods during which they would be severally regenerated, if nothing more but their age and the Rules for locating coupes were taken into account. Now as the standing timber has to be felled in equal quantities every year, we may, for purposes of calculation, suppose each compartment to be regenerated towards the middle of the corresponding Period. This enables us to determine, first, the probable quantity of the principal produce which each compartment will yield during the Period in which it will be regenerated, and, second, the respective years in which the various compartments will be subjected to improvement operations and the probable quantity of produce which each such cutting will furnish.

Let us first note that these figures cannot be arrived at without complicated calculations as to the quantity of the standing material and its future increment. It is necessary to estimate not only the quantity of produce which each crop will furnish at its regeneration, but also what each compartment would yield in the thinning and other operations during the various Periods of the Rotation, before as well as after the time fixed for its regeneration. In whatever way these quantities may be obtained, they must be totalled up by Periods. But the original distribution of the compartments having been effected solely with regard to their age and the order of their successive exploitation or regeneration, without any consideration as to the extent or density of the crops grouped together under each Period, it follows that in the Provisional Working Scheme, the periodic quantities are necessarily very unequal. Hence, the necessity for equalising them by judicious transfers of certain crops from one Period to the next above or below it.

To effect this equalization, the quantities of both principal and accessory produce for all the Periods of the Rotation, as shown in the Provisional Scheme, are totalled up. This grand total is then divided by the number of the Periods, and the quotient thus obtained gives the quota of produce to exploit during each Period. For instance, if the total quantity for the whole of a Rotation, divided into four Periods, is 5,000 000 cubic feet, then the quota for each Period would be 1,250,000 cubic feet. If (to continue our illustration), according to the Provisional Working Scheme, the quantity of produce that may be cut in the First Period is 1,500.000 cubic feet instead of 1,250,000, the former figure must be reduced to the extent of 250,000 cubic feet by transferring the compartments to be regenerated last to the next following Period. If, on the other hand, the total produce for the First Period according to the Provisional Scheme was only 1,000,000 cubic feet, then 250,000 cubic feet would have to be added to it, by transferring to the First Period a sufficient number of the compartments to be regenerated according to the Provisional Scheme, at the commencement of the Second Period. The same process is continued for the other Periods until an equal distribution has been made. But easy as the process seems, the final result is arrived at only after a great deal of careful manipulation, of trial transfers and calculations; for each transfer means that the time for regenerating the compartments concerned is changed, the yield both of the Prinicipal Fellings and the Improvement Cuttings being thereby altered. The effect of this is to obtain each time a new figure for the total produce to be felled during the whole Rotation. Going back to the case we have taken for illustration, the total quantity of produce after the transfers in question have been effected may be reduced to 4,800,000, and the periodic quota thus become 1,200,000. In any case, it is only in determining the quota for the last Period, when the yield of all the remaining compartments is added up, that the effect of the changes can be fully appreciated and it be decided, according to the extent of the resulting difference, whether these changes may be considered final and be accepted for the Final Working Scheme, or a fresh series of transfers be undertaken in order to arrive at a more approximate equalization. In the latter case, the Periodic Distribution Statement last obtained must be considered as a fresh Provisional Working Scheme, and the process described above repeated.

SECTION III.

Value of the Volumetric Method.

The operations of a forest organisation based on the Volumetric Method are necessarily very complicated. They imply the quantitative valuation of all the standing material in the entire Working Circle; the estimation of the future increment of every crop up to the moment of its exploitation; and, lastly, the determination of the quantity of accessory produce that will be furnished during the current Rotation by the crops, which will have taken the place of those regenerated early enough in the Rotation, that is to say, crops that have no present existence whatsoever. Indeed, it is the very essence and spirit of the Volumetric Method to determine the annual yield by taking into account every kind of produce realizable.

In practice this method inevitably yields uncertain results, for how is it possible to estimate the future increment, for an interval of time as long as 50 or 100 years, of crops now much below the age of maturity? Whatever procedure is adopted, it can offer no adequate guarantee of accuracy.

This uncertainty of the results obtainable could not, of course, escape the originators of the method; and, in order to avoid an undue accumulation of errors necessarily arising from a too low or too high figure fixed for the annual yield, they laid down the rule that the Working Scheme was to be frequently verified, every 10 years for instance. These frequent verifications are a necessary concomitant of every system of forest organisation based on volume. They amount to the drawing up each time of an entirely new Working Scheme, since it naturally follows that all the original crops must have undergone radical and characteristic changes since the date of the previous Working Scheme. The consequence is the inevitable instability of the prescriptions relative to the treatment of the forest, and indeed of the whole of the Organisation Project itself. The time for exploiting any particular crop, as it depends on the figure of the annual yield, of course varies with it; and it may thus happen that all the operations now prescribed for any compartment may have to be changed at the next verification. These disadvantages, which are inherent in the method itself, would of themselves suffice to justify its condemnation, especially in France where the desire for order, simplicity, and stability in forest organisation had led to the universal adoption of the system of *Tire et Aire.* But all volumetric methods must be rejected on account of the very principle they imply. Basing, as they do, the distribution of the exploitations entirely on the element of volume, they have for essential object the exact determination of the annual yield. As a matter of principle, they seek to obtain a sustained yield independently of all considerations relative to the improvement of the forest. Whether the quantity of old timber is excessively large or totally insufficient, a certain fixed quota of it must be worked out every year. In the former case the last old trees will be found in full decay by the time their turn for exploitation comes; in the second case, after a few years all the old timber will have disappeared and the felling operations will then perforce include trees still far removed from their maturity. Thus all the various systems founded on the Volumetric Method subordinate the production of the most useful timber to the condition of assuring a sustained yield.

The same is the case as regards the treatment of the forest, since these systems lead to the regeneration of some of the crops either too early or too late (both unfavourable conditions), and to the execution in them of Improvement Operations either in complete uncertainty as to the time for their regeneration, or, in the contrary case, in view of Regeneration Fellings to be made at some time other than that of their maturity. Now, in our high forests of the more valuable species, the treatment, and the cultural operations which this treatment requires, are often of far greater importance than the mere equalization of the yield. It is thus in our oak forests, in our numerous irregular high forests, in our silver fir forests which were formerly worked by Selection, and especially so in our copses under conversion into high forests. In principle, therefore, the Volumetric Method is radically defective.

The Volumetric Method has never been adopted in France. It had its *raison d'être* in Germany at the end of the last century. The forests there were in those days very irregular, and frequently contained no well marked gradation of age-classes. A great number of these were high forests abounding chiefly in beech, and belonging to petty principalities. They furnished a very considerable proportion of the receipts of the prince's exchequer. It was impossible to subject them to the Natural Method with the annual exploitations based on area, without compromising very considerably the equality of the annual returns. Besides the advantage of securing this equality, so necessary in such forests, Hartig's method of forest organisation possessed another great merit: it was the first step towards the regular organisation of high forests. Its inherent defects were soon discovered; its application, and criticism of the results obtained, showed at one and the same time these defects and the manner of correcting them. The Method of Forest Organisation by Area followed as a necessary consequence. This method has been formulated and developed in France according to the special necessities of our forests, and has been taught at our Forest School for many and many a year.

CHAPTER III.

FOREST ORGANISATION BY AREA.

SECTION I.

DESCRIPTION OF THE METHOD.

The Method of Forest Organisation by Area is based on the twofold division of the Rotation and of the Working Circle into equivalent or corresponding portions. It begins, by first dividing the Rotation into a certain number of, usually, equal Periods, and then the Working Circle into as many portions, each to be regenerated, in regular succession, during the respectively corresponding Period. These portions of the Working Circle we will term PERIODIC BLOCKS. They are intended to be exploited in equal periods of time, and ought therefore to be so formed that they may, as far as possible, furnish severally the same yield.

The correlative division of the Rotation into Periods and the Working Circle into Periodic Blocks must be made according to certain rules, which we will examine further on.

It is generally exhibited in the form of a table, in which the various compartments belonging to the several Periodic Blocks are grouped together according to their respective Periods, the characteristic letter and area of each compartment being duly entered. This table is thus a general skeleton plan of the exploitations, and constitutes what we shall call the General Working Scheme. Being drawn up once for all for the duration of a whole Rotation, it should contain nothing more than what concerns the simple composition of the Blocks, *i. e.*, give the compartments of which they are composed and the order in which they are to be regenerated.

But these meagre indications would not be enough to serve as guidance for the Executive Forest Officer. It is therefore necessary to complete them by prescribing the nature, succession, and extent of the exploitations to be made throughout the whole Working Circle. The portion of the Organisation Project which gives these details, we will designate the SPECIAL SCHEME OF EXPLOITATIONS. It consists of one or more tabular statements, in which are consigned prescriptions relative to exploitations to be made during a single Period only.

Thus, whereas the General Working Scheme applies to the whole duration of the Rotation, the succession of the cultural operations, and the annual yield are fixed for one Period only. It follows, therefore, that at the beginning of each Period it is necessary to draw up a fresh Special Scheme of Exploitations, that is to say, to arrange in advance the succession of the cuttings and similarly as before the annual yield for that Period. This last operation, in its entirety, may be termed the PERIODIC REVISION OF THE ORGANISATION PROJECT.

Lastly, in order to provide against errors in the valuation surveys and against the effects of unforeseen disasters, it is the rule to verify the quota of the annual yield once or oftener, at fixed intervals, during the currency of each Period.

Having thus far described summarily the Method by Area, we will now proceed to show how to apply it to high forests that are to be treated according to the Natural Method.

SECTION II.

FRAMING OF THE GENERAL WORKING SCHEME.

The framing of the General Working Scheme for a high forest organised by area consists wholly in the division of the Rotation into Periods and the Working Circle into corresponding Blocks.

As regards the Periods, it is, for the sake of simplicity, taken for granted that they shall be equal. Now being equal, what ought their duration to be? We proceed to answer this question.

It has been a subject of much vehement discussion, and yet the answer to it seems to us very simple. It is the rule that all the crops brought under regeneration during any Period must have their regeneration completed during that Period. Now in the majority of our forests it is impossible to effect, in a satisfactory, complete, and sure manner, the regeneration of a mass of high forest treated according to the Natural Method, without exercising great caution and judgment in locating the Primary, Secondary, and Final Fellings. Hence the necessity of making the Periods long enough to give the Executive Forest Officer sufficient time to complete the Secondary and Final Fellings with the care, precautions, and deliberate slowness, which can alone assure the success of such operations. On the other hand, the duration of the Periods ought not to exceed the number of years beyond which one could not forecast, with a sufficient degree of certainty, the cultural operations that the condition of the forest would require. These extreme limits for the length of Periods seem now to have been fixed by experience at thirty and forty years respectively, and it can only be by exception that there would be advantage in going above or below those figures. If we had a silver fir forest, the exploitable age of which was fixed at 150 years, we could divide the Rotation into five equal Periods of 30 years each, this duration of time being necessary and sufficient for a complete series of regeneration operations.

Hand in hand with this the Periodic Blocks have to be formed. To this end, the compartments, the regeneration of which is urgent (that is to say, those, as a rule, which contain the oldest stock), are, first of all, placed in the Block of the First Period, the next oldest compartments in the following Block, and so on up to the last Period, in which must be grouped together the youngest crops. The aim of the organisation must hence be to bring each compartment under regeneration as near as possible the term of its exploitability. But in distributing the various compartments thus, the fact must not be lost sight of that the Regeneration Exploitations should follow the Rules for locating coupes. And as the essential points enforced by these Rules cannot be satisfied except by laying out the coupes in the order in which they are to be exploited, it follows, as a matter of principle, that each Block should be formed of contiguous compartments, or of compartments forming together one continuous mass of forest.

Conversely, the large continuous masses of more or less uniform forest as regards age, into which the compartments naturally group themselves (one group consisting of old timber, another of middle-aged timber, a third of young timber, and so on,) determine the number and position of the Blocks, and, as a consequence, the number and length of the Periods. If, for example, the silver fir forest taken for illustration higher up contained four almost equivalent groups of crops, well defined on the ground and presenting four principal age-groups, we would naturally divide the Working Circle into 4 Blocks and the Rotation into 4 and not 5 Periods. And as the figure there adopted for the Rotation is not an exact multiple of 4, it would be necessary, if it was found expedient to have equal Periods, to reduce or increase that figure so as to make it an exact multiple, a contingency of little consequence as respects a fir forest, which becomes exploitable *towards* the age of 150 years, *more or less.*

In the case which we have been considering, we have supposed that the four Periodic Blocks naturally marked out on the ground are of equal extent or of equivalent productive power, and capable of yielding the same quantity of produce when exploited each in its respective turn for regeneration. A sustained yield is thus assured, as far as that is possible, for the whole term of the Rotation, and the Working Scheme drawn up on this basis fulfils the three principal conditions it must satisfy.

It is seldom that the formation of the Periodic Blocks can be effected under such simple circumstances. For the most part the crops belonging to the principal age-groups are not distributed in a sufficiently convenient manner for this purpose in each Block. Sometimes certain age-groups are even entirely wanting, so that, in order to be able to secure a continuous series of exploitations, there is no alternative but to collocate in the Period of the Rotation corresponding to these age-groups, crops that are either too old or too young for the purpose. In the presence of such difficulties and of a great many others which it is impossible to enumerate, but which are met with in nearly every attempt at forest organisation, the Aménagiste may find himself no little embarrassed. The consequence is that it is difficult to arrange in advance for more than one Period the succession of the Principal Fellings to be made in any Working Circle, and still more so, to forecast the yield of each Period of the Rotation. Nevertheless without seeking to effect a perfect equalization between the yields of the various Periods, it is at least necessary to form the Blocks in such a manner as to avoid too great a fluctuation from Period to Period. This object is usually attained by assigning them equal areas or, in some special cases, areas in inverse proportion to their fertility.

Thus by employing the simple procedure we have described for drawing up the Working Scheme, it is not always possible to ensure a very steady yield for the whole duration of the first Rotation; but if each Block is regenerated in its entirety and in its right turn during the Period assigned for it, the whole Working Circle will be found at the end of that Rotation to be composed of a complete series of graduated age-classes. Such a result is undoubtedly one to be desired. Nevertheless it is not to be sought by exploiting any valuable crops that may exist, long before they become exploitable. The reason is evident, for the essential object to be kept in view in organising any forest is, above all, by fixing the successive order of the exploitations, to make the most of existing crops and not to create at any price a perfect series of crops of well graduated ages—in other words, bring about the Normal State itself.

That state, which the organisation of every forest ought to endeavour to make it approach as closely as possible, is in reality a pure fiction. No forest, during the course of a whole Rotation of any length, can avoid escaping damage from various causes that suffice to compromise the existence of certain crops, break up the serial gradation of ages, and upset some of the provisions of the Organisation Project. When, therefore, in drawing up the General Working Scheme it is found necessary to include in the same Block crops of widely differing ages, it does not necessarily follow that all these crops need be exploited during the course of the Period corresponding to that Block.

To establish our position it is enough to cite a few illustrative cases.

(1.) Certain compartments containing young growth (seedlings, thickets, saplings or young poles) exist side by side with the great mass of exploitable compartments. Both sets of compartments may be included in the First Block; but the old crops alone should be regenerated during the First Period, while the young compartments should, during the same time, be subjected to Improvement Cuttings, viz., Cleanings and Thinnings. Similarly we may collocate in the last Block, with quite young crops, exploitable trees, whether these grow apart from one another or form continuous leaf-canopy. Under such circumstances, these latter would be exploited during the First Period in order to effect the desirable uniformity.

(2.) Supposing that in the pine forest which we considered higher up a fine crop of poles is, under unavoidable necessity, placed in the First Block, because it is enclosed on every side by the great mass of exploitable compartments. Is it necessary to regenerate it during the First Period in order to effect the regularization of the age-classes in the shortest possible time? We answer, No; because to do so would be to incur a great sacrifice for an entirely secondary object; and besides this, there is nothing to prevent the same difficulty recurring through some unforeseen cause. Under these circumstances the Organisation Project should confine itself simply to prescribing Thinnings, and leave to those, who will revise it at the end of that Period, the task of proposing the treatment that will then be found to be necessary.

(3.) We will now suppose that we have a compartment containing mature and decaying timber, and that this compartment stands in the very heart of the Third Block; Here the procedure would be the same as in a crop that is still young but overtaken by premature decay.

(4.) We will suppose that in order to give the most convenient form possible to the first two Blocks of a Working Circle exploited on a rotation of 160 years, it is considered necessary to collocate in the First Block a compartment aged 100 years, and in the Second a nearly equivalent compartment composed, however, of timber 150 years old. It would certainly be advantageous, as far as the produce alone is concerned, to exploit the compartment placed in the Second Block during the First Period, and that placed in the First Block during the Second Period. However it be, before this change of order could be proposed, it would be necessary to assure oneself that there would be no danger to fear from the action of the wind in consequence of this infraction of the Rules for locating coupes.

The special circumstances just described are not the only ones that are to be encountered in organising high forests. Every Working Circle, however perfectly it may be constituted, cannot but contain compartments of different degrees of fertility due to differences of soil and situation. When these differences do not affect their productiveness in any marked manner, or when it is possible to distribute more or less equally, amongst the various Blocks, compartments possessing the same degree of fertility, the division is effected by equal areas. This is the most simple and the most general case. When, on the contrary, one age-class, taken in its entirety, occupies good rich soil, while another is similarly situated on poor soil, it is necessary to include in the corresponding Blocks a larger area of the one than of the other.

However it be, the distribution of the principal exploitations and of the estimated total yield among the various Periods of the Rotation must always continue to be based on area. The result of this is that the Working Scheme acquires thereby a degree of precision and stability, which enables its main lines to be laid out on the ground in a permanent manner. On paper it may be represented in a very simple tabular form, thus :—

GENERAL WORKING SCHEME

of Working Circle LA HOUSSIERE, Area 654 Acres, 2 Roods, 16 Poles, Organised on a Rotation of 160 years.

Composition of Block to be exploited during the																			
First Period From 1869 to 1908.					Second Period From 1909 to 1948.					Third Period From 1949 to 1988.					Fourth Period From 1989 to 2028.				
Cantons.	Compartments.	Area.			Cantons.	Compartments.	Area.			Cantons.	Compartments.	Area.			Cantons.	Compartments.	Area.		
		A.	R.	P.			A.	R.	P.			A.	R.	P.			A.	R.	P.
La Houssière	A	50	0	0	La Féohère.	F	64	2	0	La Taillette	I	12	2	0	La Noire-Roche	N	15	2	20
Do.	B	37	2	0	Do.	G	20	0	0	Do.	K	106	1	36	Do.	O	87	2	0
Do.	C	12	2	0	Do.	H	100	0	0	Do.	L	15	2	0	Do.	P	40	0	0
Do.	D	30	0	0	...					...	M	37	2	0	...				
Do.	E	25	0	0	...					...					...				
Total...		155	0	0	Total...		184	2	0	Total...		171	3	36	Total...		143	0	20

The General Working Scheme once drawn up, it is advisable to detail the reasons justifying it and to decribe the spirit in which it has been conceived with reference to the Organisation Project. It is useful to discuss all its essential points, to show why it has been preferred to every other, to explain the main idea on which its lines have been fixed.

The chapter in which these points are discussed should be worded in plain, sober language, free from all preconceived bias. It ought to bring out into clear prominence all facts special to the Working Circle and show what improvements are necessary or feasible. It should explain to what extent the Working Scheme has taken account of the conditions of exploitability, the Rules for locating coupes, and the necessity of a sustained yield, pointing out where one or more of these limiting conditions acquire greater importance than all the rest. It should state the reason for, and the object of, the various cultural operations that have to be successively executed throughout the whole Working Circle with a view to its improvement, as well as the agency and means by which these operations should be carried out.

SECTION 3.

Special Scheme of Exploitations.

At the beginning of the First Period, as well as of every subsequent Period, the exploitations of all kinds to be made in the Working Circle during that Period are determined upon beforehand and exhibited in what we shall call the Special Scheme of Exploitations for that particular Period. This Scheme should show the work to be done compartment by compartment, and should remain within the broad lines sketched out by the General Working Scheme. Thus, to take an instance, in a regular Working Circle the exploitations made during the First Period would be, for the First Block Regeneration Fellings with yield based on volume, for the intermediate Blocks Periodical Thinnings based on area, and for the last Block, containing all the youngest crops, Cleanings and the First Thinning.

The Special Scheme of Exploitations should prescribe first of all the nature of the fellings to be made in each compartment, next the successive order in which the respective compartments shall be operated upon, and lastly the annual extent, volumetric or superficial as the case may be, of the various exploitations.

Usually the succession of these exploitations is exhibited in tabular form, showing at a glance the general plan of all the operations to be executed during the Period in question. Often the annual yield is similarly exhibited in one or more tables, which also contain the data from which it has been estimated.

§ 1.—*Order of the Exploitations.*

The tabular statement of the exploitations may, to give an example, be drawn up thus:—

NATURE AND ORDER OF THE EXPLOITATIONS TO BE MADE DURING THE FIRST PERIOD FROM 1869 TO 1908.

COMPARTMENTS.						NATURE OF CUTTING.		RELATIVE ORDER OF THE EXPLOITATIONS.
Blocks	Cantons.	Compartments.	Area. A. R. P.	Summary description of standing crop.	Age at end of 1868. Years.	Regeneration.	Improvement.	
I.	La Houssière.	A	50 0 0	High forest of beech and oak, somewhat open.	150	Regeneration Fellings.	...	The regeneration of these compartments will be effected as nearly as possible in the following order:— C,D,A,B,E.
		B	37 2 0	High forest of beech, oak, and hornbeam; leaf canopy complete............	160	Do.	...	
		C	12 2 0	Saplings of beech mixed with oak here and there	15		Cleanings and First Thinnings	
		D	30 0 0	State of Secondary Felling, surmounting seedlings and thickets of oak and beech.	5-15	Secondary or Final Fellings.	Do.	
		E	25 0 0	High forest on stools, oak and hornbeam	120	Regeneration Fellings.	Last Thinning.	
II.	La Féchère.	F	64 2 0	High forest of beech and oak in complete leaf canopy	125	Do.	Decennial Thinnings.	
		G	20 0 0	Young high forest of oak and hornbeam irregularly mixed............	90	Do.	Do.	
		H	100 0 0	High forest of oak, beech, and hornbeam.	110	Do.	Do.	
III.	La Taillette.	I	12 2 0	Young high forest of pure oak, old plantation.	70	Do.	Do.	The order of the Thinnings is fixed year by year in the table of the cuttings based on area.
		K	106 1 36	Poles of beech, oak, and hornbeam............	85	Do.	Do.	
		L	15 2 0	Low poles of oak and hornbeam.	45	Do.	Do.	
		M	37 2 0	Young high forest of beech with oak reserves.	70–210	Do.	Do.	
IV.	La Noire-Roche.	N	15 2 20	Open pole crop of oak, beech and ash.	40	Do	Do.	
		O	87 2 0	Saplings of oak hornbeam, and beech..........	25	Do.	Thinning in the 2nd, 3rd, & 4th, decades.	
		P	40 0 0	Seedlings of beech and oak, and high forest in the state of a secondary coupe.	3 and 4 to 140	Secondary or Final Fellings.	Cleanings.	

The essential object of the preceding table is to give a list of all the compartments, the natnre of the cuttings to be made in each, and the order in which they should be successively taken up.

The compartments are entered in a single column and are designated by characteristic letters or numbers. For greater completeness the name of the canton and the number of the Block are usually given to indicate the situation of the compartment in question. Similarly, there is a special column for the areas of the compartments, and two more for the age and a very brief description of the standing crop, information that helps to explain the treatment prescribed.

The treatment, which is nothing more than the *ensemble* of the cuttings to be made, must be noted separately for each compartment. These cuttings are expressed by their characteristic names; they may be the whole series of Regeneration Fellings here, Secondary and Final Fellings there, or simply the Final Felling in a third place, and so on to the Last Thinning, Periodical Thinnings, Cleanings and the First Thinnings, Selection Fellings, Compound Coppice or Simple Coppice Cuttings, &c., as the case may be. The main point is to characterise the cuttings by means of specific names, so that each name may represent a clear and definite idea.

The order of succession of the cuttings must be fixed in a general manner only, but to the full extent which each class of exploitations admits of. Thus the order of the Secondary and Final Fellings, which depend on the state of the crop (an uncertain element), naturally cannot be fixed. It is impossible to foretell the year in which the new seed-crop will make its appearance, or that in which it will be sufficiently complete and hardy to require a Secondary Felling, as also to forecast the quantity of produce that will have to be removed in each of the Regeneration Fellings from a given area. It would thus be folly to prescribe the order in which the compartments should be regenerated, except in so far as concerns only the succession of the Primary Fellings.

With respect to Improvement Cuttings, it is usually expedient to fix their order in the most precise manner for every year from the very beginning of the Period. This is done in the Table of the Annual Yield, in which the area to be operated upon is also given.

As regards the manner of making the cuttings, the Special Scheme of Exploitations must be entirely silent. The character of the Primary Felling (that is to say, whether it should be close or open), the more or less rapid succession of the different Regeneration Fellings, the special precautions they require, the manner of making the Improvement Cuttings, &c., all these are questions that perforce vary with the locality operated upon and with a host of natural or accidental causes. Any attempt to lay down rigid directions must run the risk of prescribing incomplete or untimely operations. Besides, there is always the liability of falling into grievous error in trying to predict the course of natural phenomena. The prescriptions of the Special Scheme of Exploitations are obligatory, once they are sanctioned by supreme authority, and it stands to reason that the Executive Forest Officer must be held responsible for the cuttings made by him. He must therefore be given full discretion in executing them in whatever way he considers best.

If it is necessary to avoid laying down in the Organisation Project the manner of making the cuttings prescribed, that is no reason for omitting to discuss and record facts that have been observed. But the place for this is not the Special Scheme of Exploitations. It should be done in the general portion of the Report, as being information that may be of the highest utility, especially to Officers appointed to a new charge. Thus, for instance, it might form a special Chapter coming after the General Statistical Report and immediately following that on choice of Régime, and styled "APPLICATION OF THE METHOD OF TREATMENT."

§ 2. *Estimation of the Annual Yield.*

Like the order of the exploitations, the annual yield must be determined for only one Period at a time.

In high forests worked by the Natural Method, the Regeneration Fellings are based on volume, and the Improvement Cuttings on area. Hence two different classes of yield, viz :—

(I) That of the Regeneration Cuttings, that is, of Principal Produce.

(II) That of the Improvement Cuttings, that is, of Accessory Produce.

In a regular Working Circle of high forest, the principal produce would be furnished exclusively by the trees felled in the Block assigned to the current Period; but, as a rule, the other Blocks also contain here and there mature trees either solitary or forming leaf-canopy, which it would be expedient or necessary to exploit as an exceptional measure during that Period. Usually in estimating the annual yield of principal produce, such trees are classed, without any qualification, amongst those of the Block of the current Period; only in the Organisation Project their relative number and importance should be clearly indicated and the compartments that contain them mentioned.

The determination of the quantity of principal produce offers no difficulty. It is obtained by enumerating the standing trees grouped into classes according to species and diameter, and multiplying the number of the trees in each class by the previously ascertained contents of a type tree, selected from amongst the standing material as presenting the average of that class.(1)

But the total quantity of produce ultimately removed during the Period necessary includes, besides the actual contents of the standing trees, also their future increment up to the time they are felled. To determine the amount of this increment it may be observed that the quantity brought under the axe is the same every

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(1) It is unnecessary to obtain actual contents with rigid accuracy, but it is indispensable, in taking the measurements, to adopt a uniform practical system. It is the only way of arriving at results that admit of being compared one with another—an essential condition for the location of the coupes, and useful afterwards for the verification of the yield. If, for instance, in the valuation it was assumed after experiment that trees measuring 16″ in girth at the height of a man contain on an average 46 cubic feet each, then in locating the fellings also it would be necessary to assign the same volume to trees of 16″ girth. Whether the average contents assumed be exact or simply approximate, the quantity exploited would always be an invariable proportional of the quantity obtained by valuation. Thus 1000 cubic feet of felled produce would actually represent 1000 cubic feet of the estimated yield. It would be otherwise if any other procedure were adopted, that was not based on the measurement of exactly measurable elements. Hence it is necessary in calculating the yield by volume to avoid estimating the quantity of standing material with the eye, or by means of type areas, or with the aid of any other such system. And for the same reason the basis of all valuations must be solely and invariably the measurement of diameter, since that of height always involves some amount of individual appreciation.

year. For the purpose of calculation, therefore, it may be assumed that all the trees will be felled simultaneously at the middle of the Period. Again we may be allowed to take for granted that the future annual increment of trees near their term of exploitability is the same as their actual average annual increment up to date. Thus to obtain the total future increment we have simply to multiply this average annual increment by half the number of years in the Period. It is obvious that the determination of the future increment must be made separately for each compartment.

The yield of the annual cuttings is, therefore, found by dividing by the number of years forming a Period the sum of the two following quantities :—

(i) The standing material or actual contents.

(ii) The probable additional growth of the standing material, or future increment.

It is always easy to determine actual contents with a sufficient degree of approximation, whereas the future increment can never be estimated with any approach to accuracy. For this reason, unless special circumstances demand the contrary, no account at all should be taken of the future increment, since it is always better to be under the mark than to run the risk of erring on the fatal side of excess. Besides, the yield of windfalls, dead timber, and other trees, the exploitation of which cannot be foreseen, proves to be, in the long run, a complete set off against the neglected future increment. Lastly, this increment does utimately enter into our calculations when the standing trees are again measured at the verification of the annual yield during the course of the same Period, and must then permanently raise the figure of the yield for the remaining years of that Period. The natural consequence is that the outturn of produce goes on increasing by small and moderate additions at regular intervals, a result greatly to be desired in the organisation of every forest.

Simultaneously with the volumetric cuttings, which furnish the yield of principal produce, other operations, termed by us Improvement Cuttings, such as Thinnings, for example, must be made in various portions of the Working Circle, and can only furnish accessory produce. These latter cuttings must have their yield based on area. By this we do not mean to say that Thinnings ought necessarily to go over equal areas every year, or that such cuttings ought to yield the same outturn year after year. Although the outturn of thinning operations is not entirely to be neglected, still it cannot be taken into account in determining the annual yield, since it is subject to too wide a fluctuation not only as regards quantity but also the class and quality of the produce obtained. Besides this, the principal and, so to say, sole object of Thinnings is to favour the growth of the promising trees forming an organic part of a canopied mass of forest, by giving those trees growing room in proportion as they require it, by the gradual removal of their less promising neighbours which prevent their crowns from spreading out. These operations demand great skill and caution, and in order that they may be well executed, the Executive Officer must be free from all preoccupation as to the quantity to cut out; and more than this, he must be in a position to judge, at the time that he marks the trees to be thinned out, when the next Thinning will have to be made over the same area. This reason suffices of itself to justify the expediency of making such cuttings within fixed limits marked out on the ground, of subjecting them to a regular rotation, and of basing their yield entirely on area.

When these exploitations can be so arranged as to annually pass over nearly equal areas during the term of a whole Period, no more desirable result could be imagined. But at the very commencement of working a forest according to some organised system, it is not always possible to secure such great regularity. Thus, for example, it may happen that a Thinning is urgently required in certain crops aggregating a large area; under such circumstances, it would be only at the second or third time of thinning those crops that it would be possible to establish a regular rotation for the operation, i. e. limit it to nearly equal annual areas by assigning to each year either one or more entire compartments or an aliquot portion of a large compartment, as the case may be. However it be, the main point to adhere to is to arrange the Thinnings in the simplest manner possible, paying due attention to the condition of the crops and to the superficies they occupy.

The Last Thinning made in a high forest may also have for object the early and gradual production of seedlings on the ground under the standing crop, such as might happen in a forest of silver fir, a seedling crop of which species makes its appearance very gradually but resists well the action of cover overhead. This Last Thinning, which may indeed be termed a Preparatory Primary Regeneration Felling, differs from all preceding Thinnings in that it clears the soil of bushes, removes overtopped trees, and occasionally raises the cover by a judicious lopping oft of low branches. It is therefore expedient to characterize it by a special name. To call it a Preparatory Primary Felling would create an ambiguity, since this designation has been applied to another perfectly distinct operation. The term Final Thinning would perhaps be the best to adopt.

The following two tables are convenient for collecting together the data and information which it is expedient to adduce in support of the estimated annual yield. The first gives the yield of principal produce, the other, the area to be thinned every year, the compartments to be operated upon, and the order in which they should be taken up.

DETERMINATION OF THE ANNUAL YIELD FOR THE FIRST PERIOD.

YIELD OF THE PRINCIPAL FELLINGS.

Compartments.		Number of Trees Counted.		Contents. Actual.	Contents. Future increment.	Contents. Total.	Remarks.
	Acres.			Cubic feet.	Cubic feet.	Cubic feet.	
A	50	Oak	525	71,375	...	388,239	The Period consisting of 40 years, the annual yield will therefore be $\frac{1,139,605}{40} = 28,490$ c. ft.
		Beech	2,272	316,864	...		
B	37½	Oak	1,181	176,125	...	348,049	
		Beech	1,092	135,687	...		
		Hornbeam	672	36,235	...		Deducting every year ¼ of the above figure to form the Reserve Fund, the annual yield of the Principal Fellings will thus be 21,368 cubic feet.
D	30	Oak	438	70,881	...	106,727	
		Beech	216	35,846	...		
E	25	Oak	803	36,058	...	155,181	
		Beech	92	10,418	...		
		Hornbeam	4,206	108,705	...		
P	40	Oak	240	34,540	...	141,409	
		Beech	815	106,869	...		
						1,139,605	

DETERMINATION OF THE ANNUAL YIELD FOR THE FIRST PERIOD.

YIELD OF THE IMPROVEMENT CUTTINGS—THINNINGS

Year.	Compartments.	Area to be thinned.	Year.	Compartments,	Area to be thinned,	Remarks,
		A. R. P.			A. R. P.	
1869	E,I,L	53-0-00	1889	I,L,C.	40-2-00	The areas to be thinned each year will be taken up in accordance with the present Table, so as to thin each Compartment at the most appropriate time, and, as far as that is possible, take up entire Compartments or aliquot portions of Compartments at a time.
1870	K.	35-2-00	1890	K.	53-0-38	
1871	K.	35-2-00	1891	K.	53-0-38	
1872	K.	35-1-36	1892	F.	64-2-00	
1873	F.	32-1-00	1893	H.	50-0-00	
1874	F.	32-1-00	1894	H.	50-0-00	
1875	H.	50-0-00	1895	O.	43-3-00	
1876	H.	50-0-00	1896	O.	43-3-00	
1877	M.	37-2-00	1897	M.	37-2-00	
1878	G,N.	35-2-20	1898	G,N.	35-2-20	
1879	I, L.	28-0-00	1899	I,L,C.	40-2-00	
1880	K.	53-0-38	1900	K.	53-0-38	
1881	K.	53-0-38	1901	K.	53-0-38	
1882	F.	32-1-00	1902	F.	64-2-00	
1883	F.	32-1-00	1903	P. D.	70-0-00	
1884	H.	50-0-00	1904	H.	50-0-00	
1885	H.	50-0-00	1905	H.	50-0-00	
1886	O.	87-2-00	1906	O.	43-3-00	
1887	M.	37-2-00	1907	O.	43-3-00	
1888	G,N	35-2-20	1908	M.G.N.	73-0-20	

CHAPTER IV.

COMPLEMENTARY DISPOSITIONS RELATIVE TO THE WORKING SCHEME FOR HIGH FORESTS

The Special Scheme of Exploitations completes the Working Scheme, and with this the Organisation Project itself may be strictly regarded as completed, since it may now be executed without the help of any further prescriptions or data. Nevertheless there are besides this some further measures to be prescribed, which are of great use in providing against contingencies likely to interfere with the Project, and in guaranteeing its faithful execution. Thus it is expedient to establish what may be called the Reserve Fund, to arrange for the verification of the yield, to suggest necessary works of improvement, and to provide for the revision of the Organisation Project before the commencement of each subsequent Period.

SECTION I.

The Reserve Fund.

The establishment of a Reserve Fund in the organisation of high forests is nothing more than the setting aside and preservation of a certain quantity of standing timber from among the crops brought under exploitation to serve as a sort of disposable savings. A Reserve Fund is as necessary in the management of forests as in every other large financial enterprise spreading over a long series of years. Without any such Reserve to fall back upon in the case of emergencies, an Organisation Project cannot but rest on an unstable basis; at some time or other immature timber would have to be cut or a deficit must occur.

In the organisation of high forests, the essential object of a Reserve Fund is to provide against extraordinary and unforeseen demands extraneous to the forest itself, or to prevent a falling off in the yield in passing from one Period to the next. On the other hand, this Reserve may, according to circumstances, also have for object the production of isolated trees of large size, or serve as a set off against accidental injuries to the forest. To take an instance: A Municipality requires an extraordinary felling, or the State is in immediate want of wood for the defence of the country; the forest must be able to satisfy either demand to a sufficient extent without its healthy regular growth being compromised thereby. Or, to take another case, it becomes apparent towards the end of the First Period that the Second Block is insufficiently timbered; some means must be found to make good this deficiency without upsetting the orginal Origanisation Project. Again in a given high forest of oak there are several choice specimens in full growth and far removed from their maturity when the time for exploiting the surrounding forest arrives. It would be a pity to fell them so soon. To take one more case, there is a fir forest in which numerous windfalls have occurred in the Block belonging to the next following Period; these windfalls must evidently be cut up and disposed of at once; and the only way to compensate for this unexpected loss is to reserve a certain number of trees in the Block under regeneration. Thus a sufficient Reserve Fund of trees provides against all such sudden contingencies.

The formation of the Reserve Fund may be effected in several ways. "Formerly" writes M. de Salomon, "it was customary to reserve a certain definite portion of the forest in one piece by itself. But this method was soon abandoned as being inadequate and failing to secure the end proposed. For except when trees of extraordinary size had to be grown, it was impossible to judge, with any degree of certainty, what crops were by their age best fitted to form this Reserve Fund. The reason is evident, for if mature or almost mature trees were reserved, it might be found necessary to exploit them at an inconvenient time on account of decay, and thus the very object for which they were reserved would be defeated; and if, on the contrary, the reserved trees were young and an extraordinary felling was urgently required under some sudden emergency, there would be no alternative but either to cut nothing at all or to exploit small and immature timber."

The remarks just quoted apply to high forests worked by the Natural Method, in which of class forests the principal exploitations come back to the same point only after a very long interval of years. A Reserve Fund composed of trees all in one piece of forest would ill fulfil the condition of always offering immediately available resources, unless indeed it covered a very large area. But it is easy to obtain the most desirable results by forming the Reserve Fund of trees scattered over all the coupes and based on their aggregate contents, a method of procedure in perfect keeping with high forest exploitations.

In the organisation of high forests by area, the quantity of standing material to be set aside for the Reserve Fund may be determined by one of two methods or by both together. The one consists in leaving out of account the future increment when calculating the annual yield; the other in reducing by a certain quantity the quota of the annual cuttings. Take, for instance, a mass of forest 150 years old; the mean annual growth is evidently the 1/150th, part of the contents of the standing timber. Given the Block and Period to which this mass belongs, the quantity of the stock to be reserved can be approximately deduced from the annual rate of growth thus determined. On the other hand, if the quota of the annual cuttings is 21,000 c. ft., 3,500 c. ft. may be preserved each year from the quantity that can be cut to form the Reserve Fund. In the latter case, the amount of the annual savings set aside is a determinate figure, while in the other case the future increment can never be known with certainty.

However it be, the Reserve Fund when based on volume always represents so much exploitable timber over and above the quota of the annual cuttings, and sometimes also comprises trees with a long future before them. At the moment of need, every cubic foot saved up, may be utilized except this last class of trees. To find out at any time the present quantity of the Reserve Fund, we have only to know according to which of the two methods above described it has been formed and the number of years it has been in existence. To utilize it, there is nothing more to be done than to cut everything in the Block under regeneration.

The quantity to set aside as a Reserve Fund is a matter of individual appreciation pure and simple. The law prescribes nothing with reference to it, except so far as communal forests of broad-leaved species are concerned, in which case the quantity to be reserved is one-fourth of the whole standing stock. Our own opinion is that this same proportion should, as far as possible, be maintained also in high forests, and that for this purpose the quantity to be annually set aside should include both the annual rate of growth and the 4th. part of the stock of the principal coupes, regular as well as irregular.[1] This latter quantity, definite and exactly known as it is, is naturally meant to be exploited first in case of need. The annual rate of growth, on the contrary, being an uncertain quantity from the beginning, the part of the Reserve Fund due to it would chiefly include growing trees or the accidental produce of the younger Blocks, the quantity of which is equally uncertain. Moreover the portion of the Reserve Fund resulting from the saving up of the annual increment does not necessarily go on increasing by the accumulation of this increment, for a portion of it naturally gets included in the valuation survey of the standing stock each time the annual yield is verified.

SECTION II.

Verification of the Annual Yield.

The yield of principal produce, after deducting the quantity to be placed in the Reserve Fund, serves as the basis for the principal fellings of the current Period. But it may happen that errors have crept into the estimate of this figure or that certain discrepancies are found to exist by actual experience of the cuttings; and the annual increment is, after all, always an uncertain quantity, and various accidents occur during the course of a Period of any length, that upset all previous calculations. It would thus be rash to go on working out the same quantity year after year as that fixed at

1. I must observe that in calculating the quantity to be reserved, no allowance at all is made for accessory or accidental produce. The result of this is that in setting aside a fourth of the total yield of principal produce, a smaller quantity is reserved than if one-fourth of the whole area were so set aside. And, after all, a large Reserve Fund entails no sacrifice: it is itself productive, and the only difficulty in connection with it is when at the outset it has to be established. Thereafter it yields no inconsiderable amount of irregular produce, variable in quantity from Period to Period.

the beginning of the Period, without checking its figure in the meanwhile. This check is what we have called the VERIFICATION OF THE ANNUAL YIELD.

The check in question consists in ascertaining, at some time during the currency of the Period, the quantity of standing material still unexploited, and then dividing that quantity by the number of years in the unexpired portion of the Period, exactly in the same manner as was done at its beginning. It is obviously necessary to employ the same procedure and the same tables as before, otherwise the results obtained on each separate occasion could not be compared together. Before dividing the quantity given by the valuation survey, it is necessary to deduct from it the still available portion of the Reserve Fund that may have been deduced from the annual yield in the first instance. This procedure is indispensable in the interests of the future. The whole of the unexploited stock, reserved in order to provide against extraordinary requirements, ought to continue to be available up to the very end of the Period, and this for the very same reasons which originally justified the establishment of the Reserve Fund. As regards the actual increment by which the standing stock may have increased since the beginning of the Period, it necessarily forms an integral part of the contents found by the valuation survey. But in revenge the valuation survey has nothing to do with the trees left standing after the Final Fellings; so that those trees in no way affect the calculation of the annual yield in the second instance.

If, owing to unforeseen circumstances, any considerable exploitations have had to be made in the immediately following Block, it might be expedient to effect a compensation by increasing the stock to be reserved during the rest of the Period. Under any circumstances, the Verification of the Annual Yield must alter the figure originally estimated, but it cannot modify the General Working Scheme, since the calculation of the annual yield is entirely independent of the formation of the Blocks. It is necessary to verify the annual yield of principal produce at least once during the course of each Period, so as to avoid all risk of having an accumulation of errors crowded into the last few years of the Period.

When the fellings that are regulated by area, notably so the Thinnings, have been arranged at the beginning of the Period for its whole duration, it is useful to verify also the succession of those cuttings, and to rectify it if necessary. Naturally both verifications should be made at one and the same time, at the end of the tenth, fifteenth or twentieth year, according to the forest concerned. The time for making these verifications must be prescribed by the Organisation Project.

SECTION III.

IMPROVEMENT WORKS.

The Table of Exploitations prescribes the nature of the cuttings to be made in the Working Circle concerned throughout a whole Period. But it lays down no injunctions as to the manner of making them. Now there are cases in which the success of forest operations depends on the execution of certain works of improvement. Thus it may be necessary to effect some artificial restocking or to make roads for the export of wood. If the Organisation Project did not consider such works and omitted to point out the means available for executing them successfully, it would run the risk of being an impracticable project and of defeating the object of the very operations it prescribed.

The most urgent works of improvement required by each Working Circle ought, therefore, to be a subject of special attention for the forester who has to organise it. The manner of executing these works, the appreciation of the relative urgency and timeliness of each, estimates of their cost, all these points should be discussed together in a single chapter of the Organisation Project. Thus the works that are indispensable for the carrying out of the Organisation Project form an essential part of the studies and proposals which compose it. Works that are simply useful also require to be mentioned, but more often it is best to leave to the Executive Officer the duty of proposing them when they are actually called for.

Among the works that are necessary must be included the establishment of a regular system for noting and recording facts and phenomena connected with the growth of the forest *pari passu* with their occurrence. The Organisation Project must therefore provide and prescribe the means and method of working these observations. Whatever the form in which this record is kept, it must describe, firstly, every kind of exploitation made, together with all concomitant circumstances of an economic nature ; and, secondly, the improvement works properly so called and all phenomena connected with the growth of the forest. From both these points of view, the keeping of a complete record is secured in a very simple manner by allotting to each compartment separate space in the record. What could be more simple than to assign to each compartment two opposite pages of a Register, one to contain facts connected with the produce obtained from the compartment, the other the phenomena relating to the growth of the living stock ? Each year it would be enough to enter all facts, that may have occurred, on the proper page of the Register. In a short time this Register would furnish a complete and connected history of the forest. A specimen form for the Register is given below :—

REGISTER

OF

FACTS and PHENOMENA

CONNECTED WITH

the Working and Growth

OF

the WORKING CIRCLE of LE FAYS

(The following two ***Forms*** *should be bound so as to face each other, as shown here; each double page will then contain a record for a single compartment extending over an entire Period.)*

COMPARTMENT E4, AREA 34 A. 2 R. 20 P.

Exploitations.

Year.	Nature of Exploitation	Density of crop.			Actual contents.			Total gross Receipts.	Exploitation charges.	Trees reserved in Compound Coppice Fellings and in Final Regeneration Cuttings									Remarks.
						Timber.				Old.			Middle-aged.			Young.			
		Area.	Number of trees.	Estimated contents.	Total.	Oak.	Other species.	R. A. P.	R. A. P.	Oak 5, in girth and upwards.	Oak from 3′6″ to 5 in girth.	Beech and other species.	Oak.	Beech.	Other species.	Oak.	Beech.	Other species.	
																			Facts relating to the various descriptions and classes of produce obtained, with their respective selling rates. Phenomena of every kind that can have any influence on the growth and regeneration of the stock (storms, drought, frost, abundance of acorns, of beechnuts &c., fires, depredations of insects, cattle &c. &c.

CUBICAL CONTENTS IN 1880, 246,738 C. Ft.

Improvement Works.

Year.	Nature and Extent of the Works executed.	Cost. Rs.	A.	P.	Information regarding the circumstances under which the Works were carried out, and the Results obtained.

SECTION. IV.

Periodic Revision of the Organisation Project.

The complementary measures, the employment of which we have just enjoined, are quite sufficient to provide against all contingencies and to guarantee the success of the operations prescribed by the Special Scheme of Exploitations. But this Scheme is drawn up for the duration of one Period only, and consequently a fresh Scheme must be prepared for the next following Period also. Like the first, this latter will determine the succession of the exploitations for the whole duration of the new Period, and fix the yield of the annual fellings as well as the quota of the Reserve Fund.

The operation here sketched, which we have termed the Periodic Revision of the Organisation Project, necessitates a new and complete study of the forest at the end of each Period. That study, while it brings out into prominence the results heretofore achieved, shows in a clear manner the modifications that it would be useful or necessary to make in the general management of the forest. Among these modifications there would be some that would in no way affect the ground-work of the Organisation Project; such would be, for instance, any proposed change in the special treatment of certain compartments. Other modifications may have for result the alteration of the boundaries of the Block; but so radical a measure should be avoided except in cases of well proved necessity. More generally it would be a change of Rotation that would seem desirable, in which case it would be enough to prolong or curtail the duration of each Period in the same proportion as the Rotation, without in any way changing the General Working Scheme.

In a well treated forest, it generally happens that a portion of the Reserve Fund is available for exploitation at the end of each Period in the Block, of which the regeneration has just been completed. The manner of turning this portion of the Reserve Fund to account is obvious enough : it must form for the next following Period a resource to fall back upon in case of emergency, and the produce furnished by it must not be considered as part of the regular yield of the forest. In the event of urgent wants arising before a new Reserve Fund can be formed, it would be perfectly logical to exploit the standing one, since it represents an actual surplus. On the other hand, had such wants arisen when the forest was just organised, they could have been met only by utilising a paper surplus existing only in the estimates. Thus in the new Special Scheme of Exploitations the utilization of the available Reserve Fund ought to present no difficulty.

The exploitation of irregular produce, i. e. over and above the fixed yield, does no harm as long as it is only a fraction of the regular yield (say for instance, a fraction not exceeding $\frac{1}{4}$), and as long as it consists only of trees that must soon fall, like the nurses in Regeneration Coupes that are already sufficiently sown with the new crop. The reason of this is obvious, for under such circumstances the exploitation of the stock in question cannot interfere, either immediately or at any future time, with the maintenance of a sustained yield or with the Exploitability chosen. The case would be quite different if, instead of being limited to a moderate figure, the proportion of the irregular produce exceeded all bounds, say, for instance, that it was equal to the regular yield of a well-stocked Block. An exploitation thus exaggerated might even prove fatal to the execution of an Organisation Project based on area.

BOOK IV.

ORGANISATION OF IRREGULAR HIGH FORESTS.

UNDER the term Irregular High Forests we include (i) all those high forests which contain crops that are of defective growth, are incomplete, or are composed of inferior species; (ii) those high forests in which an unequal gradation of age-classes would, if a regular treatment were adopted, lead to the felling of timber before it was exploitable or after full decay had set in; and (iii) also those forests in which the age-classes, instead of being differentiated into separate well-defined groups, are all intermixed so as entirely to prohibit any kind of successive order in the exploitations. Such forests are numerous, and present the most diverse forms and every degree of irregularity offering an infinitude of different types and characters.

We propose in the immediately following pages to study the organisation of forests worked by Selection and to explain how the General Working Scheme of an irregular forest of broad-leaved species should be framed. This will not only be sufficient to show how thoroughly the Area Method adapts itself to the organisation of every description of high forest, but will also prove how that Method never fails to offer the means of realising, within the measure of the possible and to any desirable extent, each and all of the principal objects of forest organisation, to wit,

(i) The most useful production,
(ii) A sustained yield,
(iii) A definite order in the exploitations, *and*
(iv) Continued improvement of the forest.

CHAPTER I.

THE SELECTION SYSTEM.

SECTION I.

GENERAL CONDITION OF OUR FORESTS UNDER WORKING BY SELECTION.

THE Selection Method of Working is simply the exploitations of primitive humanity generalised into a system. There where wood was abundant and the forest open to all comers, each one helped himself to whatever he wanted. Broken branches, windfalls, dead standing trees, dying poles, and loppings and toppings of every kind furnished the people with firewood. Timber for building and other purposes was removed from the nearest and most accessible spot, a tree here, another there, and so on. Only what was actually wanted was taken away, the branches, toppings, and useless odds and ends, and trees that were found to be unsuitable after being felled, were, as a rule, simply left on the ground.

As long as exploitations of this nature are sufficiently restricted in quantity, exploitable trees fit to satisfy all wants can never fail, and no forest is the worse for them. Nevertheless the removal of individuals here and there from the midst of a canopied mass cannot but be very detrimental to the regular growth of trees of broad-leaved species; and hence this method of working has been, as a rule, confined to our conifer forests.

There it yields results that differ according to the prevailing species and the quantity of wood removed every year. In well-wooded regions, where for the very reason that they are well-wooded, the forests are placed under favorable circumstances for growth, a forest worked merely by Selection without any fixed plan maintains itself in fairly good condition, whatever its component species, as long as only a moderate quantity is exploited every year. Thus is explained the continuance of that method of working in most of our mountain forests, whether of pine or silver fir, which have hitherto remained inaccessible to the timber-dealer. But although the method of working has been the same everywhere in those forests, their condition is nevertheless very different according to the species composing them.

In forests of pine, where the trees require bright and abundant light, the Selection System always does more or less harm. Under its operation the leaf-canopy is very far from being uniform, is often open or breached with small gaps, and consists in places of sickly saplings and poles that can never come to anything. Hence that Method of Treatment has in nearly every case been abandoned with the development of an export trade. In forests of silver fir, on the other hand, the young plant of which species bears even heavy cover for a long time, and shoots up rapidly as soon as it is uncovered overhead, crops worked by Selection remain dense and well-stocked with trees of all ages, provided the annual exploitations are moderate. It is this peculiarity of the tree that has rendered possible the maintenance of the Selection Method in our silver fir forests on mountains of medium height, even though they may be situated in the vicinity of roads and drawn upon by the surrounding country. Nevertheless people were not long in recognising the necessity of subjecting the original Selection System to certain rules having for their principal object the limitation of the quantity exploited to a fixed figure. And so the Selection Fellings thus regularised now constitute a recognised Method of Treatment.

The Method in question consists in the removal here and there of the oldest trees, of those dying, decaying or dead, and of others still in full growth, but which are required to satisfy the wants of the proprietor. It has been applied in this manner, and often with good results, to forests of silver fir and spruce, pure or mixed with beech. The quantity to be exploited, in other words, the annual yield, was usually expressed by the number of trees to be felled. When this number included only real trees and not mere poles, the average was 0·4, 0·6 or 0·8 trees per acre. For instance in the forests of Levier it was fixed for certain Working Circles at 0·4 trees, for others at 0·6 per acre. Thus supposing a certain Working Circle measured 750 acres, the number of trees felled in it annually would have been 300 or 450 according as the number per acre was fixed at 0·4 or 0·6. Elsewhere, as in the communal forest of *la Cluse* the yield was fixed at about half a tree per acre. Care was taken to remove only a very few trees from any one spot, one or two only for example, so as to avoid making too large a gap any where in the leaf-canopy, since such gaps must cause considerable injury to the forest. With this method of procedure it was necessary to spread the annual operations over a large area, and indeed, as far as the pure principle went, over the whole Working Circle. Actually however the area operated upon every year was restricted in most cases to only a single canton.

When this method of treatment has been continuously applied for any length of time, trees of all ages from the seedling to the exploitable individual are found mixed up pell-mell together. A crop of this character, even though it be a complete one, cannot but consist of crowns rising one above another. Those of the large trees, standing out as they generally do singly, begin close to the ground, while those of middle-sized trees are often weak and spare, and all the younger growth is overtopped and hence, as a rule, lanky and sickly. Exceptionally, as the result of some special cause (the wind, for example, which may have blown down all the larger trees), some fine crops assume an almost regular appearance. But as reproduction is left to chance, glades and even blanks form, which, from being more or less numerous all through the forest, aggregate together at times a considerable area.

The outturn of produce of a forest worked by Selection is, acre for acre, admittedly less than that of a regular high forest. This inferiority is due principally to the languid growth of some of the trees and the sickly condition of a much larger number, and is very marked or insignificant according to the state of the forest concerned. The quality of the produce yielded is also inferior, sometimes even absolutely bad. The chief causes of this inferiority are (i) the rapid growth of the bigger trees, which in the case of conifers produces soft-grained-timber; (ii) the formation of large knots, which are serious defects when they occur in the silver and spruce firs; and (iii) the production of various kinds of unsoundness which induce rapid decay in the wood of the species just named. These defects, like the general unsatisfactory condition of the crops, result from the exploitations being spread over too large an area. The consequence is that the damage caused by the felling and export operations is not confined to one locality (in which case it might be easy to repair or mitigate), the commission of all kinds of offences is rendered easy, and the trees that stand out isolated above their neighbours, having their crowns exposed to the full force of the wind, are thereby broken, uprooted or shaken. Nevertheless, the worst that can be said of silver fir forests worked judiciously by Selection is that they are not regular.

The Selection System is attended also by another great danger viz., the exaggeration of the fellings, the end of which may be nothing less than the general ruin of the forest. If the quantity exploited is in excess of actual production, the forest becomes thereby rapidly poorer and poorer. As the fellings remove only the larger trees, it follows that the exploitable material on the ground goes on diminishing, until eventually there is nothing left in the forest but young saplings and poles. Then the growth becomes sparser and sparser, and the whole forest at length forms one huge glade. Should the component species be silver fir, the result is countless windfalls and the utter ruin of the forest. Herein lies the inherent and prohibitive defect of the Selection System. That system is, therefore, entirely out of place in our conifer forests situated at moderate elevations, where the prevailing conditions are sufficiently favorable for regular treatment and prompt and easy regeneration. The Natural Method indeed enables us to utilize the produce of such forests in the most happy manner possible, while avoiding the defects and risks that constitute a necessary element in the Selection System.

The transformation of a selection-worked forest of silver fir into a regular high forest is effected by completing and freeing the young crops overtopped by older growth. It requires three simultaneous Regeneration Fellings, all within one and the same area and calling for great skill and care on the part of the operator. These Regeneration Fellings we will term TRANSFORMATION CUTTINGS. The end to be secured by their means is to obtain young crops, which, if they are not at once regular, are at least capable of becoming so in course of time. The fellings here referred to demand much skill and experience, and will be found described and treated of in any work on Sylviculture. We would advise the student to read up that part of Sylviculture once more, if he wishes to study with profit the organisation of a selection-worked forest under transformation.

While the transformation operations are going on in one portion of the Working Circle, the mature trees found over the rest of it must also be felled. Hence it is necessary to continue for a time true Selection Fellings. These must be so regulated as to avoid the risks inherent in the Selection System itself, and to minimize its shortcomings by gradually improving and increasing the growing stock. Our finest silver fir forests, those of Levier in the Jura, and of the Sault plain in the Aude, have been so worked, with moderation and judgment, for very nearly half a century in those compartments which have not yet reached their turn for transformation. These now contain, splendid crops, abounding in vigorous, promising growth, and yielding every year excellent produce.

SECTION II.

MAINTENANCE OF THE SELECTION METHOD.

The Selection System, if worked with judgment, preserves a forest in a canopied state, irregular it is true, but presenting everywhere trees of large dimensions. These, thanks to their size, constitute the principal portion of the stock and the most important class of the standing timber. Thanks to them, certain forests worked by Selection present the true aspect of a regular high forest: the poles, by reason of their small diameter and their contracted crowns, do not strike the eye, while the young growth, overtopped, of no height, and incomplete as it is, makes little show. It is chiefly in spruce forests that this well-marked type is to be met with; but the Selection System admits of the maintenance of a tall canopied crop of any species whatsoever.

Moreover, under this system, reproduction is constantly going on throughout the forest. The extraction of single trees here and there from the midst of the canopied mass lets in sufficient light where they stood, and a sort of twilight under the crowns of their neighbours, conditions eminently favorable to the production of seedlings. Moreover the soil as well as the seedlings thus produced are constantly protected, another point in favour of the system. Thus it is not simply a single special Period, or a certain definite number of years that is allotted for the production of seedlings, but ages without limit; in other words every portion of a forest worked by Selection is, so to say, perpetually under regeneration.

It is now easy to understand how essentially conservative a method of treatment the Selection Method is, on the sole condition that it is worked in a spirit of moderation and that it removes none but really mature trees. The trees of such forests receive individual attention, and reproduction is assured as much as it can ever be. It is for this reason that Working by Selection has to be maintained in so many cases.

The first of these cases is that of forests conserved with a view to affording protection and shelter. Such forests are scarcely met with any where but in the wildest localities, in mountainous regions, in such places, for instance, as where landslips are threatened, avalanches are to be dreaded, the formation of mountain torrents to be prevented, and dangerous winds to be tempered or kept out altogether. Thus it is immediately above a village overhung by an abrupt slope or a canton exposed to avalanches, or it is at the point at which all the waters of a mountain-side collect to precipitate themselves into the valley below, or in a high gorge where the wind rushes violently through, that the Selection Method of working must be constantly maintained. Such localities are always well defined; they are rather single cantons than large extensive tracts. The preservation of the forest there is all the more necessary, inasmuch as it is often very difficult to restore it when once it has disappeared.

The second case in which it is expedient to continue the Selection System is that of those forests, in which reproduction is uncertain or so slow that it cannot be depended upon to recrop or regenerate any portion of such forests within a given time. The cause of this unsatisfactory condition is to be traced to the soil and to the climate. Thus in a climate where extremes of heat or cold prevail, or where shelter against the severity of dangerous winds is wanting, it takes a very long time for seedlings to make their appearance; and when once they do germinate, the new crop grows very slowly, and takes a very long time to join their crowns and close over the ground. The time required for so desirable a consummation to take place is often quite unlimited; it left to itself the forest must of course eventually reproduce itself, but this perhaps not until after a whole century has elapsed. Such is the case towards the superior limit of arborescent vegetation, and also on elevated plateaux, on mountain ridges, although of no great height, and on the edges of a forest continually struck by the wind. Similarly, on soil that is barren either on account of its rocky nature or owing to its being scarped, it would sometimes be vain to expect a complete sowing of the ground; if the trees are removed before a young growth is ready under them to take their place, the forest is exposed to certain denudation. Instances of this are those masses of sheet-rock, which, without the cover of the forest overhead, would not, as at present, be carpeted over with their thick covering of moss; agglomerations of boulders retained in their place by the roots of the large trees growing between them; and those scarps and very steep slopes, on which any steady walking is out of the question, and from which every seed that falls must roll or slip down and be washed away by rain. All these various conditions of climate and soil are often found so combined that their joint effects cannot be attributed any more to one of them than to another. But however it be, their presence is betrayed by facts, which are a certain indication that the Selection Method is required there. In such places the leaf-canopy is seldom unbroken and continuous, and is usually breached with blanks or persistent glades; if the forest growth has been removed, the naked rock crops out, or if there is a covering of turf over it, this is wanting in places.

Lastly, and as an exceptional case, the Selection Method is the most convenient one to apply to high forests of slight extent, the proprietor of which requires every year a small quantity of large timber. Although the conditions of growth in any given high forest may be perfectly satisfactory, yet it may be of too limited an extent to contain a complete series of graduated age-classes consisting of regular crops. In such a mere grove of high forest trees, the Selection Method is the only method of treatment which would allow a small quantity of large timber to be cut out every year. This method of exploitation is, therefore, still applicable to a certain, by no means insignificant, number of small forests, and, notably so, to communal woods, which constitute a most valuable resource for the village or hamlet owning them. Such is the case when the area of the given forest is too small for the formation of Periodic Blocks of at least 38 or 50 acres each. The minimum area of a regular Working Circle must of course vary with the constituent species, according as they reproduce themselves freely or slowly, and with the situation of the forest, but above all with the close neighbourhood or contiguity or remoteness of other forests. In any case, it is scarcely possible to execute, during a whole Period of 30 or 40 years, an entire series of Regeneration Fellings over an area of only 25 acres with all the necessary order, and without the occurrence thereby of damage of all kinds amounting to devastation pure and simple.

Among the forests under the control of the State Department, the aggregate area of those which fall under one of the three cases just described is very considerable. Such are the forests in certain corners of the Vosges, also on the last series of plateaux of the Jura Range, and in the rocky mountains of Central France. The six Pyrenean departments contain together a considerable proportion of such forests. But it is chiefly in the region of the Alps that the great mass of them is situated. Of the 1,125,000 acres of communal woodlands that still exist in that region, probably one-half can be subjected to no other treatment but the Selection Method. They are blocks or débris of forests of silver fir, of spruce, and of beech, situated at certain points in the northern portion of the region, and of larch, of Scots' pine, and of the mountain pine (*Pinus montana, Mill.*) in the southern portion. The same species, excepting the larch and the spruce, compose the forests of the elevated portion of the Pyrenees. In Corsica, the Austrian pine is found in addition to these other species. Thus it is in hundreds of thousands of acres that we may express the total area of our forests which must continue to remain subjected to the Selection Method; and more than this, the prevailing species in those forests are all our most valuable conifers.

The larger the area of the forest to be worked by Selection is, the more necessary becomes the judicious application of that method. But the manner of its application is different for the different species. The difference is greatest between that adapted for forests of delicate species, like the silver and spruce firs, and that suited for forests of hardy species, like the Scots' pine and the larch. In the former only a very few trees may be removed from any one point ; in a silver fir forest, for instance, only one. The young silver fir requires for its maintenance only a small quantity of light, and a full canopy is one of the first conditions necessary for the favourable growth of that tree. Where it is the dominant species, we must be careful not to remove, under the pretence of making a thinning, any over-topped poles, unless these are in a dying state ; for they possess the faculty of regaining vigour and of shooting up as soon as they are uncovered, and, as a general rule, they fill up at once the place left vacant by the overtopped trees, when these have fallen, either under the axe of the woodcutter or the violence of the wind. An analogous procedure, although slightly different, must be followed in the case of the spruce, which species is slightly more hardy, has a taller habit, and forms less regular leaf-canopy than the silver fir.

For pines and the larch the treatment is quite different. Worked by the Natural Method, they require an open Regeneration Felling. When subjected to the Selection Method, the Scots' pine similarly requires the removal of several trees from the same point, so as entirely to uncover a small plot (from 8 to 14 poles, for instance), with this precaution, however, that these little gaps are made at sufficiently wide intervals. The young seedling of the Scots' pine requires plenty of light to maintain itself and develop, and the trees of these species are averse to growing up side by side unless they are all more or less of the same height. When the large trees have been felled, it is perfectly useless preserving the poles that were growing under or close against them ; such poles are always more or less sickly and can never come to any good, and their preservation would only occupy the ground to the detriment of younger and more promising growth. Thinnings are useful and sometimes even necessary in uniform crops of Scots' pine poles. The requirements of the larch resemble those of the Scots' pine, but the stronger hold which it takes of the ground gives it an advantage over the latter species, in that individuals of it, reserved far apart when the older growth has been removed, are safe against injury from winds.

Moreover the detailed treatment of the various species referred to in the preceding paragraph is different for each of them. Thus in order to obtain a crop of seedlings of the silver fir, the spruce and the beech, it is an excellent precaution to prune off the lower branches of the trees a few years before they are felled; for the pines and the larch, the same end is served by a slight or partial working up of the ground, which, by loosening the soil where it is exposed to the light, furnishes the best means for sowing the ground. Such are the principal cultural operations, extremely simple as they are, that are required in a forest worked by Selection.

The risk attending the Selection Method, when it is badly carried out, or removes too many trees from a given area, is not less great in pine forests than in those of silver fir, in larch forests than in those of the spruce. It is most to be dreaded at high elevations, precisely there where the application of that Method is always necessary and demands great skill. At such elevations, where extreme cold prevails, the years of seed are few and far between; the summer, which brusquely succeeds the winter, often injures germinating seeds and young seedlings; and, lastly, the forests suffer severely from atmospheric influences, chief among which is the wind.

Under these peculiar conditions two opposite series of phenomena may be met with. Where the land is partially covered with young forest growth, such as scattered seedlings, patches of thickets, and bouquets of saplings, the cover thus formed becomes more and more effective every year as the forest developes, and the moisture of the soil is better and better preserved during the summer. Vegetation is active, the sparse crop meets and closes overhead, and soon the forest completely covers and takes possession of the ground. On the other hand when the forest growth, composed of old or middle aged trees with lofty crowns, begins to thin itself naturally and let in light everywhere over a certain area, the trees are deprived of the mutual support which they gave each other, and the soil is exposed alternately to be washed away and to be caked. Vegetative vigour diminishes, the larger trees die off one by one, seedlings are produced in decreasing numbers, and the ground at last becomes entirely denuded of its forest growth. These two sets of phenomena may be noticed in many and many a locality. They are especially frequent and well marked in the South. The former of them furnishes a valuable lesson to those engaged in hill reboisements, while the second shows us the danger of immoderate Selection Fellings.

CHAPTER II.

ORGANISATION OF FORESTS IN WHICH THE SELECTION METHOD IS TO BE MAINTAINED.

The organisation of forests worked by Selection is as elementary in its character as the corresponding method of treatment itself. The first care which it requires, is moderation in the exploitations, this being the only means of systematising them (as far as that can be done in this Method of Treatment), and of ensuring the carrying out of all necessary works of improvement and development. We will now proceed to examine separately the method of organising forests under all the three classes of circumstances which, we have seen above, necessitate the maintenance of the Selection Method; that is to say, we will show to what it practically reduces itself in forests kept up for protection, what measures it requires in the case of forests situated at high elevations, and in what particular respect it may have to be modified for high forests of altogether limited extent.

SECTION I.

Forests of Protection.

Forests maintained for the purpose of protection perform their rôle more effectively, the taller and, hence, the older they are. The exploitability to be adopted here is, therefore, that termed by us Physical, and is determined by the natural death or complete decay of each separate tree. The consequence is that the date of the exploitations, as well as the quota of produce to be extracted at each exploitation, are always unknown quantities; and, indeed, the figure or quality of the yield can possess only a secondary and often insignificant interest in the case under consideration. Thus the Organisation Project must make no attempt at laying down any prescriptions with regard to the exploitations; these should be left entirely to the discretion of the Executive Forest Officer, who would from time to time submit specific proposals connected therewith as the occasion required.

The organisation of such forests is, therefore, limited simply to their complete closing against grazing after being clearly demarcated. To this end, it may be necessary to prescribe the execution of certain protective works, such as ditches, walls, and fences; and also certain works of conservation and improvement, such as the partial sowing up of blanks, and the weeding out of bushy vegetation to clear the ground for the natural sowing of forest species. In the majority of cases, it is in the closing of the forest against grazing that the real means of safety lies.

SECTION II.

Forests situated at High Elevations.

Under the above heading we include all those forests in which reproduction is too uncertain or too slow to be obtained within a given time, as well as those which are exposed in a special manner to injury from high winds. The majority of such forests are actually situated at high elevations, where agriculture, properly so called, is impracticable, and which in France, as a rule, begin at about 3,300 feet above the sea. And indeed, speaking generally, wherever similar rigours of climate prevail as at those elevations, it is the Selection Method that is the treatment most generally applicable.

The first point to determine in organising such forests relates to the exploitability of the trees, which, as a rule, ought never to be felled except singly, so as to avoid producing gaps through which the wind could enter. On this subject Section 72 of the Royal Edict putting into force the Forest Code lays down that "*in forests worked by Selection the Organisation Project shall pre-*

scribe the age or the diameter which the trees ought to attain before being felled." The foregoing rule is an excellent one. It prescribes, in a word, that the exploitations shall remove only those trees which are capable of satisfying in the happiest manner possible the interests of the owner. In forests under the control of the State Department, it enforces the adoption of Qualitative Exploitability based on the diameter which the trees ought to attain in order to furnish the most useful produce they can. As regards the reference made to the age of these trees, the word "age" could only have been used in the sense of the stage of growth attained, since in a forest worked by Selection it is impossible to tell the age of any tree, until it has been felled. The Aménagiste must therefore ascertain what diameter would enable the trees to serve the most important purposes or to furnish the best possible descriptions of produce. The result of this inquiry, the corner stone itself of the whole Organisation Project, may be different for different parts of the country. In the silver fir forests of the Vosges, where the great majority of the trees are destined to be worked up with the saw, it has been remarked that the maximum of utility for unity of volume is attained with a diameter of very nearly 2 feet at 4½ feet from the ground: trees of less diameter do not work up into planks so well, while the timber merchant does not care to pay a higher rate for trees of larger diameter. As a rule then, the silver fir in a Selection-worked forest of the Vosges becomes exploitable as soon as it has attained a diameter of 2 feet measured at 4½ feet from the ground. It is unnecessary to observe that it is not every forest, especially if it is situated at a high altitude, that can produce trees of that size; but, at the worst, we can always endeavour to keep as near it as the special capabilities of the given forest allow. In the Jura, a portion of the silver and spruce firs produced is cut up into planks for the cabinet-maker; but the finest and thickest and longest logs are exported to considerable distances after being simply rough-squared, and are used as beams by the builder. These entire logs are in great demand and fetch higher prices than the same wood worked up into planks; but they must measure from 28 to 30 inches in diameter at the base. In those forests, therefore, the soil and climate of which allow the trees to attain that size, the diameter of the exploitable silver fir should be fixed accordingly.

In determining the yield of Selection Fellnigs, i. e. the number of trees to be exploited each year, the Aménagiste may either allow himself to be guided by the figures of the previous exploitations or by the number of exploitable trees actually standing on the ground. For example, if anterior to the organisation of the forest the number of trees felled annually is 4 for every 5 acres, he must either maintain this figure or raise or diminish it according as he finds the forest well-stocked, overstocked or understocked as regards large trees. This he could not know, with the certainty necessary for the work in hand, except by studying closely the various crops, noting the annual increment of the trees that are near the exploitable dimensions, and, lastly, reviewing the results of the valuation survey of all the formed trees of the forest arranged into size-classes. If the yield of the previous Selection Fellings cannot be ascertained, the production of the soil per acre must serve as a guide. The amount of this production can generally be estimated with sufficient approximation by men well up in the forester's craft; those who have had much to do with the exploitation of forests easily acquire this faculty. Moreover it may be obtained in various other ways, by an actual valuation survey, for instance, of the standing material in judiciously selected canopied masses of trees of the same age. [1]

(1.) The study of the growth of trees also enables us to estimate the production of the soil in exploitable timber. Suppose, for instance, we have a forest in which healthy trees may be expected for certain to attain a diameter of 24 inches. Suppose also that the average annual radial increment has been found, by means of measurements made on felled timber, to be one-tenth of an inch. Hence it would take 60 years for a tree of 12 inches diameter to attain a diameter of 24 inches. The time required for a tree to reach a diameter of 12 inches, rarely the same for any two trees even of the same crop, might be on the whole much longer than 60 years. If we suppose it to be half as long again, i. e. 90 years, then the time required to obtain trees of 24 inches diameter would be 150 years. In the next place those portions of the forest, in which several trees of this size are found grouped together, show how many of them could stand on an acre completely stocked with them. Say that this number has been found to be 75. From the preceding data may now be calculated the total annual sum of production per acre in mature timber. Thus it might be half a tree per acre per annum, measuring from 50 to 70 cubic feet according to the height attained by the trees.

The known yield of adjoining forests growing under similar conditions and under systematic treatment would also furnish a safe guide.

These various methods can be used to check one another, but their application requires no little experience on the part of the Aménagiste.

The annual outturn of silver fir forests usually varies from 28 to 56 cubic feet per acre at high elevations, and from 28 to 98 cubic feet where the climate is less rigorous. By comparing the average annual production calculated for the whole forest with the contents of the exploitable tree, the Aménagiste can test the correctness of his conclusions relative to the yield of the former exploitations, and in any case guard himself against the risk of being much above or below the true figure. Suppose, for instance, that the annual sum of production per acre is about 70 cubic feet, and that the exploitable tree (take it to be a silver fir) measures 2 feet in diameter and contains 140 cubic feet on an average; the yield would thus be half a tree per acre, or, in other words, if the area of the forest was 500 acres, 250 trees per annum.

The order and succession of the Selection Fellings are regulated in a very simple manner. Instead of spreading the annual cutting over every crop in the forest, the practice has always been, and with good reason, to allow an interval of rest between two consecutive exploitations in any one place. Hence iu order that these exploitations may be reduced to a regular system, it is expedient to fix a periodicity for the Selection Fellings. Thus, for instance, if it is considered advisable to return once in ten years to the same compartment, it will be necessary to work through the entire forest in 10 years, a procedure which necessitates the division of the forest into 10 portions or coupes. With natural lines, as far as possible, for boundaries, these coupes need not be equal in area. Nevertheless any great difference of area is to be deprecated, at the same time that the relative extent of the several coupes should be so fixed that their productive capabilities may be appreciably the same. The partition of the forest into such coupes and the determination of the order in which they should be respectively taken up constitutes the Working Plan or permanent framework of the Organisation Project.

Continuing the illustration of the last but one preceding paragraph, suppose the forest to be divided into 10 equal coupes; each coupe would thus contain 50 acres and the annual fellings would remove from it 5 trees per acre every tenth year. If that number was found to be too considerable, if, in other words, it was considered dangerous to remove so many trees all at once from a single acre, the thing to do would be to reduce the number of the coupes. Suppose that number reduced to 6, then the Selection Fellings would return to the same spot once every 6 years and remove therefrom only 3 trees per acre. It is thus apparent that the first point of all to determine is the number of trees that may be extracted in a single operation from one acre without endangering the safety of the forest. It is only then that the periodicity of the fellings and the number and boundaries of the coupes can be fixed. The Working Plan is thus indissolubly connected with the yield of the forest. In high forests worked by Selection, more so even than in those subjected to the Natural Method, the combinations of the Organisation Project should be subordinated to cultural requirements, that is to say, to the rules of exploitation necessary for the preservation of the forest.

It is evident that by felling every year the same number of trees without any regard to their size, the annual yield cannot be the same either in respect of quantity or money-value; but in proceeding thus, the constant maintenance of the forest in a well-stocked state, or its continued improvement until it reaches that state, is guaranteed. In the first place, it is easy to see that the same number of trees may be exploited year after year in a Selection-worked forest for an indefinite period of time. If the contents of the exploitable tree be 140 cubic feet, and the sum of production of the forest 70 cubic feet per acre per annum, it is quite possible that the forest may be sufficiently well stocked with trees of all ages to bear half a tree or 70 cubic feet being removed per acre without either becoming richer or poorer. But if, on the other hand, the forest actually contained but little large timber, the same number of trees would be still cut, but these would be mostly of smaller size than the type tree of 140 cubic feet; and so the stock of the forest would go on increasing every year. On the contrary, if the trees exploited contained more than 140 cubic feet, the quantity extracted annually would exceed 70 cubic feet per acre, and the stock would go on diminishing.

Again if the total production of the soil was not 70 but only 60 cubic feet per acre, the effect of exploiting half a tree per acre would, even without any consciousness on the part of the operating forester, be that the volume of the type tree would go on diminishing until it reached 120 cubic feet. Thus under any circumstances, the system of felling by Selection so many trees per acre invariably results in eventually bringing the forest into a certain stationary condition, the stock in that state being larger, the smaller the number of trees exploited per acre is.

And more than this, the same result follows for each separate coupe, and it is this very peculiarity that enables Selection Fellings based on number of trees to be carried out in a systematic manner. The object of reducing them to a system is to concentrate each annual exploitation into a definite portion of the Working Circle, a condition that is a necessary guarantee for the judicious marking of the trees to be felled and a most fruitful source of economy in making the fellings. Moreover another systematized result of this manner of working is that the area of each coupe is then sufficiently large to admit of a short periodicity, and thus render it possible always to exploit at the right time all mature or dying trees and to avoid the simultaneous felling of any considerable number of trees within a given limited area. The periodicity of the Selection Fellings depends entirely on the forest concerned and its component species. As a rule, it is 5, 8, 10, 12, or 15 years. It ought to be short for the spruce, long for the larch, shorter in fertile soils than in barren soils, longer in rigorous climates. The periodicity of the Selection Fellings having been determined, the order in which the compartments should be exploited may be fixed at once for the whole Rotation. At the beginning the well stocked compartments will yield large timber, those poorly stocked small timber; but a certain equilibrium will soon be established, provided the annual fellings go over areas of nearly equal productive power. The only disadvantage in fixing the yield at so many trees per unit of area is the inequality of the outturn from year to year. But this inequality is more apparent than real, and it can be easily remedied by dividing the forest into Working Circles, which need not be large in forests worked by Selection.

Such is the procedure which we recommend in organising forests in which the Selection System has to be maintained. It now remains for us to say what we consider necessary as regards the actual execution of the Organisation Project.

The yield for the whole forest being fixed, as also the number of trees to be extracted each year, the Executive Officer must mark for the axe all trees that are dead, dying or unsound, as well as some others that are still growing and in a healthy condition, the latter naturally being the largest of all the trees in the coupe and limited to such as are absolutely required to make up the full number of trees fixed for the annual yield. Dead and decaying trees under 12 inches in diameter must also be felled, but ought not to be included in the yield, since they are no better than mere poles. But formed trees of that girth and upwards, which are felled because unhealthy or unsound, can on no account be omitted from the yield of the year. The unavoidable premature exploitation of formed trees under the fixed exploitable girth is compensated for by the healthy growth of the larger trees that are preserved, an indispensable set off in cases of this kind.

Besides this, it is certain that in actual practice the determination of the number of trees to fell per acre is not difficult. For it is evident that by cutting on an average two-fifths of a tree per acre per annum in Selection-worked forests managed by the State, the owner obtains from them all they can yield that is most in conformity with his wants. The result must be that 70 cubic feet will be extracted where the actual annual increment is only 70 cubic feet per annum, 140 cubic feet where it is 140 cubic feet, and so on. Is not this in truth a desirable state of things to have ?

In forests worked by Selection it is advisable to establish a Reserve Fund based on area, one of one-fourth of the whole area for instance, as in communal copses to be described further on.

SECTION 3.

HIGH FORESTS OF LIMITED EXTENT.

In a grove or forest of very limited extent worked by Selection, although the conditions of growth may be all that can be desired, yet the interests of the owner (it may be a Commune) may require Annual Exploitations and a Sustained Yield. In that case the quantity to cut yearly must be deduced empirically from the average contents of the trees to be felled, due account being taken both of the number of trees that would correspond to the annual sum of production and of the available material on the ground. That quantity should be fixed only for a limited period, and will be large or small according as the forest is well or poorly stocked with old trees. The annual yield would vary only once after a fairly long interval, to be sustained again for another interval of more or less equal duration. As to the march of the exploitations, there is no reason here for limiting them to fixed areas; for it would be a matter greatly to be deplored if poorly stocked compartments were overworked and well-stocked compartments worked under their full capacity. The Aménagiste can therefore only give the order in which the compartments should be severally taken up and state whether the periodicity should be long or short.

It is necessary to revise frequently the annual yield of forests worked by Selection, when it has been fixed according to cubical contents and not to number of trees to be felled. Such revisions constitute the entire provision against the evil results that may arise out of the necessarily complete uncertainty regarding the annual sum of production. The present condition of the forest compared compartment by compartment with what it was at the beginning of the Period, as described in the Organisation Project, and the volume of the formed trees it now contains as compared with the volume of the trees that have been exploited, will furnish data of the highest necessity for the redetermination of the yield.

CHAPTER III.

ORGANISATION OF SELECTION-WORKED FORESTS UNDER TRANSFORMATION INTO REGULAR HIGH FORESTS.[1]

A silver fir forest subjected for a long time to judicious treatment by Selection offers a very simple case of an irregular high forest. Trees of every age from the youngest to the oldest being all mixed up together everywhere, the irregularity is of a uniform character throughout the forest, and the climate and soil then serve chiefly or solely as a guide in the formation of the compartments. The state of the crop, since its composition and density and the utter confusion of ages are generally the same everywhere, can influence the operation only in a secondary or even exceptional manner. As forests worked by Selection are usually situated in hilly or mountainous country, the configuration of the ground becomes a matter of great importance and it seldom happens that it does not indicate in a clear and definite manner a natural series of compartments. As the division into compartments is thus founded on the constant factors of production, it follows that it possesses a character of permanence.

The formation of the Working Circles is independent of what is usually the most difficult condition to satisfy in that operation viz: a proper distribution of the age groups, for all the different ages are necessarily mixed up together everywhere. But it may be found expedient, before everything else, to separate from the mass of the forest those portions in which the Selection System must be maintained. By reason, say, of its elevated situation or of the absence of shelter, a forest may sometimes contain certain portions

(1.) This Chapter refers in a special manner to our silver fir forests that were formerly worked by Selection. The transformation of pine forests is an event of rarer occurrence, and is besides a less difficult matter.

in which reproduction and even simple growth may be possible only under great difficulties. The constant preservation of the leaf-canopy is here a more important condition than the transformation or regularisation of the forest. Such portions constitute the natural protection for those situated below them, and the maintenance therein of the Selection System is necessary for their own existence. They may ordinarily be recognised from the portions capable of transformation by certain distinctive characters; for instance, the beech or the spruce may there be more numerous than elsewhere, or the trees there may be dwarfed and misshapen, or the leaf-canopy may be incomplete in places or vary in density from point to point; or, lastly, special and diverse phenomena observable may point out the particular portion or belt which must be continued to be worked on the Selection System.

The requisite separation just described being effected, the rest of the forest should then be divided off into Working Circles according to the general rules regulating that operation. And, as in forests treated by Selection, trees of all ages are found mixed up together without any order whatsoever, the main point to bear always in mind is the grouping into one and the same Working Circle of only such portions of the forest as require all the same Rotation.

The length of the Rotation to adopt must, of course, depend on the diameter the trees must attain in order to yield what is in greatest demand in the market and is the most useful to the country at large. In our finest silver fir forests of the Aude and the Jura, it is only when the trees have acquired a diameter of 28 inches at the height of a man from the ground, that they are classed as large timber and possess for every cubic foot of their volume the highest money-value and the largest sum of utility they can ever attain. In such forests the problem to solve is at what age the silver fir grown in Regular High Forest will attain this diameter. The trees of a forest worked by Selection reach this size at very different ages, according as they have been overtopped for a longer or shorter time, have maintained themselves in a more or less vigorous condition, and possess more or less healthy and well-furnished crowns. But amongst these trees there must always be some that have grown up as if they had been reared in a regular high forest; they may be easily recognised by the form of their boles which are clean up to a great height; and by the thickness and aspect of their annual rings. It is the age of such trees, which have grown in a regular manner and under average conditions of fertility, and which have besides attained the dimensions corresponding to the maximum of utility, that ought to be adopted as the figure for the Rotation.

The General Working Scheme gives the order in which the various portions of the forest shall be taken up for transformation during each successive Period of the Rotation. The Periods should, as a rule, be long on account of the component species, which is with us generally the silver fir, and on account of the climatic conditions peculiar to high mountainous regions. The reason is evident, for in silver fir forests regeneration progresses very slowly, and in order to obtain it in a completely successful manner, great caution is necessary in the cultural operations. We do not estimate at less than 25 years the period of time that must elapse between the Primary and Final Fellings, and within this period at least one Secondary Felling has to be made.

The Periodic Blocks should all be of equal extent whenever the ground permits of it, or, better still, of equal productive power. Each of them should, as far as possible, form a compact mass bounded by natural limits. The observance of this rule serves in the majority of cases to indicate the proper number of Blocks to adopt, that figure being no longer, as in regular forests, determined by the number of the component age-groups, but by that of the natural topographical divisions of the ground. In forests hitherto worked by Selection, it may be a matter of great importance to have the successive Blocks of the same Working Circle following one another on the ground in the order in which they shold be taken up and in the direction opposite to that of dangerous winds. Indeed such a disposition of the Blocks is seldom impracticable in the forests under consideration. The Working Scheme is thus usually a very obvious one, and is, in any case, always well-defined.

The Special Scheme of Exploitations does not present the slightest difficulty as regards the nature of the cuttings to be prescribed—Transformation Fellings in the Block under transformation, Selection Fellings in all Blocks, the transformation of which has not yet been commenced. The duty of proposing the Improvement Cuttings to be made in the portions already transformed and, therefore, already regularized, may be left entirely to the Executive Officer, no reference thereto being made in the Organisation Project. The Cleanings, even when their utility is greatest, as, for example, in a forest of mixed silver fir and beech, could not possibly be prescribed; while Thinnings, less useful in silver fir forests than almost anywhere else, never assume an urgent character, and are, moreover, if badly executed, extremely dangerous. In the majority of cases, therefore, it is safer to leave them to those who are to execute the Organisation Project: they can judge better than any one else where and when such cuttings should be made, and will undertake them only when their utility is unquestionable. To tie the Executive Establishment down to carrying out a multitude of various operations, especially where mountain forests are concerned, would be the greatest mistake the Aménagiste could commit.

It remains now to show how the yield of principal produce for the duration of the current Period is calculated. This yield is naturally derived from two sources, (i) the produce of the Transformation Fellings, (ii) that of the Selection Fellings.

The Transformation Fellings, which are before everything else true Regeneration Fellings, ought to be based on volume. As a rule, they remove all the formed trees, in other words, trees other than mere poles; to remove anything else would be defeating their very object, which is to leave, after the cuttings have passed through, young canopied crops capable of forming a harmonious whole and of soon constituting a high forest little removed from the regular state. The Aménagiste is thus obliged to include in his estimate of the yield trees having a diameter of only 16 inches, and even of 14 inches in the majority of cases. It is clear that if such trees exist in any numbers, the transformation of the forest entails a heavy sacrifice. However it be, the enumeration and measurement of trees above a certain diameter affords the means of readily ascertaining the actual contents of the standing timber. The future increment of these trees up to the time of their exploitation cannot be determined in the same manner as that of canopied crops composed of trees of the same age. If it is desired to take this future increment into account, the Aménagiste must, in order to estimate it, go back to the figures yielded by the former Selection Fellings, or find out the sum of production of the soil. But it is better to neglect the future increment altogether, in which case care should be taken to prescribe several revisions of the annual yield during the course of the current Period.

The yield of the Selection Fellings to be made in the Blocks that have not yet come under transformation presents no difficulty. This is obvious, for in order to obtain the most desirable results possible, it is expedient to remove only such trees as could not maintain themselves in a sound state until the crops containing them reached their turn for transformation. The effect of this rule is, if we wish to work with some certainty as to results, that only mature trees are removed in the successive Selection Fellings. Treated thus, the crops still worked by Selection end by becoming gradually more and more complete. Each successive Period finds the small and healthy trees of the preceding Period grown up into a higher age-class, and in this manner the general appearance of the crops, as they approach their turn for transformation, resembles more and more that of old high forest, a most favourable circumstance whether we regard it from the point of view of improved produce or the regeneration of those crops or the maintenance of a sustained yield during the various Periods occupied by the transformation. All these results may be obtained with certainty simply by restricting the Selection Fellings to a limited number of trees, at the rate, say, of two-fifths of a tree per acre at the outside, or even at the rate of only one-fifth of a tree if the forest contains only a small stock of large timber.

This point being settled, our own opinion is that the march of the Selection Fellings in the Blocks not yet brought under transformation should be arranged in a very simple manner. Given, for instance, a silver fir forest of 1000 acres that is worked on a Rotation of 144 years, divided into 4 periods of 36 years each. We will suppose that it is considered advisable that the three Blocks which are still to be treated by Selection should be completely worked over every six years. Then their total area should be partitioned off into 6 coupes, the successive order in which these 6 coupes should be taken in hand and the number of trees that should be removed annually being fixed at the same time. If it was decided to cut on an average one-third of a tree per acre, then the total number of trees to be felled by Selection during the First Period in these three Blocks would be 250 per annum.

If there was reason to fear that too short a periodicity for the Selection Fellings would have the effect of exhausting the crops operated upon, then it could be raised to 9 years; in other words the area would be divided into 9 coupes of equivalent productive power and the successive order and yield of these coupes determined as just described. At the end of the Period, or even at each revision of the yield, the results obtained by these restricted Selection Fellings should be noted, and in this manner it would be easy to judge whether it would be expedient to maintain, raise, or reduce the number of trees fixed at starting.

With the Selection Fellings restricted to really mature trees, no matter what their size, it is possible to maintain a selection-worked forest unchanged, as regards the density of the component crops, for an indefinite period of time. Our finest silver fir forests prove this. The Blocks to be transformed last must, as a consequence of such treatment, assume more and more the appearance of regular Old High Forest until regenerated each in its proper turn, provided always that overtopped poles are on no condition removed.

Besides this, it is easy to see that with the produce derived from Transformation Fellings in one part of the forest and from Selection Fellings everywhere else, the yield of the First Period can scarcely ever fail to reach a sufficiently high figure. The extraction of material over and above the outturn of these cuttings, if it must be effected in some portions of the Working Circle in order to fill up any deficit, should hence be restricted to a few really exceptional localities, and the exploitation of such produce should be spread over a number of years so as to remove only moderate quantities at a time and avoid all risk of converting its extraction into a series of operations disastrous from a cultural point of view and dangerous in every other respect. We would deprecate any attempt to fix the Rotation for transformation below the figure that would have been required for the same forest had it been already regularised. There is no advantage to be gained by trying to hurry on; on the contrary two disadvantages inevitably follow. In the first place, too much would thereby be cut during the First Period, a result that must, imperil to a considerable extent the success of the transformation operations. We know of certain silver fir forests that have been thus overworked for only 30 years, and already they have reached such a stage that they can now stand nothing severer than the most circumspect Selection Fellings. In the second place, it is impossible to form a regular high forest presenting a complete series of graduated age-classes with a curtailed Rotation.

In the case of Selection-worked forests that are poorly stocked, it may even be found expedient to put them through a period of special preparation in order to render them capable of being transformed. For this purpose, it would be enough to let the stock of a single canton mature on by restricting the Selection Fellings therein to as low a figure as possible, or even by not touching it at all and confining such fellings to the remainder of the Working Circle. After this Preparatory Period the conserved canton may be regenerated under the most favourable conditions and without necessitating the extraction of any considerable quantity of immature timber.

In most forests worked by Selection there are always some portions, and these very generally young, which have grown up in a regular manner either as the result of accidental circumstances or of Final Regeneration Fellings. To turn such crops to the best account, it is enough if they are placed in the right Block, say, the last, for instance. But in an ill-stocked Working Circle it is often useful to include these young crops in the First Block, so that they might together constitute a notable proportion of its area, and thereby render possible the preservation of growing timber on an equal area for one Period more than in the contrary case, often assuring by that means alone the success of the transformation.

As regards blanks and glades, they ought to be restocked as soon as possible, whatever their position in respect of time in the General Working Scheme. In silver fir forests this restocking is usually a very slow operation. Shelter of every kind, whether it be afforded naturally by existing trees, scrub, and bushes, or by pines or spruce firs planted out as nurses, is indispensable in the majority of cases. The consequence is that the restoration, like the creation, of a silver fir forest is the work of two generations of men, and its difficulty can therefore be easily appreciated. And, indeed, the important nature of the task before us cannot but strike any one, if he only bears in mind that we have barely 500,000 acres of silver fir and spruce forests under the control of the Forest Department, that all the remaining areas containing these species are comparatively of very little value, and that we depend on foreign countries for an immense proportion of our annual supply of deal timber when our own mountain forests could produce it all. But silver fir forests are as quick to disappear as they are slow to reform. Thus it is a matter of no little importance how we regulate the working of such of these forests as are managed by the State, by means of judicious Organisation Projects, and above all by practising throughout the utmost economy and moderation.

CHAPTER IV.

IRREGULAR HIGH FORESTS OF THE BROAD-LEAVED SPECIES.

SECTION I.

Cultural Requirements.

The method of treatment known as that *à tire et aire* consisted in the clean-felling of equal areas in unbroken consecutive order. The Royal Edict of 1669 made its observance compulsory in high forests as well as in copses. That Edict prescribed the reservation of ten trees per French acre (1.275 English acres).

Moreover, when once a clean-felling had been made in any place, the method in question admitted no further cuttings of any kind until the next clean-felling took place on the expiration of a whole Rotation, the only exception to the rule being the Extraordinary Fellings executed under the special orders of the King's Council. Thus from one end of the Rotation to the other, the growth of the new crop was left to chance and Improvement Cuttings were not even so much as thought of.

This method of treatment was especially employed in the plains forests, which were stocked with broad-leaved species, and the produce of which could be exported for general consumption. Its essential object was the production of the large timber required by the country at large and the Royal Navy. The rigid consecutive order which the Edict prescribed for the fellings was intended before everything else to assure the complete and unqualified preservation of every crop during an entire Rotation of from 160 to 200 years, that is to say, until it had attained complete maturity.

By the time a forest reached this advanced age, the cover of the trees must everywhere have become lofty, all low undergrowth must long since have disappeared, and the soil must have been already covered with a more or less abundant crop of seedlings. The trees that had to be spared at the exploitations, were reserved simply with a view to the production of timber of exceptional size and quality. Indeed, at the age fixed for the clean-fellings, the oak trees, if there were any, could neither have possessed great diameter, nor have contained very close-grained wood, owing to the overcrowded state in which they necessarily grew up. And it was precisely in forests of oak and hornbeam, or of oak and beech, that this method of treatment was in full force.

The limited area under State control that now remains to us of our old high forests of the broad-leaved species (about 500,000 acres) was formerly subjected to the *tire et aire* method. These forests, such as they were 50 years ago, are faithfully described in the "*Cours de Culture des Bois*" of Messrs. Lorentz and Parade, and although their aspect and condition have been singularly modified by the exploitations that have been made in them since those days, yet we must still go back to the description of those forests as given by our Masters, in order to draw therefrom the necessary inspiration to enable us rightly to understand how to organise and treat them so as to regularise them.

Nearly all these forests are situated in the plains, or in undulating country where the climate is mild. Of the principal species, all well adapted to the soil and climate, they contain the oaks, beech and hornbeam, besides, in an exceptional manner, the Scots' pine, which is artificially introduced in order to repair damage caused either by accidents or faulty operations. The oak is too often found in them in a pure state, the result of a systematic attempt to exterminate the beech and hornbeam. The sessile flowered oak adapts itself better to this state than the peduncled species, the result being that we have now completely canopied masses of pure sessile-flowered oak aged from 150 to 200 years, perfectly healthy, but making exceedingly slow growth and thus yielding spongy and nerveless timber. We could cite several cases in which the trunks measure scarcely 20 inches in diameter, whereas if they had grown in association with the beech in dry soils and with the hornbeam in moist localities, they would have attained twice that thickness. The peduncled oak requires richer, deeper, and moister soil than the other species; it is the oak of low and wet situations, where it produces tough close-grained wood and attains the largest dimensions, but, like its congener, only on the condition that it is associated with other species. The hornbeam is its most useful companion and auxiliary.[1]

The majority of the class of high forests just described offer more or less numerous instances of irregularity. Here and there we still find in them superannuated trees of oak or other species, crops holding out no promise whatsoever or containing but a small proportion of the principal species, portions that have undergone deterioration or have been completely ruined, &c. Again, even the consecutive order of the cuttings which essentially constituted the method, has seldom been observed; exploitable trees have been taken out wherever they were found, and especially from such places as offered peculiar facilities for export and sale. The result of all this has been the frequent and entire absence of any consecutive order in the exploitations and an utter confusion of age-classes. Then again, the area of the annual coupes varied from year to year, according as more or less produce was required in particular years, or in consequence of marked changes made in the length of the Rotation. The inevitable result was a defective gradation of the various age-classes. Moreover, circumstances of a special nature aggravated the evils already enumerated; thus, for instance, in a great many forests, towards the end of the last century, an unlimited number of trees in crops aged from 20 to 30 years were systematically cut back, with the result that whole age-classes were thereby completely wiped out. Repeated again and again, these irregular fellings have given rise to veritable copses, both simple and compound, in certain parts of the forests we are describing. Elsewhere artificial restocking has produced whole crops of brief longevity of an entirely special type. Lastly, offences and injury of all kinds, such as the cutting down or topping off of trees, the lopping off of branches, the repeated removal of the layer of dead leaves on the ground, grazing, the browsing of cattle, the depredations of game, &c., all these causes have, singly

(1) In a pole crop from 40 to 50 years old and containing from 2000 to 2500 stems, one or two of oak to every nine or eight of beech and hornbeam would be a sufficient proportion to have.

or combined, compromised whole crops in various ways and degrees

After what we have just said, it is easy to understand how certain forests of our plains have been brought into a state of the utmost irregularity. The effects produced continue to manifest themselves even now, long after the causes, which gave rise to them and which we have just enumerated, have ceased to exist, and although the Method of *tire et aire* has long since been abandoned. The organisation of the forests treated by that method is thus a singularly complicated and difficult task and is for that very reason all the more an urgent one.

SECTION II.

Organisation of Irregular High Forests of the Broad-leaved Species.

When, after having formed the Compartments and the Working Circles and determined the length of the Rotation, the Aménagiste sets himself to draw up the General Working Scheme, he nearly always finds himself confronted with difficulties of no trifling nature. These difficulties are, as a rule, due to the defective constitution of certain crops, the irregular distribution of the various age-classes, and the unequal repartition of the crops corresponding to the principal age-classes. The formation of the Blocks thus becomes a very delicate operation. In the same manner as in regular high forests, every endeavour should be made to form them in accordance with the general principles already laid down, that is to say, they should be equal in extent or be of equivalent productive power, and be all in one piece as far as that is possible. Besides this, each Block should comprise a convenient group of compartments, in other other words, the whole or at least the greater portion of it should be composed of crops that will become exploitable during the Period assigned for its regeneration.

With respect to single compartments surrounded on all sides by others of entirely dissimilar character, and which their age, state of growth, composition or density prevent from being regenerated at the same time as the general mass of the Block in which they are situated, they must be considered apart from the rest of that Block. The Special Scheme of Exploitations should prescribe, at the beginning of each Period, the separate treatment required by each such compartment so as to turn it to good account. The Special Scheme should also endeavour to bring about the necessary harmony between the various compartments composing the Block, but without rendering necessary any great sacrifices in order to attain it.

It is impossible to foresee all the various special circumstances that one may have to deal with in organising these irregular forests. The student will gather from the annexed example, which we have expressly drawn up, some idea of the principal difficulties to be encountered in this work, and of the combinations by which it is often possible to satisfy the requirements of an effective treatment, as well as at the same time to realize, within the measure of the possible, the principal benefits to be derived from a good Organisation Project.

Given a Working Circle stocked with oak, beech, hornbeam, and other broad-leaved species ; area 5000 acres. Suppose that the Rotation suited for the forest, when it has been regularised, is 180 years, and that this figure is adopted as the basis of the General Working Scheme during the regularisation. Granted also that it has been ascertained that no crop of this forest ought to be exploited before it is 160 years old, at which age the oak acquires, under existing conditions, a diameter of 26 inches, or after it has reached the age of 200 years, when the trees begin to decay. We will further suppose that the configuration of the ground and the distribution of the crops have led to the formation of five Blocks as shown in the subjoined Tabular Statement.

Periodic Blocks.	Compartments.	Area.	Nature and condition of standing stock.	Age of stock at commencement of Organisation.	Probable Period for regeneration.
		acres.		years.	
I	A	45	Thickets and Saplings of mixed species.	18 to 20	
	B	100	Old High Forest of oak and beech.	190	1
	C	37	Pole crop of alder, dotted with old oaks.	75	1
	D	45	High Forest of beech.	140	1
	E	62	High Forest of oak sprinkled with hornbeam.	140	2
II	F	105	Pole crop of hornbeam and scattered oak.	50	2
	G	70	High Forest of beech, interspersed with blanks and glades.	120	2
	H	105	Half-grown High Forest of oak and beech.	90	3
	I	30	Pole crop on stools; hornbeam, oak, and the soft woods.	35	2
III	K	55	Young pole crop of pure oak, an old plantation.	32	4
	L	70	High Forest of oak and hornbeam with reserves of oak.	120	3
	M	75	High Forest of oak, beech, and hornbeam.	100	3
	N	60	Pole crop of the soft woods, with scattered oak and mixed with hornbeam.	40	1 and 3
	O	35	Alder copse.	10	1 and 3

Periodic Blocks.	Compartments.	Area.	Nature and condition of standing stock.	Age of Stock at commencement of Organisation.	Probable Preiod for regeneration.
IV	P	92	Young High Forest of oak and beech.	80	4
	Q	32	Pole crop of oak and beech. with an upper stage of very numerous reserves of the same species.	45	4
	R	45	Sapling crop of oak and hornbeam, over-topped with soft woods.	25	5
	S	20	High Forest of beech mixed with oak.	100	2 and 4
	T	65	Copse with standards, the hard woods badly represented.	5 to 16,	1,2 and 4
	U	57	Pole crop of oak, beech. and hornbeam.	60	4
V	V	135	Pole crop of oak, hornbeam and the soft woods.	35	5
	X	17	Open High Forest of pure oak.	180	1 and 5
	Y	30	Seedling crop of beech and oak under reserves, state of a Secondary Coupe.	5 to 10 & 170	1 and 5
	Z	40	Pole crop of birch forming the dominant species, with beech and oak.	65	1 and 5
	A B	65	Crop of High Poles of beech and oak, in good condition, sprinkled with reserves of two different ages.	70,140 & 200	2 and 5
		1492			

The figures in the last column, deduced from the actual state of the crops, may be entirely conjectural, but they cannot be dispensed with, as they afford the necessary basis for the General Working Scheme, which could not otherwise be framed. From them we conclude that the following exploitations should be made during the First Period :—

Irregular High Forest Fellings in compartments X. Y. and Z. Area 87 acres.

Regular High Forest Fellings in compartments B, C, and D, area 182 acres.

Irregular Coppice Fellings in compartments N, O, and T, area 165 acres.

Compartment X, with a limited area, is necessarily placed in the last Block, in the very middle of which it is situated. Compartment Y, which is in course of regeneration, requires only the last Secondary Fellings and the Final Felling over the new seedling crop, which will become exploitable in the last Period of the current Rotation. Compartment Z, which contains, considered as a whole, a crop of no promise and of little value, must be regenerated during the current Period, but all oak poles should be spared; these poles will form a valuable portion of the new crop. As a necessary and sufficient set off against these irregular exploitations, compartments A and E ought not to be exploited during the First Period. Compartment N must be worked as a copse with Standards, the object in view being to preserve all the useful hardwood portion of the crop; that, with the new regrowth, will together form an old copse of 72 years at the commencement of the Third Period, when the compartment in question will reach its turn for regeneration by seed. Compartments O and T will be exploited as copse when about 36 years old, the proportion of the hardwoods in them being in the meanwhile increased by means of thinnings followed by artificial planting under the cover overhead. At the beginning of the Second Period it will have to be seen whether it will be necessary to repeat once more the Coppice Fellings in these two last mentioned compartments.

Such are, in a few words, the principal exploitations that should be made during the First Period. They are restricted to an area equal to the extent of one Block, and their object is to renew several crops that have no present promise whatsoever. In making these exploitations every thing must be done that will facilitate matters for the next exploitation, during the proper Period, of the regenerated and reformed crop. These preliminary operations will thus be the first step towards order and permanent improvement.

If a similar Tabular Statement with regard to the crops to be exploited during the Second Period is drawn up, it will be seen that their exploitation will have been greatly facilitated by the work done during the First Period. It will be found possible, in the next Special Scheme of Exploitations, to arrange for exploiting with a sparing hand those crops and individual trees, respecting the good growth and promise of which there can then be no doubt. It is quite possible that compartments A and B, with their mature standards only gradually cut out, could be maintained standing until the Fourth Period, and that compartment S could be transformed in as happy a manner by means of judicious Thinnings, so as not to require, contrary to present expectation, any partial regeneration in view of the beech during the Second Period.

The student will now understand that it is easy to obtain some previous idea of the extent to which a sustained yield can be assured for each of the Periods of a Rotation, and especially for the first two or three. He will be able to note how the various crops of a Working Circle are regenerated by seed one by one, each in its turn, either during the Period to which it is assigned in the General Working Scheme or during the immediately preceding or immediately following Period. He will observe how, when the position of each compartment in the General Working Scheme is known, the object of every operation to be carried out becomes clear and well defined. Lastly, he will perceive how the General Working Scheme, although sketchy, yet absolutely necessary at the commencement of the every Organisation Project, becomes better and better defined as Period after Period passes, until it entirely loses its artificial character, and forms with the actual state of the forest a harmonious and natural whole.

SECTION III.

Necessary Results.

The Method of Organisation by Area is as simple as any that can be applied to high forests. In it the Organisation Project consists of two essential parts; (I) the General Working Scheme, which has a permanent character on the ground itself and may be indefinitely maintained unchanged; (II) the Special Scheme of Exploitations, which arranges and prescribes the operation to be made during a necessarily limited time. The whole scheme of work can thereby be taken in at a glance and its control and execution become thereby easy.

If the necessity of organising high forests is incontestible, it is equally obvious that the Method based on Area supplies the necessary starting point for the regularisation and improvement of a forest. If it be asked what we understand by these two words, which express one and the same idea? The reply is easy. They mean, in the first place, the bringing into a favourable condition or the restoration of the component crops of the forest, chiefly with the aid of time, but also by means of well-conducted operations, such as Cleanings and Thinnings. In the second place, they imply the beneficial results following from certain cultural works, such as the re-stocking of blanks, the re-introduction of the principal species which have disappeared, the augmentation of the proportion of the auxiliary species now too rare, &c. Lastly, they signify the replacement, by means of natural reproduction, of defective by well-constituted crops. All these various cultural operations merge into one common object, viz., the regularisation of the component crops of the forest—the very highest possible order of improvement we can effect, acting gradually and with moderation, in each of them.

Another class of improvement operations, the organisation works properly so called, comprises the arrangement of the exploitations according to some fixed order of succession, the creation of a convenient gradation of age-classes, and the collocation of the crops to be regularised in the strictest comformity with the Rules for locating coupes. The exploitations made in a Working Circle require to follow a very simple order; the Method of Organisation by Area permits of the establishment of this order to the farthest extent that the actual state of the forest can admit of. By means of a proper gradation of ages a sustained yield is assured and a stock of exploitable timber can never at any time fail, both ends being secured by the General Working Scheme. A judicious collocation of the crops favours their growth and permits of their being exploited in successive order: the formation of Blocks, each generally in one piece, guarantees the early attainment of this two-fold object once for all.

Cultural improvements, by which the crops are brought into a favourable condition for growth, are evidently of the highest importance; and such of this class of improvements as can result directly from the Organisation itself are assured to a sufficient extent by the judicious employment of the Area Method. It is in this indispensable exercise of the judgment and of provident moderation that lie the difficulties of that Method. Just as the greatest of all improvements that can be effected in a forest results from the growth and consequent increase of the component crops, the greatest danger to which an Organisation Project is exposed is the exhaustion of the forest for which it is drawn up. For when once it is found necessary to reduce the figure of the annual exploitations, it is nearly always impossible to effect the reduction to the requisite extent. Thus the crops are felled too young, and the impoverishment of the forest continues indefinitely. Indeed, when once matters have reached this stage, it is only a short step to make, by progressively lowering the age of the crops brought under the axe and hastening their deterioration, to accomplish the ruin of the forest. But the Method of Organisation by Area affords a sure means of obviating this danger and even of creating anew, in the shortest space of time possible, those very age-classes which are now wanting; for by means of it the exploitations can be curtailed to any extent required, and in order successfully to restore the forest, it is generally sufficient to remove, in the Fellings of the current Period, only such trees as are really exploitable.

BOOK V.

ORGANISATION OF COPSES.

A COPSE is a forest crop composed in an essential manner of stool-shoots grouped several together in clumps, or of suckers standing singly on the parent roots. Copses are exploited at a comparatively early age in order that they might reproduce themselves completely by means of the regrowth from the stool, and in the majority of cases a less or greater number of choice stems (STANDARDS) are preserved when all the surrounding forest is cut back.

SIMPLE COPSES differ from COMPOUND COPSES in that they do not contain any standards, or, if they do, these are only of the 1st. class. It need scarcely be mentioned that the standards are divided into classes according to their age. We will designate the various classes as follows:—

1st. Class Standards, those that have seen one exploitation of the surrounding forest.

2nd.................................two exploitations.
3rd ....three...............
4th ....four ....
5th ....five ....
and so on.

Standards of the 4th. and higher classes we will frequently speak of under one general name as VETERANS.

It is only after they have continued their growth, with crowns spreading out above the underwood, during an entire Rotation at least, that the standards become formed, or, as we may term them, high-forest trees. Hence the designation of COPSE UNDER HIGH FOREST (*Taillis sous Futaie*) can be applied only to such copses as are surmounted by standards that have been spared at not less than two successive exploitations, that, in other words, are at least three Rotations old. All the standards considered collectively constitute what we will term the RESERVE as opposed to the copse or UNDERWOOD.

CHAPTER I.

OUR COPSES AS THEY ARE.

SECTION I.

SIMPLE COPSES.*

The component crops of forests that are worked as Simple Coppice consist chiefly of shoots from the stool and accessorily of suckers and seedling trees.

The majority of such forests are composed of several species living side by side and associated together in diverse proportions. The climate being the same, the distribution and growth of these species may vary with the mineral composition of the soil and above all with the depth and hygroscopicity of the topsoil. The chief and most widely distributed are, among the hardwoods, the oaks, the hornbeam, beech, birch, and ash, the elms, the sweet chestnut, the maples, and the service trees ; among the softwoods, the aspen, the alder and the lime.

Some of these species, like the oaks, the hornbeam, ash, and sweet chestnut, the maples, the alder and the lime, possess the faculty of reproducing themselves from the stool. The stools themselves enjoy, under the coppice method of cutting them, a longevity extending over several centuries, and, thanks to a result easily explained, they even seem under that treatment to acquire a greater longevity than seedling trees. Other species, like the beech, the birch, and the aspen, do not grow well from the stool ; but the second of these three trees reproduces itself very freely by seed, and the last by suckers, wherever they have once gained a real footing. The sweet chestnut is often grown as copse either pure or mixed with other species. It scarcely forms with us natural forests, those we have being nearly all artificially raised. The sessile-flowered oak, like the holm oak and the Toza, forms of itself forest masses which thrive well under the Coppice Régime. Such forests, composed of a single species, are, to speak truly, the exception, and the majority of our copses contain, associated in varying proportions, nearly all the broad-leaved species indigenous to the locality.

On lowlying, wet, level ground, in deep and rich alluvial soil, the alder often constitutes the larger portion of the copses there, in company with scattered ash, hornbeam, elms and peduncled oaks. These copses are the best stocked and the most productive that we have, and when standards are preserved in them, it is there that we find the largest specimens of the peduncled oak, such as furnish us with the strong and durable timber in such great request for civil and naval constructions. The same species are met with in the copses of our plains, where the soil, although less wet, is sufficiently deep and moist. There also they form well stocked crops, in which the proportion of alder decreases, while that of the aspen and hornbeam increases. In our hilly and mountainous districts, and even in those plains, of which the soil is dry, shallow, and occasionally stony, the sessile-flowered oak is more abundant than its peduncled congener. It forms frequently enough the greater portion of the crops containing it, its companions being the hornbeam and beech, and in silicious soils also the birch. In Southern France the holm oak is found on dry and rocky soils. Associated as a rule with the sessile-flowered oak and with various species of shrubs, it constitutes simple copses covering immense areas. The Toza also forms fairly good simple copses in the barren soils of the Southwest.

Such are, if a few young standards be excepted, our principal types of forest in which the method of Simple Coppice has now for a long time prevailed. It is needless to observe that these types present each a great many shades of variety in one and the same forest. As regards the frequent differences in the outturn of material or receipts yielded by simple copses, although growing under identical conditions, they can be referred to only two causes: viz., the condition of the standing stock, and the age fixed for exploitation.

If the composition or condition of a copse is defective either because the more valuable species are wanting or are present in insufficient numbers, or because the crops are not as complete as they might be, these shortcomings may be remedied by planting what is necessary as soon as each successive coupe is exploited and cleared. This cultural operation need never fail, if the requisite care, money and time are expended on it ; but it does not suffice of itself to make the copse yield the best descriptions of produce or the largest income of which it is capable. In copses, as in high forests, it is also necessary that the stock be exploited at the right age.

A forest worked as a simple copse yields scarcely anything besides firewood or charcoal, vine props, hoops for casks, poles, and bark. But even these descriptions of produce it will furnish in very different quantities according to the age at which it is felled. The clumps of young shoots on newly cut stools at first stand apart from each other, leaving the greater portion of the soil exposed. As long as this continues, the production of ligneous matter is small in spite of the vigorous growth of the young shoots. As they grow on, they close their crowns over the ground and thus reform the leaf-canopy. From this time onwards the annual sum of production is considerable until it reaches its maximum. It is only later on, when the copse, then old, begins to thin itself under the action of natural forces and allows the direct rays of the sun to reach the ground here and there that the annual production diminishes like the faculty itself of the copse to reproduce itself from the stool. Such are the facts as we find them, and the conclusion to be drawn from them is that the standing stock in simple copses increases in a much higher ratio than its own age.[1]

People do not easily conceive what an enormous difference five years added to the necessarily short Rotation makes in a copse. Actual experience alone can carry with it complete conviction. A copse at 30 years is, so to say, an entirely different forest from the

1. Oak copses are not seldom met with, which at the age of 10 years contain 280 cubic feet per acre, being the equivalent of 28 cubic feet per acre per annum ; at the age of 20 years 840 cubic feet, being an increase since the age of 10 years at the rate of 56 cubic feet per acre per annum ; and at the age of 30 years 1400 cubic feet, exclusive of 280 cubic feet removed in the interval in thinning operations. Thus, during the third interval of 10 years, from the age of 20 to 30 years, the annual sum of growth per acre is still 56 cubic feet, and the actual production 84 cubic feet.

same copse 10 years earlier. At the later age it consists principally of large poles, the branches of which, in the high leaf-canopy they form, are alone equal to all the thin branchlets which compose the whole stock at the lower age. Moreover, at the former age circulation under the leaf-canopy overhead is easy : the copse is no longer the tangled mass of thin wiry stems it was ten years before. If the age of felling is raised, before many Rotations are over, the relative proportions of the various component species become entirely changed, and this for the better. Indeed, in lengthening the Rotation there is everything to gain, nothing to lose. But, unfortunately the greater portion of our copses belongs to private proprietors, who all, or nearly all, commit the egregious mistake of exploiting their forests too early (at 12, 15, or at the outside 18 years), when they could in nearly every case double their income by simply doubling the duration of the Rotation. If proof of this is wanted, here it is. As a rule the money value of a copse at the age of 30 years is at least four times that of the same 15 years earlier, so that by doubling the Rotation and exploiting only half the original area, the receipts would still be twice as large as what is now obtained by exploiting at 15 years instead of at 30.

SECTION II.

Copses with Standards.

The designation of Coppice with Standards, Compound Coppice, Coppice under High Forest, or High Forest over Coppice we apply to the method of treatment which consists in growing above the copse or underwood trees of large size belonging especially to the species oak, such trees standing out well away from each other and, for that very reason, growing under conditions different from those obtaining in completely canopied high forest. The production, in a comparatively short time, of oaks of the largest size and of closer grain than those grown in regular high forest, the rearing, in a secondary manner, of large trees of other valuable species such as ash or elm, which do not come up well in close leaf-canopy, such are the chief advantages offered by the Compound Coppice method of treatment. As regards the underwood, or copse properly so called, without forgetting that it yields valuable produce, it must be looked upon chiefly as an indispensable auxiliary means for preserving and protecting the soil and as a nursery for future standards, those, viz., which are to take the place of the trees felled in the exploitations.

In forests under State management the selection and number of the trees to reserve in each coppice coupe is regulated by the Edict promulgated in 1827 with the Forest Code. But the wise provisions of that Edict are very far from being followed everywhere to the full extent required ; for it must be confessed that if, on the one hand, care has been generally taken to reserve the number of First Class standards prescribed by it, on the other hand, but little attention has in the majority of cases been paid to the much more important injunction, according to which no trees should be felled except such as ARE DECAYING OR CANNOT GAIN BY BEING PRESERVED FOR ANOTHER ROTATION OF THE UNDERWOOD. Let us also add the sad fact that only too often have fine oak standards of the second and higher classes been sacrificed with the avowed object of reducing the area covered by the crowns of the reserve and of favoring the growth of the underwood. It is to this circumstance chiefly that we must attribute the diversity to be nowadays observed in the constitution and composition of our copses with standards. This diversity may often be observed simply by going from one coupe to an adjacent one of the selfsame forest, and reflects as clearly as in a mirror the proclivities and mental attitude of the Forest Officers who have selected the standards therein. However it be, the density, growth and production of the underwood depend necessarily on the constitution of the reserve ; the more numerous the latter is, especially as regards large trees with dense, low crowns, the more open, sickly and small will be the underwood. It has also been noticed that in the immediate neighbourhood of large trees the coppice stools lose earlier the property of throwing up shoots. But in revenge it is in these very places that we find the greatest number of seedlings of oak and other species, of which the former will furnish the very finest individuals possible to recruit the reserve, and the latter young and, therefore, vigorous stools to fill up the blanks caused by the fall of the large trees and to replenish the underwood.

Seedlings of the various species are produced in copses under the most various conditions. Those of the soft woods and of other species with light seeds come up as soon as the exploitation of a coupe uncovers the ground; while those of beech and oak usually make their appearance under the cover of an old underwood a few years before it is felled, this being of certain occurrence when such underwood is tall and the reserve numerous. Then, again, animals help to disseminate a fairly large quantity of acorns and beechmast, and in consequence scattered seedlings of oak and beech are not unfrequently to be met with under old underwood. But seedlings of the hardwoods often disappear, if not wholly, still very generally, from causes which affect each different species in a special manner. Beech seedlings, which stand well under cover, die off as soon as they are exposed to the sun, unless they have already attained a certain age and size. The young oak seedling, on the contrary, requires plenty of light; but it grows slowly during the first few years even in the open, and it disappears the moment it is overtopped by young coppice regrowth possessing dense foliage, like the stool clumps of the hornbeam and the lime. Herein we see a fruitful cause of the paucity of young standards of the more valuable species in so many of our copses.

The peduncled and sessile-flowered oaks are our two forest species, which have been specially selected for growing as standards over copse. These two species are often found standing side by side in the forest; but, as a general rule, the first flourishes chiefly in the wet, deep and rich clays common to lowlying, level situations, while the second delights in less clayey land and in the gravelly soils of our plains and hills. It is also an established fact that in nearly every copse that is in a flourishing state the underwood is composed of mixed species, a notable proportion of them consisting of such trees as exercise a fertilising effect on the soil by reason of their abundant foliage and are able to maintain themselves alive and prosper under the spare crowns of the peduncled oak, and even under the fairly dense cover of its sessile-flowered congener.

The faults attributed to oaks grown as coppice standards are (i) that they do not possess the same length of bole as trees grown continuously in leaf-canopy; (ii) that they are more liable to be misshapen than high forest trees; and (iii) that they are more often than these latter rendered unsound through accidents and by defects which affect principally oak-timber. These disadvantages of the coppice system are undeniable, but it does not rest with us whether we are to rear high forests everywhere and give up a method of treatment that is actually practised throughout a very considerable portion of the forests of this country. Moreover we consider that this method of coppice treatment is, as a rule, the one best adapted to the interests of the private proprietor. We believe that in a great many cases it is able to satisfy to a sufficient extent the requirements and the special interests of the Communes. Besides, it is incontestable that, when wellapplied, it offers the means of assuring a supply, if not of the largest quantity of the most useful produce, at least of a considerable quantity of very useful produce and of closer-grained timber than that furnished by high forests.

It is not, therefore, unnecessary or unimportant to understand thoroughly the advantages as well as the disadvantages attaching to the Compound Coppice Method of Treatment. The actual treatment, *i. e.*, the mode of applying it, always affords an opportunity of attenuating the latter and turning the former to the best account. And, indeed, the organisation itself of such forests furnishes that opportunity. In forests worked as Compound Coppice, regeneration is immediate and the treatment simple and easy, characteristics in which that method of treatment shares to almost the full extent of Simple Coppice. But the production and development of shoots from the stools are hindered by the cover of the standards, and the work of treatment becomes complicated by the always difficult task of creating a Reserve composed of the more valuable species. Copses with standards furnish timber of large size, almost exactly as real high forests do; but the quantity of such timber is small. The Compound Coppice method of working is suited to the rearing of isolated trees; it allows their crowns to develop in perfect freedom, whereby their boles increase rapidly in diameter and close grained wood is formed. But in consequence of the ever recurring periodical clean felling, the roots of the trees find themselves placed in a soil that is alternately covered and uncovered, their boles remain short or become clothed with epicorms, some of the branches in their crowns die or are broken off, and generally they become liable to suffer from numerous defects and dangerous kinds of unsoundness. The standards may be felled one by one at the very moment when each has acquired its highest utility, that is to say, at extremely different ages, especially so in the case of oaks. But, on the other hand, the ever-changing conditions through which those trees have to pass bring about the premature decay of a great many among them.

Such are the principal facts that may be observed in our compound copses, facts of extreme diversity and varying importance from forest to forest, coupe to coupe, nay from one point to the next. The application of this method of treatment is thus far from being easy and uniform, as one might be led to imagine. It demands intelligent and unceasing care in the selection of the standards, in which operation the exercise of the forester's judgment goes for a very great deal. It presents difficulties of an entirely special character, due to the mixture of species and the extremely various conditions under which seedlings germinate and maintain themselves under the low cover of the underwood. A clear and enlightened knowledge of these facts is indispensable to obtain from the Compound Coppice method of treatment really good results.

CHAPTER II.

ORGANISATION OF SIMPLE COPSES.

The organisation of a copse is often regarded as a more or less mechanical operation, consisting simply in the division of the forest into regularly worked coupes in accordance with local usage.

This is an error greatly to be deplored in a country, the greater porportion of the forest of which is treated as copse. The result of this erroneous belief is seen in the enormous loss of produce and income unconsciously incurred by a large number of proprietors, whose forests, although *laid out in regularly worked coupes*, are nevertheless *badly organised.* For instance, some of them are exploited at the age of 20 years, whereas, if maintained up to the age of 30 years, their yield would be doubled; others again are treated as simple copses, when they ought to be worked as compound copses.

In nearly every copse, we find ready to hand a complete series of compartments completely defined on the ground both by the division lines between coupes already exploited, and by roads, paths, watercourses, and other natural lines. The first thing to do is to survey and map out these compartments, or at least make a sketch map of them, in order to enable the Aménagiste to examine and describe the various crops and group them into Working Circles.

In forming the Working Circles care must be taken to avoid making them too large. In most cases, it will be found advantageous to limit the area of the annual coupes so as to distribute the fellings in the most convenient manner possible; and in this respect it is desirable, if not always, at least in the majority of instances, to consult the interests and convenience of the local timber trade.

But the number and size of the Working Circles must depend chiefly on the configuration of the ground, on the system of roads already laid out or projected, and on the distribution of the age-classes resulting from previous exploitations.

The Working Circles being once formed, the main point to be attended to in organising a simple copse is the determination of the Rotation. Formerly, the produce of such forests used, for the most part, to be converted into charcoal for the metallurgist. In order to meet this special circumstance it was usual to work simple copses on short Rotations. Since then, however, the situation has undergone a complete change. The demand for charcoal has greatly fallen off ; while cordwood, especially unsplit billets, and, in some districts, certain descriptions of builders' and artificers' wood, such as mine props, for instance, are more sought after and command higher prices than wood suited for charcoal making. The bark also raises in a very marked manner the value of oak copses. Hence before adopting for the length of the Rotation 12, 15, or 18 years, which numbers seem to be fixed by universal custom in every part of the country, the Aménagiste would act wisely if he first satisfied himself that no better results could be secured with a longer Rotation. Whether we consider private woods or communal forests, there is nearly always advantage in raising the Rotation to 25 years at the least, and often up to as high a figure as 30 years.

In the case of woods belonging to private proprietors, the only safe and intelligent way of determining the length of the Rotation is to compare the capitalised values of the standing crop at various ages with the corresponding receipts.[1]

If the copse is owned by a Commune, the interest of which class of proprietor is to obtain the largest income it can from its forests, the simple comparison of the annual receipts realizable with different Rotations suffices to resolve the problem. As long as the average annual receipts go on increasing with the age of the exploited crop, it is obviously to the interest of the Commune to lengthen the Rotation accordingly. Suppose, for example, that the produce of a copse is worth £6 per acre if felled at the age of 20 years, £10 per acre if felled at 25 years, and £15 per acre if felled at 30 years ; then

1. For example see page 104.

the corresponding average annual receipts are respectively 6 shillings, 8 shillings and 10 shillings per acre, and the most advantageous Rotation would certainly be not less than 30 years. As a rule, the average annual receipts go on increasing with the age of the crop, and this, too, rapidly. And we may observe that Section 69 of the Royal Edict promulgating the Forest Code, which Section applies in the case in question by virtue of Section 134, directs that, whenever possible, the lowest age at which a copse may be cut shall be 25 years. And, as a fact, there is every advantage in lengthening the Rotation for the working of simple copses belonging to Communes up to the highest limit of age, at which the stools can throw up vigorous and abundant shoots. In dry and shallow, and hence bad, soils a simple copse in no case yields much produce. In moist and deep, and, therefore, good soils, abundant and valuable material can be obtained by growing old copse.

The Rotation being fixed, it now remains to draw up the Working Scheme. The first thing to be done here is to divide the Working Circle into coupes of equivalent productive power. The expediency of this procedure has scarcely ever been contested, although at first sight it might appear simply calculated to save the Executive Forest Officer the trouble of measuring out his annual coupes by actual survey. But it is easy to understand that the definite location of the coupes on the ground guarantees the exploitation of each one of them at the right time, assures a greater equality in the outturn of produce each year, establishes once for all in a permament manner a regular order for the successive fellings, and enables the eye as well as the judgment to recognise with precision and clearness the desirability of certain improvement works, when these should be undertaken, within what limits they should be executed, and in what order they should be taken in hand. Hence the expediency of effecting this primary division of the forest area in the most advantageous manner possible. To this end it is necessary first of all to ascertain what cantons are bounded by natural lines, or what groups of compartments possess one and the same situation and description of soil. This is the very keystone of the whole division. The boundaries and topography of these cantons should then be entered on the map of the Working Circle concerned, and their respective areas computed; after which each canton should be divided into an integral number of equal coupes.

Suppose, for instance, that we are given a Working Circle measuring 625 acres, to be divided into 25 coupes, and that it contains a natural canton consisting of a well-defined piece of sloping ground comprising 90 acres. This canton must be divided into 3 or 4 coupes according as its fertility is below or above the average. The procedure just described enables the Aménagiste to draw up a really good and simple Working Scheme, instead of one that looks simple only on the map with coupes of perfectly equal extent bounded by straight and parallel lines.

In dividing a copse into coupes, the first two Rules for the location of coupes must be rigorously observed. The necessity of exploiting plot after plot in their successive relative order, and of giving the coupes the most regular form possible is so obvious, that the forester's instinct alone would lead him to do so. The exploitation of all the coupes situated in one and the same canton in accordance with the order in which they succeed each other on the ground is not always feasible during the first Rotation; but it rarely happens that this order cannot be followed from the commencement of the second Rotation, and this without entailing any sacrifice worth considering. Suppose for example, that in the Working Circle referred to in the preceding paragraph there was a coupe that was badly placed as regards the age of the contained crop, so that, if taken in hand in the relative order of its situation, it would have to be felled at the age of only 17 years. This age would obviously be too early, since the Rotation is one of 25 years; but as it has to be exploited twice in the course of 17+25=42 years, it could, if desired, be felled on these first two occasions at the age of 21 years, a mode of procedure that would often be adopted with profit.

The boundaries of the coupes ought to consist of straight lines, or of natural lines such as roads, watercourses, ridges, &c. Under any circumstances, they should be arranged, as far as possible, with special reference to export lines, and in such a manner as to provide each and every coupe with an easy outlet for its produce.

The necessity of giving every coupe an independent outlet for the export of its produce very frequently leads to the establishment of bridle-paths broad enough to serve as roads. But the preliminary divison of the Working Circle into natural cantons is the essential point of departure in securing the best distribution and net-work of export roads possible.

The breadth to give to the division lines between the coupes must vary with circumstances. Forty inches may be enough for a line on which, owing to steep gradients, carts could not be used; while a width of 10 feet would allow of the easy passage of carts, and 16 feet in most cases be as much as would ever be required.

The direction in which the successive coupes should follow each other is not without some importance, even in simple copses. In each canton taken separately the cuttings should progress in the direction opposite to that of cold or dry winds or, in exceptional cases, opposite to that of winds which blow in a constant manner. But it is easy to understand that this Rule for the location of coupes possesses less importance here than anywhere else. Besides this, the maintenance of permanent belts of forest fringing the outside edge of the coupes is the best means of protecting them against dangerous winds.

The number of standards to reserve in any simple copse must be prescribed by the Aménagiste, who must also determine what species alone shall be so reserved. In most cases oaks, ash and birches are at once the most useful and the least hurtful of all our species to preserve. Nevertheless it seldom happens that there is no advantage to be gained by reserving a few individuals of all our large forest species. As regards the damage resulting either from the presence of cover overhead or from the loss of so many stools due to the preservation of the standards, it is very slight as long as the number of the standards does not exceed sixteen per acre.

For communal forests the Royal Edict, under which the Forest Code was promulgated, prescribes in a universal manner the reservation per acre of from 16 to 20 standards of the second and higher classes capable of growing on for another Rotation (Sections 70 and 134). The Compound Coppice Treatment is thus the rule for this class of our forests, and the Simple Coppice method can only be allowed under exceptional circumstances. These circumstances should be fully described in every Organisation Project, which proposes the adoption of Simple Coppice in forests belonging to Communes.

The best distribution for the standards of a simple copse is, as a rule, in belts fringing the division lines of coupes and the boundary of the forest. With such a method of distribution a great number of standards, and these even standing quite near each other, can be preserved without any detriment to the underwood. Such standards produce an abundance of seed, which can be gathered with profit in certain years ; they afford to the coupe in which they stand excellent protection ; they yield wood suited for the builder and the artificer ; they form capital boundary marks ; and, lastly, they adorn the forest.

The establishment of these belts, whether single or double, the width to give them along the edges of the coupes and along the main division lines, the selection of the trees to be reserved for that purpose, the stage up to which they should be allowed to grow, and the special precautions to attend to in order successfully to renew these belts, all these points should be equally indicated in the Organisation Project.

The up-keep and improvement operations required in simple copses are mostly limited to the mere exclusion of men and cattle, and the filling up of blanks. The exclusion of men and cattle is all the more necessary, as the stock is renewed at short intervals and is hence only for a very few years at a time old enough to have little to fear from the numerous risks to which it is exposed, principally from grazing and fires. On this head, what is required to be done is different for different forests ; but the most important work of all without exception is fencing. An effective barrier, such as a sunk fence difficult to cross, is one of the best guarantees for the safety of a copse. The Organisation Project ought to provide for the establishment of such barriers as well as for the filling up of the blanks which are common enough in simple copses.

The growth of sowings or plantations made with our most valuable species is very slow as long as the young seedlings have not joined their crowns and closed over the ground. Besides this, it takes at least one Rotation and exploitation for the seedling plants to furnish real stools ; and, indeed, it is only after such individuals have been cut back a second time, that their stools throw up a strong clump of shoots. This circumstance must not be lost sight of by the Aménagiste.

CHAPTER III.

ORGANISATION OF COPSES WITH STANDARDS.

SECTION I.

Compartments. Working Circles. Rotation. Exploitability of the Standards.

In copses with standards the Compartments and Working Circles are formed in the same manner as in simple copses, and with the same objects in view. In any case, in studying and describing the forest, special attention should be paid to the reserve, not only because it represents the principal element of production, but also because in the growth of the trees (*trees* in the strict sense of the word), of which it is composed, it furnishes the most certain criterion we can have of the fertility of the soil.

It is no doubt expedient to group together to form each Working Circle crops growing under the same conditions of fertility. But besides that this procedure presents many difficulties, there is no great harm in including in the same Working Circle compartments of unequal fertility, provided that the species composing the underwood can all be exploited at one and the same age.

As a matter of principle the length of the Rotation to adopt in copses with standards is irrevocably governed by two conditions. In the first place, it cannot exceed the age at which the underwood would cease to reproduce itself completely from the stool; and, in the second place, it must be long enough to allow the future first-class standards (viz., those to be reserved from amongst the underwood when it is cut) to attain a length of bole sufficient to let them be considered as tall trees, and a diameter large enough to enable them to stand being isolated. Determined on these considerations, Rotations for copses with standards would, as a rule, be comprised between 30 and 40 years.

It is certain that with a long Rotation, of 36 or 40 years for instance, a Thinning would be required at about the age of 30 years, thereby rendering it possible to obtain in any kind of soil whatsoever the best results that can be expected from the Compound Coppice Method of Treatment. [1]

As regards the Reserve, we know that it consists of standards of the 1st., 2nd., and higher classes. Now it is clear that each time a coupe reaches its turn for exploitation, it contains no standards of a lower class than the second; hence it is always those of the second and higher classes which furnish the trees to be felled. Such trees would be, firstly, those that are decaying, misshapen or weakly; secondly, those among the healthy and vigorous trees which, from being badly situated, interfere with the growth of other standards possessing a higher value and a higher future promise; and, thirdly and lastly, all mature and exploitable trees.

Thus the age at which the standards are felled is always some multiple of the Rotation of the underwood. But it is not possible to express it in figures. The reason is evident; for, to take an example, in copses belonging to the State and to Communes, the oak is not exploitable until it yields the most useful produce of which it is capable, and, since the utility and the money value of an oak tree increases very rapidly in proportion to its size, it follows that oak standards become really exploitable only one by one as each reaches maturity. Hence as long as an oak is sound, as long as it has no trace of decomposition either apparent or concealed, as long as the aspect of the bark or the crown, the abundance and vigour of

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1. A century or more ago the majority of the copses belonging to the Communes and to the State in the east of France were worked on a Rotation of 30, 35 or 40 years. When this last figure was adopted, the copses so worked were designated *hauts taillis* (high copses). But since the middle of the last century, a large number of communal forests were divided into systematically ordered coupes by officers of the Survey Branch of the Forest Department working more or less at haphazard and never departing from the number 25. This was the be-all and end-all of the organisation of those forests. Thenceforward the felling of large timber went on rapidly increasing and the trees were cut for the most part at the age of 75 years, instead of being preserved until they were 150 years old. Thus was brought about the disappearance of the oak from many and many a coupe, and from our finest forests.

the foliage or branches show that it is healthy, or, to use the words of the Royal Edict, that its condition is such that it can prosper for another Rotation, it must not be abandoned to the woodcutter, whatever its age or size might be. Such is the rule, simple enough, to observe with regard to the exploitability of oaks reserved over copse, if we wish to obtain from them the maximum utility or money value of which they are capable.

The same rule holds good with regard to the other species, standards of which it is expedient to preserve for the production of timber, such as the ash and the common elm for instance. With respect to such species as the hornbeam and even the beech, which are included in the reserve simply to yield firewood and to furnish a sufficient stock of seedlings for the maintenance of the underwood, they need not be spared after they have reached the category of 2nd. or 3rd. class standards. Nevertheless there are some forests in which, the beech being the predominant tree, there is advantage in preserving standards of that species up to a more advanced age. But this circumstance is really peculiar and limited to communal forests, for it is evident that State forests, situated on a soil specially adapted for the cultivation of the beech, ought without any hesitation to be converted into high forest, and that for that reason the selection of the standards therein ought to be regulated by the exigencies of the conversion.

In copses belonging to private proprietors the standards cannot be preserved except for a limited period. As soon as a certain age has been reached, the rate of increase in the money-value of the standing trees begins to fall below the percentage of interest demanded by investors in forest property in the locality; this then is the age at which the standards ought to be felled. But it is clear that this age must vary for different trees according to the less or greater vigour of their growth and the additional value which each would acquire during the course of another Rotation.

If, as we have said, the treatment of forests of broad-leaved species by the Compound Coppice method is eminently suited for the private proprietor and satisfies well the interests of the Commune, this is so only on the condition that the selection of the standards is carried out methodically and in the proper spirit.

Hereon hinges the success itself of the organisation and treatment of such forests. We must hence dwell on this subject in a special manner. And here the facts connected with the actual carrying out of the operation require to be as fully discussed as the general principles themselves on which it is based.

SECTION II.

The Selection of Standards in Compound Copses.

The trees to reserve as standards to grow above the underwood or copse proper should be selected chiefly from among such species as can yield timber. In the first line of these we must enter the peduncled and sessile-flowered oaks, the cultivation of which species as isolated specimens originally gave rise to the Compound Coppice method of treatment, and is still to this day its chief *raison d'être.*

After these two oaks, which are to be met with in nearly every one of our copses, we will cite, as coming after them in point of importance, the elm and the ash, and then the beech, the true service tree (*Pyrus Sorbus*), the wild service tree, the wild cherry (*Prunus avium, Linn.*) and the aspen. None of these species, however, ought to play more than a secondary *rôle* in the constitution of the reserve. As a rule, therefore, they ought not to be reserved except in order to take the place of the oak, when that species is quite absent or is represented only by individuals of no promise whatsoever. Nevertheless, when in any copse the growth of one of these secondary species is fine and vigorous, it really seldom happens that there is no interest in reserving a few good specimens of it and maintaining these until complete maturity. Choice individuals of any species whatsoever will always yield large timber of no inconsiderable value. Hence the surest indication of the usefulness of any given standard is, after the species to which it belongs, the state of its growth.

It is equally expedient to include among the standards of the 1st.class, and even among those of the 2nd. class, a few individuals of certain species, like the hornbeam and the birch for instance, with a view to the production of a sufficient supply of seed and, hence, of young plants to perpetuate the copse, protect the soil, and promote the growth of the more valuable species. Moreover, such standards will furnish at each exploitation of the forest a not inconsiderable contingent of produce in the shape of firewood.

§ 1. *Forests managed by the State.*

In forests in which the production of standards is more remunerative than that of the underwood, it may be taken for granted, as a matter of principle, that every isolated and growing tree ought to be reserved. Hence in copses belonging to the State, and especially in such as can produce oak of large size, no limit can be laid down as regards the number of the standards to reserve, except in in so far as that they shall not touch one another or interfere with the free development of their neighbours. The same rule applies to communal forests in the interests of the proprietary Commune itself. It is prescribed in the last paragraph of Section 70 of the Royal Edict of 1827 in so far as formed trees, that is to say, standards of the 2nd. and higher classes, are concerned. We would, moreover, be above all just reproach, if, as is prescribed in the first paragraph of the same Section, we reserved only 20 standards per acre from among the underwood at each exploitation. Even for the private individual, it is, as a rule, advantageous to preserve all formed trees that are not yet exploitable, provided always that their crowns do not touch one another. Numerous cases are to be met with of copses ruined or badly damaged by an immoderate felling of the old standards. On the other hand, there is none to be seen which has not been improved and enriched by a numerous reserve composed of large trees. Such is the fact, and it is thereon that we must base the treatment of our copses with standards.

A numerous reserve of oak, containing a considerable proportion of trees of large size, has, besides, the cultural effect of helping to maintain that species by means of abundant seedlings and of assuring a constant supply of standards for future exploitations. After the old oak standards have been felled, the underwood, hitherto kept down by them, does not at once recover itself and shoot up with any vigour. In this state it is replenished and completed by the appearance of certain species, like the aspen or the birch, under the light cover of which young oak seedlings can continue to vegetate on throughout a whole Rotation. Thin and lanky and badly formed, these plants, when cut back at the next exploitation, throw up each a strong master-shoot, which develops vigorously and forms 30 years later on an excellent standard of the first class. Thus, besides the direct advantage in point of revenue which the reservation of formed trees offers, it is also accompanied by most important cultural benefits in copses with standards. As the rapid growth of trees reserved above coppice underwood has for prime cause the isolation of their crowns, this isolation, complete or almost complete as it must be, is naturally the principal point to consider as regards the distribution of the standards. Now it often happens that two crowns, that stood apart when the trees were first reserved, begin to touch one another later on and to crowd against one another to such an extent as to compromise each the other's growth. This undesirable contingency can be either obviated from the very beginning or actually met by the exploitation of one of the two trees. When they belong to different species, there is, of course, no difficulty in knowing which of the two to fell; and, similarly, when they belong to the same species, it is obvious that the one which is of inferior growth should be cut. But when the only difference between them is that one is older than the other, the question as to which of the two should be preserved becomes slightly more complicated. As a rule, it would be the larger tree that would be reserved, if it is healthy and vigorous; for, in the first place, that tree really produces not only more wood, but also wood possessing a much higher value and utility, and, in the second place, it will supply the axe of the wood-cutter sooner and with greater certainty with an exploitable tree.

It will thus be seen that the problem to solve in the operations connected with the selection of trees to be spared is not the formation of a reserve on any fixed and immutable type. On the contrary, the end to be kept in view is to turn to the best account possible a given coupe and the materials it offers. The solution of the problem, often of a complex nature, varies, so to say, at each step, a circumstance that is a source of not a few difficulties. But once the nature and extent of these difficulties are fully appreciated, the problem stands out clear in all its bearings. The organisation of the forest should provide for a correct solution of it.

In actual practice, as the operations connected with the selection of standards require sustained attention, a distinct act of judgment, so to say, for each separate tree, it is almost impossible to direct them properly, while at the same time keeping the Field Record Book, in which the number and classes of the trees marked for reservation are noted. It is, moreover, dangerous to complicate the selection of the trees to be reserved by the simultaneous measurement of the trees to be felled. As far as we ourselves are concerned, if we were obliged to conduct these two operations simultaneously, it is our firm conviction that we would expose ourselves to the certain risk of making most serious mistakes in both of them. Besides this, after the trees to be reserved have been marked, it requires very little time to estimate the quantity of the trees to be felled, scarcely six minutes per acre. For the least extent that the selection of the reserve is delayed and protracted by the simultaneous valuation of the timber to be felled, what an amount of time is wasted, that could be much more profitably spent!

The operations just referred to form the most important part of the duties of a Forest Officer. One day spent in selecting trees for reservation means thousands of pounds worth of wood finally given up to the axe of the wood-cutter and large areas either irretrievably ruined or maintained in a high state of production. Those who conduct these operations must hence devote to them the full quota of time required by them, and the owner of the forest must accept as inevitable the larger outlay due to that very fact.

§ 2. *Private Forests.*

The selection of standards in private forests is just as important an operation as in State and communal forests, and, indeed, is very often beset with even greater difficulties. Here also the real gist of the problem lies in the thorough appreciation of the conditions, which the standards ought to satisfy in order that they may be considered exploitable. Whereas in copses managed by the Forest Department the epoch of exploitability coincides for each tree with that of its maturity, in the woods of private proprietors, on the contrary, every tree must be considered as exploitable, the value of which, at the time the standards are selected for reservation, does not appear to be susceptible of further and continuous increase throughout the whole of the next Rotation at the customary rate of profits required by investors in forest property. By selecting a few promising trees from among the standards of each class and comparing with each other the mean values of the Standards of the several classes, we are enabled to estimate with sufficient approximation the profit or loss for the proprietor resulting from the further preservation for one Rotation of standards of each of the several classes, and thus to determine at what age the reserved trees should be felled. [1]

But if in this comparative estimate it be found that the oak standards generally become exploitable at the end of their fourth Rotation, are we to infer thence that it is the interest of the proprietor to fell every one of his standards of the third class? We say, No; for amongst these trees there must always be a certain number, which, being endowed with exceptional vigour, increase in size much more rapidly than their contemporaries. Such trees, belonging to the species oak, may be distinguished at once by their general aspect—an ample and well-furnished crown, dense foliage and superior girth; thus they may measure 2 feet across, while the rest of the same class are not more than 20 inches in diameter. The consequence is that, cubic foot for cubic foot, they command higher prices. It happens in nearly every case that it is advantageous for the proprietor to preserve them for another Rotation, and this not only on their own proper account and because of the very considerably augmented value they must acquire, but because they will furnish at the next exploitation fine large timber of a class that is always in great demand, and which can hence never fail to draw a much larger number of purchasers than if the fall consisted only of small wood. On the other hand, it frequently happens that there would be loss in preserving badly grown or unpromising young trees, and, above all, inferior standards of the first class.

The conclusions to draw from the preceding considerations are, firstly, that the trees to be exploited in each coupe should not be indicated in advance in the Plan of Selection of Reserves, as belonging to such and such a class; and, secondly, that the ques-

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(1) See example given at page 108, Footnote.

tion of whether any given tree is exploitable or not, must be decided only at the marking for reserves, just as is done in forests managed by the State. As regards the selection of the large trees which it is expedient to preserve as an exceptional measure, that is purely a matter of skill and policy, requiring care, attention, discernment, and a thorough knowledge of all facts regarding the growth of standards and the value they acquire as they develop. In certain districts in France an increase in diameter of 25 per cent. suffices to double the value of an oak tree. Thus an oak standard measuring 16 inches in diameter at this moment and worth £1-4s. may sell for £2-8s. when its diameter has increased by only 4 inches. Prepared with such facts, we may, it is easy to conceive, proceed to select the standards to be preserved in any coupe with a full knowledge of what we are going to do.

As a matter of fact, whatever the nature of the proprietor concerned, it is always the vigour of growth of the tree concerned, which ought to decide whether it should be preserved or felled. The vigorous tree attains a large size in a comparatively short time, a circumstance which alone renders its preservation desirable. An oak standard 2 feet in diameter is worth now, say, £4. Suppose that the state of its vegetation is only moderately vigorous, and that it will measure at the end of the next Rotation of 25 years not more than 28 inches; it will then be worth in the same market only £6-8s. But if its growth is vigorous, it may attain in the same time a diameter of 32 inches and fetch £10. Supposing the latter to be the case, would it be right to fell the tree at once or let it stand for another Rotation? If it is felled at once, the annual income it would represent would be 5 shillings. The same method of arguing holds good for the tree of 32 inches diameter as for that of 24 inches diameter, and it may be found that the very same reasons exist for preserving also the bigger tree. In any case the larger the tree is, the greater the vigour it should possess to justify its further preservation.

The large standards which enrich the stock of a copse are, as a rule, vigorous trees, since they have, as a fact, attained their present dimensions in a relatively short time. We meet with enormous beech which, thanks to an ample crown, have grown at the rate of more than two-fifths of an inch in diameter per annum, so that they measure a good 40 inches when one hundred years old. We have seen sold for £40 the bole of an ash 41 inches in diameter and still comparatively young. Analogous cases may be cited respecting trees belonging to all our large forest species. Thus it is not the actual diameter that a standard has acquired, but the state of its vegetation, which ought to decide whether it should be felled or preserved. It hence follows that every operation for the selection of standards involves considerable powers of appreciation, even in woods belonging to private proprietors.

Moreover, the reservation of large trees has not only the single advantage of increasing the income derivable from a forest. These trees, since they would, as a rule, be felled at the next exploitation, must on that occasion, be the best guarantee that the standards of the third class will be respected : when old veterans are not to be found in a coupe, it rarely happens that trees in full growth and still vigorous are not felled in their place.

Again, large trees standing in an exploited coupe protect against the wind standards of the first and second classes, which would otherwise not unfrequently be irremediably ruined. Lastly, they simplify in every exploitation the selection of the standards to be reserved, and assure that operation being well conducted merely from the fact that they render unnecessary the reservation of numerous standards of the first class, which can attain their full value only in a comparatively distant future, after passing through all the risks to which growing trees are exposed ; such standards only harm the underwood with their low cover, and rob it of its best stools. Hence it is an excellent rule to follow, in selecting the standards, to reserve the finest specimens of every species whatsoever, for the forester cannot fail to appreciate the other trees according to their real merits.

A few words will suffice to serve as a conclusion to what we have just said on the subject of the selection of a reserve over copse. We possess in France 3,750,000 acres of State and communal copses, the majority of which can furnish the most choice produce, viz., oak timber of large size. Two-thirds of this area belong to Communes, and must remain for a long time yet, if not for all time, subjected to the present *régime.* If to this be added the fact that private woods are also for the most part worked as coppice with standards, it will be perceived that the area occupied by forests treated according to this method must be measured by millions of acres. Thus our copses with standards constitute unquestionably the principal source of our forest wealth. They would be for France a veritable mine of treasure, if properly treated and endowed with a good reserve. We can now understand how important an operation the selection of coppice standards is, and how much special and assiduous care and attention it demands from those whose duty it is to conduct it.

SECTION

The Working Scheme.

§ I. *Selection Plan of Standards.*

The points we have drawn attention to in the preceding pages relative to the choice, number, and distribution of the trees to be reserved over copse are in conformity with the prescriptions laid down by the Royal Edict of 1827.[1] But what we have said with reference thereto, as well as the prescriptions actually enforced by that Edict, necessarily possess the character of general rules. It is easy to understand that in applying these rules, it may be expedient to modify them according to the various prevailing conditions of soil, crop, and vegetation, and according to the nature of the owner of the forest concerned. The duty of suggesting these modifications

(1) Section 70.—*At the exploitation of the underwood 20 poles from it shall be preserved per acre. When this cannot be done, the reasons for not so doing shall be stated in the Report submitted on the completion of the operations connected with the selection and marking of the standards* (procès-verbal de balivage et de martelage).

Standards of the 2nd. and higher classes shall not be *felled unless they are in a decaying state or are incapable of flourishing up to the beginning of the next Rotation.*

Section 134.—*All the prescriptions given in the second, third, fourth, fifth, and sixth chapters of Sub-head II. of the present Decree are applicable to woods belonging to Communes and Public Foundations, with the exception of Sections* 68 *and* 88, *and saving the modifications which result from Sub-head VI of the Forest Code and the prescriptions of the present Sub-head.*

Section 137.—*In coupes in woods belonging to Communes and Public Foundations, the reserve prescribed by Section* 70 *of the present Decree shall consist of* 16 *standards at least, and of* 20 *at most per acre.*

In cuttings made in the Reserved Fourths the number of trees preserved shall be 24 *at least, and* 40 *at most per acre.*

belongs to the Organisation Project, and the examination and discussion of reasons, inseparable from a subject of so much difficulty, leads in the case of every forest to the drawing up of a regulation, which forms part of the Working Scheme, and which we will term the Selection Plan of Standards.

This Plan is based on the exploitability of the standards of each species concerned. In forests managed by the State, the standards that are expected to yield builders' and artificers' timber ought to be preserved up to their individual maturity. The Selection Plan of standards should mention the species to which such standards should be restricted, the relative order of preference to observe with regard to them, the longevity of each species, and the signs that indicate that they have become mature. The appreciation of these facts is necessarily left to the entire discretion of the Executive Forest Officer. The Selection Plan of Standards should also give a list, in their order of importance, of the secondary species, such as the hornbeam, the birch, and some others included in the reserve. It should state the reasons for preserving a certain number of individuals of these species either up to the end of the third Rotation or up to the moment they reach the category of standards of the third class. It should indicate and explain the reasons for any exceptions that may be called for to the general prescriptions of the second clause of Section 70 of the Royal Edict of 1827, and by this means obviate the evil results that would arise from their strict application to all the standards without distinction of species. It is impossible to fix in advance the number of standards of the several classes to reserve at each exploitation, at least as regards the standards intended to yield timber. This is due to the fact that no standards ought to be felled except when they are mature, unless they are decayed, misshapen, or badly placed. In certain cases large trees approaching maturity may form the most numerous class ; in other cases, it may be the second or third class of standards that may compose the largest portion of the reserve, thus rendering it impossible, in selecting the trees to be reserved, to establish a fixed or the desirable proportion between the various classes. These irregularities in the distribution and number of the Standards may present themselves even from coupe to coupe, and even from one point to another in the same coupe. There is no immediate remedy for this, and all that can be prescribed in the Selection Plan is the preservation as first class standards, quite irrespective of number, of well-constituted individuals of the principal species, taking care that they are spaced in such a manner that every one of them may be in a position to form a full, healthy crown. As regards the secondary species, on the contrary, it is necessary to restrict the number of the standards between an upper and lower limit, since they naturally occupy the place of more valuable species, and may even do harm to the reproduction of these latter, when they are too numerous.

Thus, the Selection Plan may be drawn up in the most simple manner.[1] It ought to contain information indispensably required by the Executive Forest Officer ; it ought to support the proposals made by adducing the most important facts connected with the growth of the forest; it ought to demonstrate the necessity of taking account of the condition and position of each tree before deciding to preserve or fell it, of noting the object to keep in view and the difficulties to be met with in selecting the trees to be reserved, and, by means of the special care and attention which it should enjoin in the carrying out of this operation, of making it attractive for the operating Executive Officer, fully weighted as he is with the interests and responsibility entrusted to him. Moreover, we cannot fail to draw up a good Selection Plan if we always bear in mind that it is the thickness of the reserved trees and not their number, which constitutes the wealth of a copse as of a high forest.

§ 2. *Division into Coupes and the Tabular Exploitation Scheme.*

The division of a Working Circle into coupes, *i. e.*, the drawing up of a Working Plan based on area, is effected on the same principles in copses with standards as in simple copses. Thus each natural canton must be divided into an integral number of equal coupes bounded by lines following the natural movements of the ground. The successive exploitation of the coupes must be arranged exactly in the order in which they follow each other on the ground, barring the few breaks that are unavoidable during the first passage of the explotations *i. e.*, during the First Rotation. Each coupo should be provided with a convenient export road to serve as an outlet for its produce. And lastly, the coupes should be arranged so as always to conform to the Third Rule for locating them.

1. See example given at the end of the chapter.

According to this Rule the coupes should succeed each other in the direction contrary to that of dangerous winds. Its observance acquires great importance in copses with standards. The reason is evident, for the reserved trees, being completely and all at once isolated at each exploitation, run the risk of being uprooted or snapped in two by the wind or damaged by the breaking off of some of the principal branches. Now, it is a fact established by experience that the majority of the trees blown down or injured by the wind in Compound Coppice coupes suffer in this manner the very year in which the coupe is exploited and also in the following year.

If, therefore, the coupe under exploitation is protected by old copse with all its numerous standards, the injuries caused by the wind can in most cases be entirely prevented ; and if, besides this, the coupe is narrow, the protection becomes in every respect complete. Lastly, when it is possible, by exploiting the forest on each side of the same road or path in alternate years, to maintain this protection during the space of two years, the safety of all the standards, to whatever class they belong, is assured in the most effective manner during these two critical years of their existence. It is unnecessary to add that the last coupe exploited in a canton situated on the edge of a forest and directly exposed to dangerous winds may be protected by means of numerous reserves forming together a curtain along the boundary, and composed principally of trees capable of resisting the wind, like border beeches, for instance, in France. This is a detail of cultural work, which the Organisation Project need only recommend in a general manner.

The Working Scheme for a Circle of copse with standards does not assure to any great extent a sustained yield or equality in the annual outturn. This inequality is unavoidable, owing to the differences to be always met with, in going from one coupe to the next, in the constitution of their chief element, the reserve. This Working Scheme, to say the truth, is nothing better than an incomplete framework, which collects into a single scheme the exploitation of the most diverse crops. But the selection of the trees to reserve always affords an opportunity for working each individual crop in the happiest manner possible, according to the resources it offers. A few special details of work, which the Organisation Project may legitimately discuss and prescribe often offer a further means of improving the forest in the future.

We give below, as an example of a proper arrangement of work as far as the mere paper Organisation Project is concerned, the Tabular Working Scheme of a Circle of copse with standards.

EXAMPLE OF A WORKING SCHEME OF A WORKING CIRCLE OF COPSE.

WORKING SCHEME,

CIRCLE OF THE LITTLE WOODLANDS ; AREA, 318A. 0R. 26P.

Name of Canton	Running number of coupe	Area			Age of the under-wood	Year of first exploitation	Age of under-wood at that exploitation	Year of second exploitation	Age of underwood at that exploitation.	Remarks.
		A.	R.	P.	Year					
Le Fays	1	10	1	20	32	1871	33	1901	30	The age of crops occupying less than 1 acre are left out of account.
	2	10	1	20	32	1872	34	1902	30	
	3	10	1	20	32	1873	35	1903	30	
	4	10	1	20	17	1878	25	1904	26	
	5	10	1	20	17	1879	26	1905	26	
Bois rond	6	11	2	8	26	1874	30	1906	32	
	7	11	2	8	26	1875	31	1907	32	
	8	11	2	8	26	1876	32	1908	32	
	9	11	2	12	22	1877	29	1909	32	
Le Vernois	10	9	2	0	18	1880	28	1910	30	
	11	9	2	0	18	1881	29	1911	30	
	12	9	1	36	18	1882	30	1912	30	
Rieppe	13	10	1	36	17	1883	30	1913	30	
	14	10	1	36	17	1884	31	1914	30	
	15	10	1	36	16	1885	31	1915	30	
	16	10	1	36	15	1886	31	1916	30	A. R. P.
	17	10	1	36	13, 9	1887	30, 26	1917	30	13 Years 6 2 20 9 Do. 3 3 16
	18	10	1	28	13, 9	1888	31, 27	1918	30	13 Do. 6 0 0 9 Do. 4 1 28
	19	11	0	4	4,	1892	26	1919	27	
Les Noues	20	11	0	4	4,	1893	27	1920	27	
	21	11	0	8	8, 14	1889	27, 33	1921	32	8 Years 8 2 16 14 Do. 2 1 32
	22	11	0	8	14	1890	34	1922	32	
	23	11	0	8	14	1891	35	1923	32	
	24	10	2	0	7	1894	31	1924	30	
Bois banni	25	10	2	0	7, 6	1895	31, 32	1925	30	7 Years 5 0 20 6 Do. 5 1 20
	26	10	2	0	6	1896	32	1926	30	
	27	10	2	0	5	1897	32	1927	30	
	28	10	2	4	2	1898	30	1928	30	
	29	10	2	4	2	1899	31	1929	30	
	30	10	2	4	1	1900	31	1930	30	

Example of a Selection Plan for Standards for a Working Circle of Copse with Standards.

SELECTION PLAN.

Working Circle of the Little Woodlands, belonging to the Commune of........

The species to be grown as standards in this forest are, according to their order of preference, as follow :—(i) for the production of timber, the oaks, ash, aspen, and the birches ; (ii) principally for the production of seedlings and the maintenance thereby of those species in the underwood, beech and hornbeam; and (iii) as an exceptional case, a few indviduals of any other species.

In this forest oaks remain iu a flourishing condition for a whole century or for two centuries, and even longer, according to the parti cular individuals of those species and the places where they stand. The timber of these two trees remains sound as long as visible outward decay has not set in, and a few dead branches here and there in the crown do not cause any appreciable harm to the trunk. It has been observed that the boles deteriorate at the core only when they present to the sight large excrescences or holes, or when the tops of their crowns are rendered completely leafless by age. It is the marked impoverishment of the foliage and the almost completely arrested production and development of the annual shoots which, as a rule, indicate here the maturity of these oaks. Oak trees will, therefore, not be felled until they are mature, unless, indeed, they crowd one against another too much. In this latter case, all other things being equal, that tree will be reserved by preference from among the rest which possesses the largest dimensions.

The ash, which attains a large size only in the moister portions of the forest, grows there vigorously and remains sound up to the age of from 120 to 150 years. But whatever its age and the locality in which it stands, it ceases to flourish as soon as the heretofore rapid development of its crown falls off in an appreciable degree ; the bark of the trunk then becomes blackish and covered with cryptogamic plants, as also the extreme short and irregular branches. The general appearance of the crown is then one of languishing vegetation. Where the oaks are wanting, the ash should be reserved without any limit as to number, provided that the trees thus preserved stand well apart.

The aspen enjoys here a longevity which varies greatly between 80 and 90 years. It remains sound only as long as it is growing rapidly; and while in this state, its bark retains its lustrous appearance on the upper portion of the bole, and its crown is perfectly full and well furnished with branches on every side. It is mature, when dead bark covers the whole length of the bole, and the extremities of the branches begin to wither and dry up. Once it has reached this stage, it decays in a very few years. In the absence of any better species, the aspen may with advantage be reserved, but, as a rule, for two Rotations only.

The birch, which grows less rapidly, possesses on the whole greater longevity. It flourishes up to the age of 60 years at least, and in most cases up to 100 years, provided, above all things, it stands completely isolated. Trees which possess a broad and thick foot are the most vigorous. There is no advantage in preserving birch, once the crown has lost some of its branches and the branchlets begin to die. This is a sign that the tree is mature. The birch, useful as a standard scattered about here and there and up to the end of the fourth Rotation at the outside, ought not to be numerous enough to form a sort of leaf-canopy, which keeps down the underwood and does serious injury to the oak.

The beech has its use chiefly in those portions of the forest, which are elevated and stocked with birch, where no other species could protect the soil and yield a full underwood. Individuals of this species may, as a rule, be reserved up to the category of 3rd. class standards in order to serve as prolific seedbearers. Those which are of tall habit do least damage to the undergrowth. Beech standards should, as far as possible, be well distributed amongst more numerous standards of the valuable species, and they should, with rare exceptions, be felled at the end of their third Rotation, their place being taken by younger individuals of the same species.

The hornbeam, which grows abundantly in the low and rich portions of the forest, forms an excellent auxiliary species in the underwood; but it may become harmful, especially as standards, by taking up the place of other species and interfering with their reproduction. It will be enough if we reserve a few trees of this species for one or, at the outside, two Rotations, particularly in places where it is rare.

The alder may be able to furnish a few standards of the second and even the third class, but only along the immediate banks of watercourses and in the absence of oak and ash.

The elm, which also grows in this forest and is of the common kind, possesses a thick cover and yields a soft wood, which unfits it for serving as a standard tree.

After the formed trees have been marked, the further preservation of which is justified by the species to which they belong, by their state of growth, and by their relative situation, and which trees compose the essential portion of the reserve, the youngest class of standards will be selected, first of all, from among the youngest oak poles of the underwood. All individuals of this species that are well grown must be preserved, provided they stand sufficiently well apart from one another (from 20 to 27 feet for instance) so as to be free to develop a full crown.

Where there is no oak, flourishing ash poles, strong and vigorous aspen (easy to recognise by the distinctive marks they present to the eye) and birches of robust growth selected at proper intervals will form, no matter what their number, the necessary complement to advantageously complete the reserve.

With respect to beech and hornbeam the procedure must be entirely different. First class standards of these species should be preserved here and there, not less than 8 to the acre. At the same time they must not be so numerous as to predominate over all other species and injuriously influence the composition and growth of the forest. It will be safe to limit the maximum number to 16 per acre, that is to say, they should stand from 50 to 70 feet apart when more or less uniformly distributed over the ground.

CHAPTER IV.

Complementary Operations of the Organisation Project for Copses.

The various works which the Organisation Project may have to regulate and prescribe are of very different kinds. They include works properly so called ; works necessary for protection, such as fences, &c. ; for working, such as roads ; for surveillance, &c., &c. They are, so to say, accidental in their nature, whereas cultural works have, on the contrary, an essential character. These latter are, according to the particular case concerned, Improvement Cuttings, viz., Thinnings and Cleanings, the pruning off of branches and removal of epicorms, reboisements and draining.

The object of Thinnings in simple copses is, firstly, to favour the diametral growth of the poles of the underwood by clearing the forest round them to a sufficient extent (but such an operation can be useful only to shade-fleeing species, like the aspen, the oaks, and others [1]) ; and, secondly, to render available, before and independently of the main exploitation, certain kinds of produce, such as osier, stool shoots with dead crowns, and decaying shrubby growth. Neither of these objects possess under ordinary circumstances any great importance ; and, indeed, in a simple copse, the Rotation is too short for there to be any great number of cases of well-marked advantage in making a Thinning.

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1. The coppice crops composing the Reserved Fourth of the Commune of Chargey-lès-Port (Haute Saône), and which have been subjected to Thinnings since 1832, were of the same age as the present century, *i. e.*, 50 years old in 1850. After that year these old coppice crops were exploited on three or four several occasions, a very numerous reserve having been left on the first occasion. Seedlings then made such a poor show, that the inhabitants of the Commune formed the impression that the canton was ruined. To-day it is covered with an exceedingly fine pole crop of beech, oak, and hornbeam.

The case may, however, be quite different in compound copses worked on a long Rotation. Nevertheless the growth of the poles of the underwood is a minor matter compared with an abundant yield ; the extraction of small wood that is in a dying state is costly in proportion to its actual value, and can form only a secondary object of thinning operations. Thus the main object here is quite different from that sought in Thinnings made in a crop of trees of the same age ; briefly, it is the encouragement of those poles of the underwood, which are to become first-class standards at the next exploitation. These may not only be improved in their growth by means of Thinnings, but when that operation has been neglected few and even no poles really fit for reservation may in consequence be found to exist. The poles of an underwood which are to form the First Class Standards of the next Rotation must, for the most part, be thin and weakly, or at least be prevented from growing freely by the surrounding inferior poles ; thinning operations offer the means of opening out the forest round them sufficiently to enable them to expand their crowns and acquire a greater diameter before the surrounding underwood is completely cleared at the next exploitation.

If there are any seedlings on the ground, these cannot but be suppressed by the immediate cover of the underwood overhead and be eventually killed before the next coppice felling ; here, again, thinning operations afford the means of saving a certain number of them by raising the cover immediately overhead. Lastly, it sometimes happens that seedlings of the hardwoods are entirely wanting ; thinning operations provoke their appearance by opening out the leaf-canopy, and by necessarily getting rid of a portion of the trailing shoots, which interfere with the work of the wood-cutter, and which he, therefore, removes. All these excellent results may be obtained by simply thinning out the leaf-canopy (i) over and round the poles that are to form the first-class standards at the next coppice exploitation ; and (ii) in the portions of the forest stocked with species requiring abundant light, such as aspen, ash, alder, and oak ; and by cutting out shoots that are in a dying state, so as to raise thereby the cover, however slightly that may be. But it would be a great mistake to prune off the side branches of the coppice poles, or to clear the ground of low vegetation, or to cut out anything whatsoever without well-proved necessity. When a Thinning has been properly made, the simple layman walking through the forest would never imagine that the wood-cutter has just passed through with his axe.

Thus the operation of Thinning, properly so called, is really made, so to say, only in places. Taking the forest as a whole, the underwood may seem not to have been touched at all and to be as full as before, only obviously harmful or overdense growth having been removed. Such Thinnings always constitute a delicate operation; to execute them successfully the one idea to bear in mind before every thing else should be that the soil can never be too well covered.

Indeed Thinnings made in copses are often termed Cleanings, but this misnomer creates a mistaken idea and gives rise to a real danger, since the operation of Thinning affects only the leaf-canopy, and has nothing to do with the general clearing of the soil below In thinning copses, attention is scarcely ever paid to opening out the leaf-canopy round the crowns of second-class and older standards hard pressed on every side by the surrounding coppice poles; and yet these trees are thereby exposed to the loss of some of their principal limbs. unsoundness of the trunk being the result. In a great many cases, it is chiefly to trees thus menaced that Thinnings are useful, to the individuals of the reserve, therefore, rather than to those of the underwood—it being always clearly understood that the operation should touch nothing below the tree or pole to be freed, but be strictly confined to the portion of the forest on a level with its crown.

A Thinning cannot be made with real success or with complete certainty as to results except in copses already of a certain age and situated in good soil. In every case in which Thinnings are practicable, they should be prescribed in the Working Scheme, and their nature and extent should be defined in the General Statistical Report. Instances have frequently occurred, in which the omission of such details has led to deplorable mistakes on the part of the Executive Staff. In the last place, it is only about the eighth or tenth year before the coppice exploitation that a Thinning can be made with the most useful results; and we may say in a general manner that a copse, like a high forest, ought not to be thinned, except when the crop considered as a whole is composed of individuals possessing the dimensions of poles.

The operation of Cleaning in copses has also for special object the preservation and unhampered growth of seedlings that are later on to become standards. The intermixture of species in simple copses improves and augments their production. In the mixed crop, the softwoods furnish a large quantity of produce, and as they shoot up rapidly in height, the cover of their crowns is low only for a short time. Hence, in simple copses, the cases in which Cleanings are really of any use are few and exceptional.

In copses with standards the *rôle* played by the softwoods and by secondary species varies with each of them. The coppice regrowth of the alder, for instance, forms during its first year a dense, thicket, which seems to defy any of the hardwoods to grow under it. Nevertheless, when towards the age of 20 years the alder crowns have got up well above the ground, we find under them small seedlings of oak, which have persisted on in spite of the thick cover, and which soon shoot up with considerable vigour, if the copse remains unexploited for any length of time. Cut back at the next coppice felling, or, when they are straight, even simply left to stand as they are, they are able to keep pace with the new alder regrowth until they get ahead of it and live on for centuries. It is scarcely possible, on account of the exuberant growth of the alder, to uncover the young oak seedlings by means of cleaning operations. What is required is rather an early Thinning made over the suppressed seedlings.

With aspen in the copse the case is quite different. Young oak is never wanting on the ground under the light cover of that species, and it would even appear that it is the natural forerunner of the oak in good soils and must hence be utilised accordingly. But it does some harm by its extreme abundance. Nevertheless as it shoots up with difficulty from the stool, it often suffices simply to top it off when it overhangs young oak.

Under birch the oaks and other hardwoods introduce themselves with even still greater freedom. To save young oak overtopped by birch, it is enough to lop off a few of the lower branches of the younger individuals of the latter species. Later on, the crowns of the birch, which have a tendency to spread out rapidly, may be completely isolated, with the oak standing out between.

The stool regrowth of the hardwoods is much more injurious to seedlings under them, these seedlings rapidly dying off and completely disappearing under the action of the low cover it forms. Hence it is to this regrowth that the cleaning operations properly so called, the object of which is to save the seedlings of the valuable species, should be directed while the copse is still quite young. But it is obvious that these Cleanings require a light and skilful hand Thus it is only a few branches that have to be broken off or have their ends twisted or cut off, care being taken not to injure the underwood in any way. Again, the seedlings to be saved must be chosen from among the largest and most vigorous ones, and their number must be limited, so that they may not be too close together and may be situated only at such points, as where they could afterwards be utilised as standards. Executed in this spirit, the cleaning operations will be confined to a small number of isolated points and will be undertaken in the interests of only a single seedling at any one of them.

In copses with standards, even more so than in high forest, the work of cleaning belongs chiefly and peculiarly to the guard in charge of the beat. There is little to be done, but that little cannot be done in a single operation. The copse is continually growing up with great rapidity, and if any useful results are to be secured, the cleaning operation over each seedling must be repeated over and over again. In other words, there is something of this work to be done every day, and this something the moment it becomes necessary. Now no one can be better adapted for it than the resident guard. The Organisation Project may with advantage contain prescriptions respecting the execution of the Cleanings; it may fix the years in which those Operations ought to be carried out in each coupe and explain exactly what they require to be done. But nothing can assure complete success except unremitting attention on the part of the Forest Officer charged with the work and adequate remuneration given to the guards, who acquit themselves well of a task demanding so much care and skill.

The pruning of the standards is a veritable plague in compound copses. When it is resorted to, scarcely a single tree escapes the operation, and we know of many a forest, in which it would now be impossible to find a single tree, that has not been ruined by the pruning to which it has been subjected. No formed tree can be deprived of one or more of its large limbs without suffering a loss of vigour and a marked derangement in its vital functions, and without the production of a wound injurious in itself and often fatal on account of the various kinds of unsoundness it gives rise to in the trunk itself of the tree.

Among the standards, timber trees like the oak, which, constituting as they do, the most precious element of the forest and destined to be spared for several more Rotations, cannot be pruned in the strict sense of the term. To convince oneself of this, one need only cut through the trunk of an oak that has been pruned some years previously and observe for himself the deterioration and unsoundness to be traced back to that operation. Except the removal of the lower branches, already thin and half withered in consequence of early suppression, of first class standards, it is never permissible to touch the crowns of oak, ash, elm and other valuable trees.

As regards the standards preserved chiefly as seedbearers, and which can yield only firewood, people might be led to think that there was advantage in pruning off their lower branches in order to raise the leaf-canopy, thereby allowing a certain number of such trees (*e. g.* beech) to be reserved without any serious injury to the underwood. Here also pruning is more hurtful than useful, whenever it removes anything more than very thin branches, and these only from young trees, like first and second class standards, the object of the operation being, as we all know, simply to prevent the growth of low overhanging boughs. But when such branches have once developed themselves, their contribution towards the annual increment of the trees to which they belong more than compensates for the slight loss of growth suffered by the underwood. We must, therefore, always abstain from mutilating formed trees by depriving them of their large limbs or any considerable portion of their foliage. It is better to reserve a smaller number of such trees than to go and spoil them.

The necessity of pruning, properly so called, its effects in the given forest, and the limits within which it may safely be carried out, ought therefore to be separately discussed in the Statistical Report attached to the Organisation Project.

But the proper organisation of a forest must have nothing to say on the subject of this operation, unless it be to adopt a Rotation of sufficient length to effect a natural pruning of all the boles up to the required height.

If the organisation of a forest ought to occupy itself little or not at all with the removal of large branches, the case becomes quite different when we come to the removal of epicorms. In most copses with standards, the pruning off of the epicormic branches, which make their appearance on the boles of the reserved trees after the underwood has been felled, constitutes an improvement operation of very great importance. It is the necessary complement of a method of treatment, which alternately isolates and shuts up in the midst of dense leaf-canopy the trees preserved at the general exploitations. In many forests of mediocre growth, the operation in question becomes a necessity in order to save the oak standards from a premature death. Whenever this is so, the Aménagiste ought to consider this improvement operation in all its bearings in the General Statistical Report, and follow up the Selection Plan for Standards with directions as to how it should be effected. This is the surest means of having the work done at the right time. As a rule, the epicorms, which are mere branchlets, ought to be cut off flush with the trunk of the tree, and it is enough if the boles of the trees operated upon are in this manner cleared up to two-thirds of their length; but it may be found expedient to repeat the operation at the end of the second or third year.

It is not seldom that artificial restocking has to be resorted to in some of the blanks, which are common in compound as well as in simple copses. The Organisation Project ought to consider and prescribe such works, so as to guarantee their proper, timely, and methodical execution. When a forest contains numerous blanks, it may be found advantageous to wait and have them restocked naturally by preserving on their edges, during a whole Rotation, a belt of copse from 35 to 50 feet broad, instead of clean-felling without any reservation the underwood of all the coupes. With tall surrounding belts of copse such as these, the area of the blanks must necessarily grow more and more contracted, and in nearly every case end by becoming completely resown, thanks solely to the long-continued influence of the shade afforded by those belts, of the consequent moistness of the soil, and of the shelter and seed furnished by them.

The Organisation Project should prescribe the Thinnings that must be made every ten or twelve years in these broad conserved belts. If the blanks cover more than eight or ten acres, the Aménagiste may, while not omitting to recommend the preservation of such belts, enjoin their being artificially restocked with trees of rapid growth, such as pines, or birch, or alder, according to the prevailing soil. Under the light cover of those species the oak will make its appearance unassisted; but that is no reason why the Organisation Project should not discuss and lay down the various operations that may be required in the crops thus raised. As regards the reintroduction or augmentation, in the midst of the underwood, of any valuable species, it is, as a rule, scarcely possible to obtain it successfully except by means of a judiciously chosen Rotation and a well-constituted reserve, and with the aid of Improvement Cuttings (Thinnings and Cleanings). Planting in the midst of underwood standing on stools usually entails a heavy outlay without any compensating advantage.

Draining is still more rarely called for than any of the preceding operations. It is required only in water-logged soils, where excess of moisture is hurtful simply because it is due to the water being stagnant; but bogs seldom occur except in mere patches, and their draining would cost more than the game is worth. As regards open drains cut through wet land, in which the water is perpetually renewed, their only effect is to diminish vegetative vigour, and they have often been known to cause the premature decay of oaks that had already grown up into strong healthy trees. They only affect detrimentally the quality of the timber of oak, elm, and ash trees, and, after all, interfere with a proper mixture of the softwoods.

The keeping of a Control Register is of great use in the case of copses with standards, and this chiefly for the information it can furnish about the standards. The keeping of such a register, giving a simple but complete account of all necessary facts and circumstances, must be enforced by the Organisation Project. If, to take a particular case, in marking for Standards it was decided to exclude from the second class all trees exceeding 12 inches in diameter, and to note down in the Recorder's Field-book every standard of the third and and higher classes measuring 20 inches in diameter and upwards, it would be easy to keep a separate account in the Control Register (i) of all veterans, which possess for us a higher value than any other portion of the crop, (ii) of trees from 14 to 18 in inches in diameter, comprising all standards of the third and higher classes except the veterans, (iii) of trees with a diameter of 12 inches and less, comprising all the second-class standards, and (iv) of all the standards of the first class. With the oaks noted separately and all other species grouped under a single head, the Register would be full of the most valuable information respecting the forest concerned. Then, again, if Control Registers were kept everywhere, the Forest Department could know at once how many large oak trees we possessed in France, and how many it was raising to take their place when they would be felled.

CHAPTER V.

THE RESERVED FOURTHS.

SECTION I.

Legal Bearings of the Subject.

A fourth of the area of communal woods has to be entirely set aside from the remaining portion of those forests, this latter alone being subjected to the ordinary exploitations. Section 93 of the Forest Code puts this subject as follows :—

One-fourth of the forests belonging to Communes and Public Foundations shall always be set aside as a reserve, whenever these Communes or Public Foundations possess at least 25 acres of wooded land, whether in one piece or in several plots.

This rule does not apply to forests cropped entirely with a coniferous species.

The aggregate area of the Reserved Fourths established in accordance with the Section just quoted is actually 677,500 acres. They thus represent a considerable and a very important portion of the forest property of our Communes.

The reservation of one-fourth of the area of Communal woods may be traced back to a date much earlier than that of the Forest Code of 1827. The rule which that Code enforces is simply reproduced from Section 2, Chapter 25, of the Royal Edict of 1669. That Section runs thus :—*A fourth of common wooded land situated on the best soils and in the most convenient localities shall be reserved to grow up into high forest.* The Reserved Fourths of communal woods have thus been in existence for a very long time, and very often, indeed, they comprise the best portions of those forests. But the intention of the Forest Code is not to let them grow up as high forest, as was that of the Royal Edict of 1669, but simply to economise for the Commune resources which could be utilised in extraordinary emergencies; and, as an actual fact, the greater portion of these Reserved Fourths is subjected to the same Régime as the contiguous Working Circle composed of the ordinary coupes.

Under the authority of sections 16 and 90 of the Forest Code, the exploitation of the Reserved Fourths is classed under the head of extraordinary cuttings, which, we know, cannot under any circumstance be made without the special order of the Chief of the State. Thus, however important and extensive the Reserved Fourths may be, their exploitation cannot be regulated in advance, that is to say, it cannot be rendered amenable to any Organisation Project.

The Royal Edict, under the authority of which the Forest Code was promulgated, clearly defines the object of the Reserved Fourths by fixing the term of their exploitability. On this subject Section 140 of that Edict runs textually thus:—

"*Save in the case of death, permission to fell among the Reserved Fourths shall not be granted except under well-proved necessity and in the absence of other means of providing against it.*"

The preceding rule discovers great wisdom and foresight, founded on a perfect acquaintance with the circumstances and needs of our Communes. The procedure to follow in applying this Section is obvious. An application for an extraordinary felling having been made by the proprietary Commune, only two fundamental questions require to be answered, the first by the Forest Department, "Are the trees, permission to cut which is solicited, in a dying state? The other by the Civil Authorities, "Has the necessity for such a cutting been well proven, and is there no other way of meeting this necessity?"

The disadvantages arising from such a state of affairs are numerous; but they sink into insignificance before the advantages offered by the reservation of a fourth of the total area of the communal woods, which henceforth forms a constant provision against distress, a necessary guarantee for the conservation of the whole of such forests.

Thus the Communes may (and they cannot be prevented from doing so) make unreasonable or mischievous demands for permission to cut in the Reserved Fourths. It does not matter a bit if they do so, for it is in their own interests that these Reserved Fourths have been established and that the duty of managing them under such entirely special circumstances has been entrusted to our Department. The treatment of the Reserved Fourth of a communal forest consists, so to say, of a series of sudden and unforeseen exploitations. This is inevitable, but, thanks to special rules made for its protection, the Reserved Fourth is usually that portion of the forests in question, which is in the most satisfactory condition. The exploitations in an unorganised forest can, of course, never be ordered in any rigid manner. Nevertheless, however true this may be, it is not difficult to conceive what that order ought to be and to adhere to it as closely as possible at each exploitation.

SECTION II.

Descriptive Statement.

If the regular organisation of the Reserved Fourths of communal woods is incompatible with the satisfaction of extraordinary and unforeseen wants as they arise, it is not the less indispensable to organise a canton covering 125 acres and even less, in order to impose some sort of order on the exploitations made therein. This object may be secured by simply dividing off the Canton in question into compartments. This division being effected, in a simple manner, in accordance with the prevailing age-classes and natural topographical lines, and represented on a map which also gives the areas of the several portions of the canton, the essential part of the work is complete. It is always easy to add to this map a Descriptive Statement of the compartments and to prescribe the regular keeping of a Control Register, alloting to each a separate sheet on which to note down all the exploitations made therein, together with all concurrent and consequent facts. The order in which the compartments should be taken up may also be discussed and suggested. In many cases this order may be secured by simply numbering the compartments consecutively.

Moreover, there is nothing to prevent the clearing and maintenance of the boundary lines of the compartments, which should run along natural features and be selected with a view to the easy export of produce rather than to give the compartments equal areas. In a word, there is no measure for securing a well-ordered exploitation, that is not compatible with the management of the communal Reserved Fourths, if we except only the prevision of the epoch of each felling and also its character, points which cannot, from the very nature of the things concerned, be determined beforehand.

The question of a well-ordered exploitation, of little account when the Reserved Fourth covers only 25, 50, or 75 acres, acquires a directly increasing importance with the area of the wood, and may even sometimes become an absolutely necessary one, when the Reserved Fourth is large enough to form of itself a veritable forest. But, in that case, the number of the compartments is bound to be large, the construction of roads or bridle-paths dividing off the forest into compartments becomes a necessity, and, since the extraordinary cuttings are naturally made more frequently, any order fixed for them in the Descriptive Statement can be soon established on the ground, if the Executive Forest Officer only takes the trouble to observe it. The result of this is, that the working of the forest betrays all the characteristics of a regular organisation, only a single essential element being wanting, viz., the prevision of the extent of the exploitations.

We give below an example of a Descriptive Statement of a Reserved Fourth.

DESCRIPTIVE

OF THE RESERVED FOURTH

Canton.	Compart-ment.	Boundaries.	Area.	Situation and soil.
			A. R. P.	
	1	West, Compartment 2; South, road from Velle to Falun.	21-2-11	Ridge and gentle slope northwards; sandy clay with iron ore.
	2	East, Compartment 1; South-east, road from Velle to Falun.	16-1-19	Northerly slope; soil as above.
	3	North-west, Compartment 2; South-east Compartment 4.	11-0- 3	Slope falling eastwards; clayey sand, moist and deep.
Wood of Les Chailles	4	North-east, Compartment 3; South, Les Rayons road.	25-1- 7	Hollow like an amphitheatre, open on north side; soil as above.
	5	North, Les Rayons road; East, compartment 6.	15-3-16	Plateau and gentle southern slope; sandy clay with pebbles.
	6	East, Compartment 5; North, Les Rayons road.	10-2-37	Slope falling very gently southwards; soil as above.
	7	West, bridle-path; South, Compartment 8.	10-3-23	Plateau and gentle northward slope; clayey sand with pebbles.
	8	North, Compartment 7; West, bridle-path.	17-1- 1	As above.
	9	East, bridle-path; South, Compartment 10.	9-2-22	Plateau; clayey sand with pebbles; Ling bushes here and there.
	10	North, Compartment 9; East, bridle-path.	11-1-33	As above.

To impress the desirable order on the exploitations, in view chiefly of providing the shelter so necessary for the standards, the cuttings should pass successively through Compartments 71, 8, 9 and 10, and then through 1, 2, 3, 4, 5 and 6. In order to obtain

1. The boundaries on those sides, of which no mention is made, are fields and arable land.

2. All the compartments have been divided off from each other by means of cleared lines $6\frac{1}{2}$ feet wide.

STATEMENT

OF THE COMMUNE OE VELLE.

Age in 1878	Standing Stock.	Remarks.
Years.		
29	Copse of oak almost pure, with second-class standards, few, tall and deteriorated through epicorms.	This compartment was last exploited at the age of 52 years after a Preparatory Felling.
15	Copse of oak, hornbeam and softwoods; standards few of oak with some beech.	
19	Copse conposed chieky of oak and softwoods; fine oak standards; growth of crop vigorous.	
19	Copse of oak, bornbeam and softwoods; standards few but tall.	
1	Young copse of almost pure oak; standards very numerous of oak, first and second class.	This oak copse, only recently raised, has just been exploited for the third time.
5	Copse of pure oak surmounted by a numerous reserve of first and second class oak standards, of average growth, clear of epicorms.	Same origin as above.
26 & 25	Simple copse of hornbeam, oak and softwoods; a few birches; growth active.	This compartment was planted in 1818, cut back 10 years later, and has as yet been exploited only once.
24 & 20	As above.	As above.
26 & 25	Same as above, but less full.	As above.
24 & 20	As above.	As above.

the best result practicable it will be expedient at once to thin the crop in Compartment 1, and postpone its exploitation till that of the canton of La Brande has been completed.

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3. The general situation is level, at 1000 feet above the sea. The soil belongs to the Oxford clays, covered over in places with clayey sand containing pisiform grains of iron ore; it is silicious and fairly stiff.

4. The crops of moderate vigour are the best, especially as concerns formed trees, wherever hornbeam forms part of the underwood.

SECTION III.

TREATMENT.

The Treatment of the Reserved Fourths of communal forests is much more important than even their organisation. On this subject, as nearly all the Reserved Fourths hitherto established are worked as copse, although the Forest Code just stops short of prescribing their treatment as high forest, and the Royal Edict admits no term for their exploitation except the beginning of decay of the individual trees, it is advisable before everything else to indicate the rules and the principal points to observe and attend to in making the Extraordinary Compound Coppice Fellings.

In the first place, as regards the age for exploitation, most crops constituted as copse can with great advantage be allowed to stand on, and not be cut except as compound copse, until they are 40 years old. It is not rare for a copse of that age to yield in hard cash four times as much as a copse of 20 years, while the first-class standards preserved are worth eight or ten times as much. Only it is advisable to make, after the crop has reached the age of, say, 30 years, a suitable Thinning as a preliminary measure. This operation improves the growth of the underwood as well as of the standards, while in addition to this it yields saleable produce and necessarily provokes the appearance of seedlings, which become useful later on.

The selection of trees for standards is regulated by Section 70 of the Royal Edict of 1827. We know that Section 70, by its second clause, which is of universal application, prohibits the fellings of standards of the second and higher classes, unless they are in a decaying state or are unable to live for another Rotation. On this head it was not possible to prescribe any thing more for the extraordinary cuttings than for those made in the regular way. As regards first-class standards, their number is fixed in the case of the ordinary fellings at 16 at least and 20 at the most per acre by the first clause of Section 137, which runs thus:— "*In the fellings made in Forests belonging to Communes and to Public Foundations the reserve prescribed by Section* 70 *of the present Edict shall consist of* 16 *first-class standards at least and* 20 *at most per acre.*" But in the Reserved Fourths these figures must be respectively 24 and 40 in accordance with the second clause of section 127, which is of entirely special application, and is couched in the following terms "*Inthe fellings made in the Reserved Fourths the number of trees to be reserved shall be* 24 *at least and* 40 *at most per acre.*"

It must not by any means be understood thereby that these figures refer to the total number of standards of all classes. They apply only to standards of the first class excluding those of all higher classes, whatever their number. This point has been clearly established by M. Bagneris in his Manual of Sylviculture in which he expresses himself thereon as follows :—

"It has been argued from the word '*tree*' in the clause in question, that the number fixed includes standards of all classes. Now, in the first place, Section 137 does not say so. It overrules only the first clause of Section 70, the only one which lays down the number of standards to be preserved. In the second place, by the expression 'first-class standards' (*baliveaux de l'âge*) is generally understood individuals of the same age as the underwood from which they are selected for preservation. Now Section 140 provides that the portions which comprise the Reserved Fourth of a communal forest, ought not, as a general rule, to be cut except when in a decaying state, that is to say, when every indinidual has become a tree in the ordinary acceptation of the word. Being necessarily unable foresee at what age cuttings would be made in each case, the legislator employed the word 'tree,' by which must be understood individuals of the same age as the underwood, without any reference whatever to the standards of the other classes fixed by the second clause of Section 70. It would besides be absurd to maintain that the legislator has shown less solicitude for the Reserved Fourth than for the ordinary cuttings; and it would be just as reasonable to assert that because the first clause of Section 137 does not specify that first-class standards alone are meant, therefore, the number 'not less than 40 and not more than 50' includes equally well all classes of standards. This contention has never been raised".

As the Forest Code refrained from prescribing the rearing of the Reserved Fourths as high forest, it was expedient for the Royal Edict promulgating the Code to enforce the selection of the standards with a view to growing them as high forest over coppice. If it can be of some importance to the inhabitants of a Commune to receive a large quantity of firewood in their annual supply from the produce of the regular fellings, it is always a matter to be desired that the Reserved Fourths should produce chiefly timber. The various classes of timber are what can alone satisfy in a direct manner the extraordinary requirements of the Communes, just as they constitute the chief value of the cuttings.

There are just a few communal forests, the Reserved Fourths of which are stocked with broad-leaved species and are in the state of high forest. In most of them the predominating tree is the beech, which in one or several compartments forms crops of poles and sometimes even of high forest trees. In such woods reproduction from the stool would be unsatisfactory both on account of the species concerned and of the age of the standing crop. It would thus be an operation extremely to be deplored if we were to work them by *tire et aire* or as copse: the result would be the deterioration and even the ruin of the canton. Now pole crops of beech allow of fairly severe and very productive Thinnings being made in them. Repeated frequently, as extraordinary wants arise, such Thinnings would each time yield a considerable quantity of produce, and this up to the age of fertility, *i. e.*, up to, say, from their sixtieth to their seventieth year. Thereafter seedlings would begin to make their appearance on the ground; and the moment this took place, the extraordinary wants of the Commune could be met to their fullest extent and without compromising reproduction by means of Secondary Fellings repeated at short intervals, should those wants so require.

If the adoption of the High Forest method of treatment necessarily postpones the realization of produce, can this be urged as a prohibitive objection against it? It is true that if we have to wait 30 years at least before exploiting a copse, we must wait double that time before attempting to regenerate a high forest crop. But, on the other hand, this latter yields from time to time, at short intervals, accessory produce and, in the end, an outturn of higher value than that of coppice fellings renewed at short dates. Only, it is necessary that Forest Officers alone should have authority to propose the Thinnings to be made, both in order to improve the standing crop and to provoke the appearance of seedlings, objects the fulfilment of which alone would allow of the standing crop being drawn upon in case of unforeseen necessity. The kind of treatment here suggested, consisting as it does of successive Thinnings, which permit of the high forest trees being exploited at a comparatively early age, was not known before in France. It is easy of application, and it is moreover frequently adapted for private woodlands constituted as high forest.

Numbers of people are inclined to imagine that the money value represented by no matter what high forest necessarily increases only at a very low rate per cent. But the rate of profits on investments in forest property, far from being allowed to regulate the working of communal forests, is for the most part an indeterminate quantity. It is certain that if any one purchases a copse worked on a short Rotation and yielding a fixed income, he can calculate the profits he will derive by comparing the amount of that income with the amount of the purchase money. Neverthless there is often very great advantage, even as regards the rate of profits, in adopting rather long Rotations. But when we have to deal with high forest trees, who is in a position to say that it yields such and such a rate of profits? When we preserve a tree, it is not for one or two years, but for 25 years at least. The rate of profits then depends on the present value of that tree and that which it will acquire at the end of 25 years. Now this latter is unknown, and, in consequence, so is the rate of profits.

The point to establish, one that leaves no room for doubt afterwards, is the growth of the standing timber concerned—its increase in diameter, for instance, whether it is slow or rapid. We fell a tree, and examine the thickness of the youngest annual rings. If we find that it is one-tenth of an inch, it follows that the tree has been gaining in diameter at the rate of one-fifth of an inch every year or 5 inches in 25 years. Under these circumstances, a beech tree with a diameter of 15 inches would measure 20 inches at the end of that time; while its volume will have more than doubled, since the cubical contents of a tree obviously increases as the square of the diameter. The rate of profits derived from a forest composed of such trees would be 3 per cent., if the price of a cubic foot of middle-sized timber were the same as that of a small log, and if, moreover, it were taken for granted that prices remained stationary during the whole period of 25 years. But fluctuations are inevitable, and is it then possible for any one to say whether the rate of profits would be three or four or six per cent? Of course not. The future is pregnant with uncertainties, and here again those will reap an advantage who display the greatest skill and the farthest-reaching foresight.

Too often it happens that a Commune, having debts to pay, the interest on which is 5 per cent, finds that it possesses only young timber in the Reserved Fourth of its forests. This young timber, so people say, does not yield 5 per cent. Now, in the first place, no one can prove the truth of this assumption, and, in the next place, if, for argument's sake, we granted its truth, it would be necessary to sell off the whole forest, since by hypothesis it is unable to yield as much as 5 per cent. The question to consider is hence this, "Is the forest in question worthless, and would the Commune better its own position by selling it?" When the Reserved Fourth does not contain exploitable wood, it is to the ordinary fellings that the Commune must look for the means wherewith to pay the interest on its debt, and even to clear the debt itself once for all. There is no other remedy.

Analogous conditions to those met with in high forest cantons of broad-leaved species are found in reserved blocks cropped with conifers, and in old copses of 50 or 60 years and upwards of age, the regeneration of which by seed requires, so to say, only its partial exploitation at short intervals of time, as we shall see in the following Book on Conversion, Operations.[1]

In the organisation by area of high forests of conifers belonging to Communes, the present practice is to set aside as a reserve not the fourth part of the area of the forest, but the fourth part of the timber to work out every year. This procedure, in entire conformity as it is with the spirit of the Forest Code and of the Royal Edict promulgating the former, is an excellent one, but on two

1. Each species, in order that it may thrive, requires more or less exposure to sunshine. Those that require it most are aspen, ash, the large maples, the elms, the wild cherry, none of which grow well except with their crowns perfectly free on every side. Then come birch, alder, oak, lime, the common elm, which do better in the open than in leaf-canopy. Lastly, we have hornbeam and beech, which attain a large size in leaf-canopy, provided their crowns are allowed to spread out a little.

conditions. The first is that the reserved portion shall not be considered as utilisable at the very outset of the organisation, while it exists only on paper and has not yet been constituted on the ground ; for to act otherwise would mean that there would be nothing fit to cut when the day of necessity arrived. The other condition is that the quantity reserved shall really represent the fourth part of all the produce, *principal*, *accessory*, and *accidental*, for it ought to be sufficient to meet all the extraordinary wants of the Commune, as well as all emergencies arising out of the organisation itself. It *must* therefore be considerable.

BOOK VI.

CONVERSION OF COPPICE INTO HIGH FOREST.

General Considerations.

Forests constituted as high forest yield on the whole more useful and more abundant produce than if they were worked as copse. The inference to draw from this is that it is the duty of the State to convert into high forest all the copses it possesses. The object of the conversion is to replace the copse, composed of shoots from the stool, by high forest crops grown entirely from seed. Indeed, to whatever age we may allow a copse to grow on, it will always remain a collection of stoolshoots. It cannot develop in the same manner as a mass of high forest trees; besides this, its growth is precocious and begins to languish at an early age; and, lastly, it decays prematurely without yielding, as do crops of high forest, timber of large size. Hence, whether we regard its origin or its aftergrowth, or consider it from an economical or cultural point of view, a copse presents no points of resemblance in any essential detail to a high forest. It hence follows that the conversion of a copse into a high forest cannot be effected by means of Transformation Fellings, or by merely modifying the actual standing crop. Simply making a few Thinnings or removing some of the trees or carrying out any other like operations would have no other result than that of changing the condition of the copse, while still preserving its essential character of being a copse. The conversion of a copse means then nothing less than the regeneration of the entire forest by seed, the end in view being to replace the old stock on stools by high forest crops of all ages from the young seedling to masses of exploitable timber.

Communes that are owners of forests would seem to be placed in the same position as the State, but it is easy to understand at the very first glance that the replacement of the crops aged, say, from 1 to 30 years, which constitute the accumulated capital of a copse, by the much larger stock of a regular high forest, is possible only on the condition of foregoing a portion of the annual production, and thus necessarily of reducing the quota of the cuttings and restricting the exercise of its rights on the part of the present generation. This reduction may be slight or considerable, according as the standing stock to be replaced by high forest is large or small, or contains within itself the materials for easy and rapid or difficult and protracted regeneration. Under certain circumstances it may be kept down at as low a figure as one could desire by a skilful Organisation Project, and spread more or less equally over all the successive Periods of the Rotation adopted for the conversion. But in no case can it be obviated. The conversion of a copse into high forest hence demands on the part of the owner a willingness to forego for the time being a portion of his income, and to transfer, for the benefit of future generations, this portion to the capital sunk in the standing stock. We have no right to expect the Communes to submit to such a sacrifice; and, for a long time to come, save in a few exceptional cases justified by special circumstances, there is very little probability that the Communes as a body will be able to undertake so desirable a modification of their forests. Hence it is only the forests of the State that we shall chiefly have in view in considering the question of the conversion of copses into high forests.

If it is the duty of the State to convert its copses, we consider that it is advisable to take up this work progressively, and not to attempt it except in such forests as offer the necessary resources for its success. To establish our position we have only to remind the student that the object of every conversion is to get rid of actual stool-crops by having recourse to natural reproduction or to artificial planting and sowing. Now the conversion of a copse into a high forest is an operation so full of risks and uncertainty, besides being difficult and expensive, that it is much better to abandon all idea of attempting it than to undertake it without having the essential materials at hand.[1] What we have just said admits of only a single exception, viz., the case of a forest growing in very poor soil or in soil that has undergone hopeless deterioration, that is to say, soil on which stool crops make wretched growth and can be easily and profitably replaced by a conifer crop. This case excepted, the conversion of copses into high forests by means of natural reproduction is the sole method that ought to be adopted, not only because regeneration by natural means is obtained with greater certainty and at less cost than by artificial methods, but also because self-sown crops are always finer and more vigorous than those raised artificially.

We ought also to add that in most copses the ground can be sown naturally to a sufficient extent only by the standards and by the older stool-poles, the cover of which is high enough up above the ground. When an old copse, being exploitable as such, is pre-

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1 The presence of stool-shoots in the midst of the seedlings is the worst danger to be encountered in conversion operations. Whereas seedlings do not begin to shoot up rapidly until after their first youth, after the age of 30 years for instance, stool-shoots push up apace at once and it takes them only a few years to suppress any seedlings coming up with them. Once stool-shoots are exposed to abundant light, they can be kept down only by repeated Cleanings which must be begun at once, otherwise the task soon multiplies and gets beyond control, and a few years of delay may result in the stool-shoots gaining complete possession of the ground. In any case a mixture of seedlings and stool-shoots forms two discordant elements of growth. The latter overtop the former and oppose their development to such an extent that if the crop when it arrives at the low pole stage (which it generally reaches towards the age of 40 years), is not composed exclusively of seedling trees, it is only too probable that it will be a wretched one and without any prospect of improvement.

If the presence of stool-shoots in the midst of selfsown seedlings is so full of danger to them and calls for so much careful precaution, what must be the case when the seedlings have been raised artificially? For in this case the young plants, necessarily few and far between and thrown back in their development, are fatally doomed to disappear from the midst of the stool-shoots in the course of a few years. The creation of a forest on a perfectly bare soil is certainly a less expensive and more certain operation than the conversion of a copse into a high forest by artificial sowing or planting. That method is hence applicable only in the blank portions of ruined copses. As for those portions which are badly stocked, which contain only the softwoods or in which the principal species is conspicuous by its absence (*e. g.*, a copse of hornbeam), it is a safer plan to modify their condition gradually, say by exploiting them twice over as compound copse, than to attempt their direct conversion.

served, its growth is obviously not stopped, the leaf-canopy continues to rise away from the ground for several years, and, when it consists of mixed species, the stock thins itself spontaneously all the earlier, the more rapidly the clumps of short-lived trees disappear ; and, lastly, the faculty of producing seed increases as that of throwing up shoots diminishes. But complete fertility is not attained until the crowns have acquired a certain fulness and the older stool-shoots have become small trees. Copses of oak and beech often do not become completely fertile until about the age of 60 years. Complete fertility betrays itself on the ground by the seedlings which make their appearance, no matter what the soil on which the seed falls. Hence to regenerate a copse by seed it suffices to allow it to grow on until it becomes really fertile, and then, and only then, to proceed to make Regeneration Fellings in the manner best suited to the species concerned. This end is attained all the earlier and the more effectively, the more numerous the standards are. From the observations we have just been making it follows that the conversion into high forests of the State copses ought not to be undertaken except on the condition that the crops contain within themselves all the necessary elements to secure the regeneration of the forest by means of self-sown seedlings of the one or several species, which it has been decided to rear as high forest trees. When these elements are wanting or are present only to an inadequate extent, it is much better to wait and to continue working the forest as coppice until a sufficiently large number of standards has been reserved with which to obtain a more or less complete sowing of the ground. It is only then that the Regeneration Fellings can be taken in hand in a really timely manner, and the new seedling crop obtained without any expenditure and with the fullest possible measure of success, provided always that the conversion operations are carried out with all due care and foresight.

Such are, as regards the condition and composition of a compound copse, the circumstances that, in our opinion, should exist to justify its immediate conversion into high forest. We now proceed to inquire what conditions as regards the soil it is necessary or simply expedient to have in order to grow a high forest, and what circumstances render urgent or desirable the conversion into high forests of the copses belonging to the State.

It has been said with reason that the poorer a forest soil is, the more careful we should be to maintain the cover, and, as a consequence, the more important it is to grow high forest on it. Theoretically this proposition is rigorously true, provided always that the species selected for this purpose are adapted to the soil and climate. Practically it admits of some exceptions, and, to say the least it requires some explanations.

In certain soils, deep, yet nevertheless free and little fertile of themselves, the High Forest Régime becomes a necessity, as the only one capable of preserving the fertility of the soil and of preventing the ruin of the forest. The finest high forests in France, viz., those of Bersay, of Bellème, of Perseigne, and of Fontaineblean are a standing proof of this. These forests are situated on almost purely silicious soils, the fertility of which is due entirely to the protecting dense leaf-canopy overhead. Were this cover to be destroyed either by unskilful working or by some accident, the topsoil would at once lose all its valuable qualities under the direct action of the sun, the ground would be overrun by ling bushes, and it would be futile to demand from it under the Coppice Régime those magnificent oak and beech, which form the present canopied masses that now cover it. The ruined copses of Fontainebleau itself, of Ermenonville and hosts of other forests situated on sandy soils furnish too evident a proof of this. In such soils, therefore, there is absolutely no choice left as regards the Régime to adopt. Treated under any other than the High Forest Régime, the forests standing thereon would be bound to deteriorate rapidly, and yield produce both limited in quantity and of poor quality. The sessile-flowered oak, the beech, and the hornbeam associated with each other are the chief species to grow in such forests. Besides these, the birch is generally found in abundance on such soils.

The Jurassic limestones usually give a more or less undulating character to the country. Often they form plateaux intersected by sinuous valleys and ending in abrupt slopes. The topsoil, being the remains of the limestone rock washed away by rain, is simply a mixture of silicious sand, clay, oxide of iron, and of fragments more or less small of the limestone. This red earth is generally very shallow, being from 6 to 8 or 12 inches deep; it is apt to dry up rapidly, because rain falling on it filters away with great ease through it and through the underlying fissured rocky strata. Nevertheless the forests situated on these limestone plateaux are not so liable to deteriorate under the coppice treatment as forests on silicious soils. After every exploitation, soils resting on limestone rocks are overrun with various and abundant herbaceous and shrubby growth, which protects it from the direct influence of the sun's rays. On this account forests situated on such soils maintain themselves complete and full of vitality even after centuries of treatment as copse. Nevertheless it is a matter of experience that these copses grow slowly and yield at the age of 25, 30 or even 35 years only small firewood. Such are the forests of Haye, of Auberive, of Chatillon-sur-Seine, of Braconne, and a great many others, the formation in question being very extensively distributed, and composing the largest proportion of the forest soil of France. Now it is beyond dispute that the High Forest Régime is essentially suited for these forests, provided the beech is treated there as the dominant tree, since it is the only one among the broad-leaved species that can grow with some vigour and acquire large dimensions in those soils. But it is advisable to associate with it the sessile-flowered oak and to preserve, as stop-gaps to form a complete leaf-canopy, individuals of the hornbeam which species always grows in less or greater abundance in those copses, and which more than any other helps to maintain them in full vigour.

There are also other soils containing a larger proportion of clay in the top-soil than those already referred to, large extents of which bear forests that are treated as copse. They are for the most part met with in the plains, sometimes on hilly ground, more rarely on low mountains. They belong to very various geological formations, such as the clay schists, the variegated sandstones, the iridescent marls, the lias, the green sandstones, the Bressan rocks, &c. These soils, usually deeper than those referred to in the preceding paragraph, are always also moister and more fertile, and are as a rule, adapted for the oak. The forests that cover them stand being worked as copse perfectly; but it is indisputable that on these soils, being as they are of average fertility and suited for the oak, the High Forest Régime yields much better results than that of Coppice. Instances of such forests are those of Champenoux in Lorraine, of Trois Fontaines in Champagne, of Chaux in Franche

Comté, and of Longchamps in Burgundy, the sessile-flowered oak in the drier portions or on rolling ground, the pedunculate species in the moist or wet portions, associated the one with the beech, the other with the hornbeam or with such species as can be grown there with the greatest advantage.

Going up the ascending scale of soils according to their fertility for forest purposes, if we look at the forests situated on old or recent alluvial deposits, such as are to be met with on the banks of the Saône and of the Adour, or in localities analogous to those of the forests of Mont-Dieu in the Ardennes, of Coucy-Basse in the Aisne, and of the majority of the forests in the plains of Southern France, we cannot but regret to find only copses there, where the finest high forests of oak could be reared. But the pedunculate oak, the only one of our two principal oaks that can be successfully grown in these rich and wet soils, possesses a very light cover. Even when standing close enough together to form leaf-canopy, it affords to the soil below but little of that protection so necessary to preserve its fertility and to prevent its becoming overrun with grass, and to assure to its own bole the amount of shade necessary to save it from an invasion of epicorms. When raising it as a high forest tree, it becomes incumbent, much more so than in the case of the sessile-flowered species, to associate with it some species possessing dense foliage, like the hornbeam for instance, to complete the leaf-canopy.

In these very soils, the pedunculate oak grown as a standard over copse shoots up rapidly and acquires a considerable length of bole. It yields a close-grained wood, less suited than that of the sessile-flowered species for the purposes of the cabinetmaker and the cooper, but valuable for the civil and dockyard engineer, and, as a rule, for all purposes which require combined strength, elasticity, and durability. Thanks to its light cover and to the height of its crown above the ground, thanks also to the exceptional fertility of the soils in question, in which the aspen, the ash and the alder flourish, the underwood alone, filling up the space between the crowns of the standards, yields a considerable quantity of produce, which in certain districts, where poles of all species are used for mine stays, commands an extensive sale at remunerative prices.

A well constituted high forest of the pedunculate oak would, we believe, yield much more valuable produce. But at present none such exists anywhere in France in the soils we have just been describing. Moreover, on account of the difficulty of substituting a high forest for copse in very rich soils which are liable, the moment the leaf-canopy has been rent, to be overrun with high grass and the soft woods, we consider that for the present it is better to maintain the present Régime and simply to perfect it as far as possible, than to undertake conversion operations under extremely difficult conditions and with doubtful prospects of success.

CHAPTER I.

ORGANISATION OF COMPOUND COPSES UNDER CONVERSION.

SECTION I.

Preliminary Operations.

Taking the conversion of a forest as a whole, its object is to form a Working Circle of High Forest containing a complete series of the different age-classes. Hence the various portions of the forest cannot be converted simultaneously, but gradually one after another, the operation being spread over a space of time equal to the Rotation, on which the forest would be worked if it were already constituted as a high forest. The Aménagiste should, therefore, take in hand first of all those portions, which are the best adapted for the purpose, and gradually prepare the rest for conversion while at the same time improving them.

But if it is necessary to prepare a copse, whether simple or compound, for conversion by letting it grow on, that is no reason for doing this simultaneously all over the forest from one end of it to the other. This preparation would be premature except during the period immediately preceding that in which the actual conversion is to follow. We may, therefore, have to make one or more coppice exploitations in those portions of the forest, the conversion of which is yet distant; nay, as a general rule, no other procedure is practicable. A portion of the copse is by this means renewed before its actual conversion, and the owner of the forest realises thereby what he cannot well do without, viz., his exploitable wood and timber.

After what precedes, it is easy to form an idea of the general march of the conversion operations. Given, for example, a real copse, composed chiefly of shoots from the stool; the Aménagiste must first determine what time the conversion of the whole forest will require, then fix the successive Periods of the Rotation and the portion of the forest to convert (that is to say, the Block to regenerate by seed) during each of them. He must next lay down for each Period prescriptions regarding the preparation for conversion of the corresponding Block, the actual conversion of the Block thus prepared during the immediately preceding Period, and the continuation of compound coppice exploitations in the Blocks to be prepared during the subsequent Periods for conversion. Such is a general idea of all conversion organisations, to which each particular case can be referred as a type. It is as simple as it is excellent.

We now proceed to describe the various working combinations and cultural operations that enter into the conversion of compound copses into high forests. At the outset we must take for granted as a necessary postulate that all these copses contain within themselves all the elements required for their successful regeneration by seed. We do not intend to say anything regarding simple copses, since their conversion is after all only a particular case falling under the general question treated.

The preliminary steps to take in drawing up the Organisation Project for the conversion of a copse into high forest are in no way different from those adopted in organising a high forest. It will thus be sufficient if we explain what points require special attention in the examination of the compartments, in the formation of the Working Circles, and in the determination of the Rotation.

§ 1. *Formation of Compartments.*

The division lines of the former coppice coupes can serve, provisionally at least, for the boundary lines of the compartments. It will be possible later on to decide which of these lines should be permanently retained and which rejected; and wherever new lines are found necessary, these should follow topographical features and other natural boundaries.

In examining the compartments, special attention should be paid to the standards, to give a good idea of which the Aménagiste must note the species to which they belong, their soundness and vigour, their number and distribution, their vitality, and the length of their boles. At the same time the constitution of the underwood must be regarded from the point of view of its mode and vigour of growth, of the relative proportions of the component species, of stool-shoots and seedling plants, of the density of the stock and the effective causes that have brought about its present state. It should always be borne in mind that the chief object of the examination is to ascertain what available resources the copse examined offers for its conversion into high forest by means of natural reproduction. The situation and the soil must be described and considered in the same manner as in every other case of forest organisation ; but, as a rule, the safest criterion of the fertility of each compartment is to be found in the way in which the standards have grown up and are actually growing, and in the habit, height, and degree of vigour of the formed trees.

The examination of the compartments thus conducted and recorded serves before everything else as the basis for the constitution of the Working Circles of the future high forest, and for the determination of the Rotation to adopt in each of those Working Circles.

§ 2. *Working Circles.*

When the forest to be converted covers a large area and consists of a number of Working Circles of compound copse, it is advisable to group together in each Working Circle of the new organisation a certain number of the former. Many advantages result therefrom ; for instance, the Aménagiste may by this means be able to form each of the Periodic Blocks either of a whole Coppice Working Circle or of contiguous and similar portions of several such Working Circles. Cases in which this is feasible are rather rare ; yet when the opportunity offers itself, it should be seized at once, as it facilitates the drawing up of the General Working Scheme, the advantageous distribution of the felled produce, and the successive preparation of the standing stock for the conversion operations as they fall due.

However it be, every Working Circle of the new organisation ought, as a rule, to comprise more than one of the original Coppice Working Circles, or parts of several such Circles. The main point to insist on is that it should contain at the very beginning of the new Rotation a sufficiently large area fit to be regenerated at once by seed, and hence capable of constituting the First Periodic Block.

Nor is the condition of the other parts of the new Working Circles without some importance. It is just as desirable to have the second Block of each one of them rich in standards and well constituted as regards its underwood, so as to yield a sufficient quantity of produce and at the same time offer the means of successful natural regeneration during the Second Period. And more than this, it is a good thing to have, outside the First Block, coppice crops old enough to bear productive fellings at the very commencement of the conversion, and of sufficiently well-graduated ages to provide against any interruption in the serial succession of the exploitations to be made.

It is easy to conceive how a period of waiting well spent in the necessary preparation for conversion enables us in most cases to secure all these results in a timely and complete manner.

Such, barring some exceptions, are the essential conditions that must be realised in order to form the new Working Circles, by grouping together into them the existing coppice crops, which in other respects may, for the matter of that, present all and every degree of variety.

§ 3. *Rotation.*

By the term *Rotation of Conversion* we understand the time required to create a well-graduated succession of seed-grown crops conveniently distributed between the principal broadly-defined high forest age-classes, from the young carpet of seedlings to the exploitable mass of full-grown trees. When the conversion of the forest, that is, its replacement by a new generation of seed-grown trees, can be taken in hand at once, the Rotation of Conversion ought to be the same as the Rotation that would be adopted, had the forest been already constituted as a high forest. We will term this the NORMAL ROTATION.

The reason for not adopting a different Rotation for the conversion is evident, for the essential point of the matter is that the Rotation should be equal to the length of time necessary to obtain a complete series of seed-grown crops of graduated ages from the germinating seedling to the exploitable tree.

But if it is necessary to wait some time before undertaking the conversion operations, if, for example, the coppice crops to regenerate first require to be allowed to grow on for another 30 years while being in the meanwhile prepared for the purpose, the conversion of the entire Circle cannot be completed before the end of the Normal Rotation augmented by 30 years.

In any case, the length of the Rotation of Conversion depends on that of the Normal Rotation, which can be determined in accordance with the same economic and cultural considerations as in the ordinary organisation of a constituted high forest.[1]

SECTION II.

The General Working Scheme.

The next step after the Working Circles have been constituted is to draw up the General Working Scheme for each Working Circle taken separately ; that is to say, the Rotation is divided into Periods and the Circle into Periodic Blocks, and the compartments of each Block are grouped together in the order in which they should be taken up for conversion. The principles to follow in arranging the Blocks and Periods in conversion organisations will be apparent from a perusal of the following paragraphs, in which we propose to examine some General Working Schemes drawn up to suit the circumstances most usually met with.

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1. The trees standing in a compound copse do not afford the means of determining the length of the High Forest Rotation. Since they have grown up in complete isolation, their boles have remained short, but have increased in girth more rapidly than those of otherwise similar trees forming part of a canopied forest The ages of these two categories of trees being the same, the dimensions of the one and of the other are nevertheless different. Hence with the help of the data furnished by the elements of a compound copse we can estimate only approximately the time required for obtaining the girth suitable for all the principal usages to which the wood is put. However it be, this period of time ought to be long enough to render it certain that we shall find trees of the exploitable dimensions at its close.

First Case.

Let us suppose that it is desired to convert into high forest a wood of small extent, consisting of a simple Working Circle of compound copse, and divided into 30 coupes of equal extent stocked respectively with crops from one to thirty years old. Let us also suppose that this wood offers all the resources necessary to enable conversion operations to be started forthwith.

An examination of the standing stock has shown (i) that the six coupes cropped with underwood from 25 to 30 years old contain a very numerous reserve, which forms a leaf-canopy equal to that of a Close Primary Felling, the underwood being in consequence thin, sickly and sparse, (ii) that the stock in the latter coupes contains fewer standards, but consists of a flourishing underwood, in which the more valuable species are well represented, and (iii) that the exploitability of the forest under a seed-grown crop would require a Rotation of 150 years.

This Rotation being divided into 5 Periods of 30 years each, we will suppose that the General Working Scheme has been drawn up thus :—

First Block	Coupes aged from		30 to 25	years.
Second Block...............	do.	do.	18 to 13	„
Third „	do.	do.	12 to 7	„
Fourth „	do.	do.	6 to 1	„
Fifth „	do.	do.	24 to 19	„

The Special Scheme of Exploitations for each Period would then be broadly thus :—

First Block	Regeneration Fellings.
Second Block..................	Thinnings or Preparatory Cuttings.
Third, Fourth and Fifth Blocks united	Compound Coppice Fellings, over one-thirtieth of the aggregate area every year.

SECOND PERIOD.

First Block..........................	Cleanings and First Thinnings.
Second Block................................	Regeneration Fellings.
Third Block	Thinnings Preparatory to Conversion.

Fourth and Fifth Blocks ... } Compound Coppice Fellings over one-thirtieth of the aggregate area annually.

And so on for the remaining Periods.

The result of the treatment here sketched out would, of course, be the successive replacement of the copse by seed-grown crops of graduated ages forming together a regular high forest.

Second Case.

In the preceding case we supposed that the First Block could be at once regenerated by means of self-sown seedlings obtained from the large number of standards composing the existing stock. A case of this kind rarely presents itself, and in the greater number of instances it is necessary to fall back on the poles of the underwood, in order to supplement the standards in forming the closeness of leaf-canopy required by a Primary Felling and effecting the regeneration of the First Block by seed. But oak and beech poles, even those that have grown up from the stool, seldom produce fertile and abundant seed before the age of 50 or 60 years. Moreover, the self-sown seedlings of these species die out when the cover of the trees that are to shelter them is not sufficiently high above the ground. Lastly, the poles of the underwood that must necessarily be cut back in a coppice crop aged only about 30 years when a Primary Felling is made, cannot but shoot up again abundantly from the stool and thus produce clumps of shoots offering an obstacle to the appearance and maintenance of seedlings.

For all the reasons just given, it is necessary, in the case now under discussion, to put off high forest regeneration operations until the underwood has become old enough to be really fertile, to be no longer able to shoot up anew, except in an imperfect manner, from the stool, and to have attained a greater length of bole. While waiting until this happens, the opportunity should be seized of preparing, by a proper course of treatment, the crops that are first on the roster for conversion ; and in order to simplify the work of organisation, this period of waiting, which we will term the PREPARATORY PERIOD, may be made equal to one of the regular Periods of the Normal Rotation.

The General Working Scheme will, of course, resemble very closely that given under the first case, while the exploitations to make throughout the whole Working Circle during the Preparatory Period should be arranged thus :—

PREPARATORY PERIOD.

First Block............Preparatory Cuttings or Thinnings.

Second, Third, &c., Blocks.................. } Compound Coppice Fellings.

At the end of this Preparatory Period the forest will have become fit for its conversion to be undertaken under the same circumstances and in the same manner as those already described in our first hypothetical case.

Third Case.

Instead of a wood of small extent, we will now suppose that we have to do with a large forest divided into a considerable number of Working Circles. In this case it is, as a rule, necessary to group together several of the Coppice Working Circles to form a single one of high forest. Then, as under the preceding hypothesis, we have first of all to decide whether the conversion of the crops which constitute the First Block can be at once taken in hand, or whether it is necessary to have recourse to a Preparatory Period.

In the former case we must group together in the First Block old coppice crops containing numerous standards and fit at once to reproduce themselves by seed by means simply of the ordinary Regeneration Fellings. At the same time care must be taken to place in the Third, Fourth, and later Blocks crops of sufficiently well-graduated ages to enable us to form of the whole taken together, or better still of each separate Block, if that is possible, a Working Circle of copse to be exploited regularly as Compound Coppice during the First Period. As regards the Second Block, as it must be subjected to purely Preparatory Cuttings (Thinnings and Cleanings) during this same First Period, there is no object in concerning ourselves about forming it of crops presenting a series of graduated ages. We need simply allot to it Compartments which will at the end of that Period be fit to regenerate themselves by seed.

We thus see that the exploitations to make throughout the entire Working Circle during each Period of the Normal Rotation may generally be summarised as follows :—

First Period.

First Block	... ...	Regeneration Fellings.
Second Block	... ...	Preparatory Thinnings.
Third Block	... ...	Compound Coppice Fellings.
Fourth Block	... ...	do. do.
Fifth Block	... ...	do. do.

Second Period.

First Block	... ...	Cleanings and First Thinnings.
Second Block	... ...	Regeneration Fellings.
Third Block	... ...	Preparatory Thinnings.
Fourth Block	... ...	Compound Coppice Fellings.
Fifth Block	... ...	do.

And so on for the Third, Fourth, and Fifth Periods.

Fourth Case.

However extensive the forest to be converted may be, it may be found necessary to pass through a Preparatory Period before beginning to regenerate it by seed. In this case, the First Block must be constituted on the same principles as those sketched out for the Second Block in the preceding hypothetical case, and, as regards the Second, Third, Fourth and Fifth Blocks, care should be taken to allot to them crops offering a suitable gradation of ages. The exploitations to be made over the whole Working Circle during the Preparatory Period would then follow the general plan given below :—

Preparatory Period.

First Block....................	Preparatory Thinnings
Second Block................	Compound Coppice Fellings
Third Block....................	do.
Fourth Block..................	do.
Fifth Block....................	do.

This preparatory stage would then be succeeded by the real Conversion Rotation, during which the operations would follow the general lines hereunder indicated.

FIRST PERIOD OF THE CONVERSION ROTATION.

First Block....................	Regeneration Fellings
Second Block....................	Preparatory Thinnings
Third Block....................	Compound Coppice Fellings.
Fourth Block....................	do.
Fifth Block....................	do.

And so on during the Second, Third, Fourth, and Fifth Periods. If, besides this, each of the Blocks other than the First comprises in itself a complete series of Coppice Fellings, the general Working Scheme becomes very simple.

But actually this happy coincidence rarely occurs, and when it does not exist, it would be a great mistake to force matters in order to obtain the simple outline of work which it renders possible. It is in the general conditions imposed by the organisation of the forest, in the cultural treatment which the conversion demands, and in the gradual improvement of the forest, that the necessary solution to the question connected with the General Working Scheme should be sought.

Thus, by way of resuming what we have said, we see that the success of an organisation for conversion depends entirely on the efficient manner in which the various cultural operations are executed, if the General Working Scheme is based on the following conditions :—

(a) The First Block stocked with old copse possessing a high cover and containing a sufficiently large number of seedbearers to admit of the immediate conversion of that portion of the Working Circle. (b) The Second Block composed of coppice crops of any ages whatsoever, but containing in a numerous reserve, or at least in the underwood, or still better in the reserve and the underwood together, species suited for high forest growth in sufficient proportion to be capable in a short time of forming by themselves a complete leaf-canopy. (c) The other Blocks comprising the rest of the coppice crops, no matter what their density and the component species, but only of sufficiently well-graduated ages, and above all, old enough to furnish at once and without any interruption principal produce, that is to say, to admit of being worked profitably and continuously for the market.

Such are the general conditions which it is always possible to realise after a Preparatory Period of sufficient length, equal, say, to a long Coppice Rotation. Occasionally, of course, there are circumstances of an exceptional nature to be met with, such as compartments so rich in seedlings, or saplings and poles sprung up from seed, that they can be *transformed* into a true high forest by means of mere Improvement Cuttings accompanied with the extraction of a few trees. It is evident that such crops would find their natural place either in the last Block or in the first, since regeneration by seed has already been effected and the chief and sole object of the conversion fully accomplished. In other cases, in compound copses in which the beech is the dominant species, it may happen that by far the greater proportion of the stock of a large part of the forest has sprung up directly from seed, stool-shoots, birches and the soft woods being in the minority. Here, instead of continuing to work the last few Blocks as Coppice, it is often found advisable to execute therein mere Improvement Cuttings or even simple Transformation Cuttings. These latter operations, consisting as they do in the extraction one by one of the reserved trees, of stool-shoots and of the soft woods, may be found suited either for whole Blocks or for only some of their component compartments. There are many other special circumstances to be met with. Nevertheless, all things said, copses seldom, if ever, lose their inherent constitutional defect due to their having grown up from the stool; and as the presence of stool-shoots in the midst of seedlings is the greatest danger to be obviated or overcome in the conversion of a forest, it is wise to mistrust all exceptional cases in drawing up the General Working Scheme: too often such exceptional cases are entirely delusive, and exist only in the imagination of the Aménagiste.

SECTION III.

Special Scheme of Exploitations.

The various combinations, which enter into the organisation and working of a forest in each of the hypothetical cases of conversion that we have just been describing, have all a close analogy with each other and possess the same characteristics of symmetry and simplicity.

The Special Scheme of Exploitations ought also to be clear and precise as respects its form, which ought to be so constructed as to meet every kind of difficulty that may be encountered in practice with regard to the nature, march, and location of the ordinary fellings. This object is easily enough attained, thanks to the fact that a large proportion of the fellings are necessarily based on area, and may, therefore, be rigidly fixed in advance for every successive year for each Separate Block.

We give below an example of a Special Scheme of Exploitations to be made during the First Period of 40 years in a Working Circle divided into 4 Blocks and already in a perfect state of preparation for conversion. It will help to explain, better than any amount of rules, the general procedure to follow.

EXPLOITATIONS TO BE MADE DURING THE FIRST PERIOD FROM 1871 TO 1910.

Block.	Cantons.	Compartments.	Area. A. R. P.	Description of standing crop.	Age in 1871	Treatment required.
		A	90 1 0	Old copse, oak and hornbeam... ...	72 to 70	Regeneration Fellings.
		B	55 2 24	As above, with a few standards... ...	65 to 63	...... Do ......Do ....
		C	46 0 12	As above...	62 to 61	...... Do ......Do ....
I	Bois banni	D	103 3 8	Underwood spare, surmounted by standards forming an open canopied mass of large trees.	72 to 66	...... Do ......Do ....
		E	50 0 32	Old copse, oak and beech, with numerous standards	57 to 56	Thinnings and Regeneration Fellings.
		F	82 2 8	Old copse, beech, hornbeam & oak, no standards	60 to 58	.... Do ....
		G	85 0 24	As above	55 to 53	.... Do ....
		H	105 2 36	Copse of mixed species, with numerous standards	21 to 19	Cleanings in accordance with special proposals, then decennial Thinnings.
II	Blinottes	I	31 3 20	As above	18	................Do ....
		R	97 3 8	As above	17 to 15	................Do ....
		L	69 0 16	As above	11 to 10	................Do ....
		M	117 0 24	Copse of hardwood species, with fairly numerous standards	9 to 6	................Do ....
	Morhaye	N	105 3 0	As above	4 to 3	................Do ....

EXPLOITATIONS TO BE MADE DURING THE FIRST PERIOD FROM 1817 TO 1910.
(*Continued.*)

Block.	Cantons.	Compart-ments.	Area. A. R. P.	Description of standing crop.	Age 1871.	Treatment required.
III	La Voivre	O	61 2 36	Compound copse, with fairly numerous standards	40 to 38	Compound Coppice Fellings; Thinnings 10 years before exploitation
		P	36 0 36	As above	34	................Do ....
		Q	30 3 0	As above	32	................Do ....
		R	21 2 12	Copse of alder, with a few oak standards...	28	................Do ....
	Bois des Cailloux	S	100 1 0	Copse of beech and oak, with a few standards...	14 to 12	................Do ....
		T	73 0 32	As above	12	................Do ....
		U	41 3 32	... ... Do	10	................Do ....
		V	80 0 24	... ... Do	5 & 4	................Do ....
		X	76 0 12	... ... Do	4 & 3	................Do ....
IV	Feigne basse	Y	106 3 0	Compound copse, hornbeam, oak, and birch...	37 to 33	Compound Coppice Fellings; Thinning 10 years before exploitation.
		Z	40 2 12	Simple copse of birch, alder and oak.	33 to 32	................Do ....
		A.A.	72 2 32	Compound copse containing glades and blanks	31 to 29	................Do ....
	Mare-au-Chêne	A.B.	82 1 8	Copse of hornbeam and oak, with a few standards	27 to 26	................Do ....
		A.C.	42 3 20	As above	24	................Do ....
		A.D.	64 0 0	... ... Do	23 to 20	................Do ....
		A.E.	101 0 16	... ... Do	2 & 1	................Do ....
	Total......		2043-1-4			

YIELD OF THE CUTTINGS BASED ON AREA.

Year of exploitation.	Regeneration Fellings. First Block. Compartments.	Areas. A.	R.	P.	Thinnings. First and Second Blocks. Compartments.	Areas. A.	R.	P.	Thinnings. Third and Fourth Blocks. Compartments.	Areas. A.	R.	P.	Compound Coppice Fellings. Third Block. Compartments.	Areas. A.	R.	P.	Compound Coppice Fellings. Fourth Block. Compartments.	Areas. A.	R.	P.
1871	A	22	2	8	F	27	2	0	Q	31	1	0	O	22	2	28	......	......		
1872	A	22	2	8	F	27	2	4	A A	36	1	16	O	22	2	28	......	......		
1873	A	22	2	12	F	27	2	4	A A	36	1	16	O	22	2	28	......	......		
1874	A	22	2	12	E	25	0	16	R	21	2	12	......	......			Y	26	2	25
1875	D	25	3	32	E	25	0	16	A B	27	2	4	......	......			Y	26	2	25
1876	D	25	3	32	G	28	1	19	A B	27	2	4	......	......			Y	26	2	32
1877	D	25	3	32	G	28	1	19	A B	27	2	8	......	......			Y	26	2	32
1878	D	25	3	32	G	28	1	24	A C	21	1	28	P	36	0	36	......	......		
1879	B	27	3	12	H	52	3	16	A C	21	1	32	......	......			Z	20	1	4
1880	B	27	3	12	H	52	3	20	A D	32	0	0	......	......			Z	20	1	28
1881	C	23	0	4	I	31	3	20	A D	32	0	0	Q	31	1	0	......	......		
1882	C	23	0	8	K	48	1	24	S	25	0	8	......	......			A A	36	1	16
1883	F	27	2	0	K	48	1	24	S	25	0	8	......	......			A A	36	1	16
1884	F	27	2	4	L	69	0	16	S	25	0	8	R	21	2	12	......	......		
1885	F	27	2	4	M	58	2	12	S	25	0	12	......	......			A B	27	2	4
1886	E	25	0	16	M	58	2	12	T	24	1	24	......	......			A B	27	2	4
1887	E	25	0	16	N	52	3	20	T	24	1	24	......	......			A B	27	2	8
1888	G	28	1	19	N	52	3	20	T	24	1	24	......	......			A C	21	1	28
1889	G	28	1	19	H	52	3	16	U	20	3	36	......	......			A C	21	1	32
1890	G	28	1	24	H	52	3	20	U	20	3	36	......	......			A D	32	1	0

Remarks.

The Primary Fellings that will have to be made a second time, and the Cleanings and other cuttings based on area which have not been provided for in this table, will form the subject of special proposals appended to the regular annual working proposals.

The Secondary Fellings will go through the compartments under regeneration, as far as possible, in the same order as the Primary Fellings. The enumeration and valuation of the trees to fall in these Fellings, i. e., trees and poles 4 inches and upwards in diameter, gave in 1871 the following figures.

YIELD OF THE CUTTINGS BASED ON AREA.
(Continued)

Year of exploitation.	Regeneration Fellings. First Block. Compartments.	Regeneration Fellings. First Block. Areas. A. R. P.	Thinnings. First and Second Blocks. Compartments.	Thinnings. First and Second Blocks. Areas. A. R. P.	Thinnings. Third and Fourth Blocks. Compartments.	Thinnings. Third and Fourth Blocks. Areas. A. R. P.	Compound Coppice Fellings. Third Block. Compartments.	Compound Coppice Fellings. Third Block. Areas. A. R. P.	Compound Coppice Fellings. Fourth Block. Compartments.	Compound Coppice Fellings. Fourth Block. Areas. A. R. P.	Remarks.
1891	......	....	I	31 3 20	V	26 2 32	......	....	A D	32 0 0	A..............217 cubic feet
1892	......	....	K	43 1 24	V	26 3 4	S	25 0 8	....	....	B..............135 ....
1893	......	....	K	48 1 24	V	26 3 4	S	25 0 8	....	....	C..............144 ....
1894	......	....	L	69 0 16	Y	25 1 16	S	25 0 12	....	....	D..............354 ....
1895	......	....	M	53 2 12	X	25 1 16	S	25 0 12	....	....	E..............153 ....
1896	......	....	M	53 2 12	X	25 1 20	T	24 1 24	....	....	F..............193 ....
1897	......	....	N	52 3 20	A E	25 1 12	T	24 1 24	....	....	G..............179 ....
1898	......	....	N	52 3 20	A E	25 1 12	T	24 1 24	....	....	
1899	......	....	H *	62 3 16	A E	25 1 16	U	20 3 36	....	....	Total ....1,375 cubic feet.
1900	......	....	H *	52 2 20	A E	25 1 16	U	20 3 36	....	....	Deduct ¼ for the reserve ......344 cubic feet.
1901	......	....	I *	31 3 20	O	22 2 23	V	26 2 32	....	....	
1902	......	....	K	48 1 24	O	22 2 28	V	26 3 4	....	....	Balance ....1,031 cubic feet.
1903	......	....	K	48 1 24	O	22 2 23	V	26 3 4	....	....	
1904	......	....	L	69 0 16	Y	26 2 25	X	25 1 16	....	....	
1905	......	....	M	39 0 8	Y	23 2 25	X	25 1 16	....	....	* The coupes marked thus will bear Final Thinnings.
1906	......	....	M	39 0 8	Y	26 2 32	X	25 1 20	....	....	
1907	......	....	M	39 0 8	Y	26 2 32	......	....	A E	25 1 12	
1908	......	....	N	35 1 0	Y	25 0 36	......	....	A E	25 1 12	
1909	......	....	N	35 1 0	Z	20 1 4	......	....	A E	25 1 16	
1910	......	....	N	35 1 0	Z	20 1 8	......	....	A E	25 1 16	

A study of the preceding tables, with the operations prescribed therein, and of the state of the various standing crops will bring out the following leading points :—

(a) The First Block, covered with very old coppice crops preserved now for 40 years, some of them poor, others rich in formed trees, but all completely fertile, will be subjected to Primary Fellings during the first 20 years of the Period; there thus remain 20 years in which to obtain the regeneration of the portions reached last of all by these Fellings. These Fellings, which ought to be very lightly made, are not expected to yield any considerable quantity of principal produce. Instead of being regulated by volume, a procedure which would lead to the whole Block being worked through in a very short time, or would have for necessary result the untimely felling of the standards, they must be located on the basis of area. The advantages of this are (i) that they can thereby be spread over a convenient number of years, and (ii) that the Executive Forest Officers are given the complete latitude necessary for operating with all due care and foresight. The Secondary Fellings will remove a fairly large quantity of produce, about 3000 cubic feet per acre, and will be made in accordance with the varying requirements of the seedlings. With respect to them also full latitude is left to the Executive Officers within the limits compatible with the management of the forest by the Department itself.

The whole of the Second Block, as well as the compartments of the First Block to be regenerated last, will be subjected to Decennial Preparatory Cuttings as soon as the coppice crops they contain reach the age of 30 years. Arranged so as to form a simple and continuous succession of annual operations, these cuttings will help to gradually bring the Second Block into as favorable a condition for regeneration as the First Block actually is. The Thinnings to be made at the end of the Period in compartments H and I, which will stand first for regeneration during the Second Period, have been characterised as Final Thinnings. The result of these Thinnings will be the appearance of seedlings, which will probably enable the Executive Establishment to begin the Secondary Fellings from the very commencement of the Period, and to at once and for ever afterwards employ the volumetric method of working out the yield.

The coppice crops of the Third and Fourth Blocks can be cut as compound copse only once during the entire course of the First Period; but, by reason of the actual distribution of the age-classes, these two Blocks will be worked thus in alternate years, so that at the end of the following Period it will be possible to continue the series of Compound Coppice Fellings in the Fourth Block alone. Indeed, the crops in question will be felled only between the ages of 36 and 42 years, so that they will necessarily yield a very large quantity of produce. Moreover, the preceding tables prescribe a thinning of the underwood in these crops 10 years before they are finally felled. The advanced age fixed for their exploitation and this preliminary Thinning will contribute to modify in the most happy manner the constitution of these crops as regards their component species, while a judicious selection of Standards will endow them with numerous well-grown trees.

The maintenance of the yield at a sufficiently high figure during the Second Period may be reasonably counted upon. The reservation of promising trees in the First Block, the constitution and age of the crops in the Second Block, the abundance of useful material in the compound coppice crops composing the Fourth Block, and the reserved fourth of the total volumetric yield, a portion of which can always be drawn upon, will be a sure guarantee of this.

CHAPTER II.

CULTURAL OPERATIONS IN CONVERSIONS.

It is especially easy to study, plan out, and establish the organisation of a forest with a view to its conversion ; in revenge, there is nothing which requires more care, foresight and *savoir faire* on the part of the officers charged with its execution. A few general observations, therefore, seem to be called for on this subject. Without them it will be impossible to understand thoroughly the conditions which underlie the drawing up, as well as the execution, of Organisation Projects for the conversion of copses into high forest.

In a copse containing within itself all the elements necessary for its conversion into high forest by means of self-sown seedlings, the cultural operations required for effecting its conversion consist as a rule of Preparatory Cuttings, of Regeneration Fellings, and of Compound Coppice exploitations. What are the points to be specially attended to in making these several fellings ? We proceed to answer this question below.

SECTION I.

The Preparatory Cuttings.

The object of the Preparatory Cuttings, as their name indicates, is to *prepare* the crops composing the Block concerned for conversion, that is to say, for natural reproduction by seed by means of the ordinary High Forest Regeneration Fellings. This preparation itself consists in letting the copse grow on until it becomes fertile, and in favouring its growth by means of judiciously executed Cleanings and Thinnings. It is especially these Thinnings that have received the designation of Preparatory Cuttings.

It is advisable to repeat them pretty frequently, say, every 10 or 12 years. As regards the manner in which they must be made, the main points to attend to are (i) to set free the crowns of the standards that are surrounded on every side by the underwood, (ii) to diminish gradually the proportion of the softwoods in the underwood by removing such individuals of those species as interfere with the development of poles of the hardwoods, and by thinning out some of these latter where they are growing too close together, and (iii), and lastly, to thin out the stool- clumps by extracting the weaker of the erect shoots, so as to strengthen the crowns of the rest. But every thing that helps in covering the soil, such as overtopped shoots, and even trailers, brushwood and bushes of every species, ought not to be removed except in the Last Thinning, viz., that which immediately precedes the Regeneration Fellings. All the standards without exception, which can prove useful in the regeneration, ought to be respected. It is chiefly, and one may say, even solely, on the standards that we have to rely for sowing the ground. Besides this we could not remove a large tree without breaking the leaf-canopy and thus encouraging the appearance of brushwood in the space now covered by the lofty crown of that tree. And more than this, to cut down any of the standards means to deprive the compound copse of its most effective elements of production.

The essential object of the Preparatory Cuttings is thus to secure general favorable growth and the development of trees of the hardwood species, primarily in the reserve and subsidiarily in the underwood. Their execution is at the same time difficult, and admits of no vacillation and timidity on the part of the operating forester.

SECTION II.

The Regeneration Fellings.

In conversion operations the Regeneration Fellings comprise Primary and Secondary Fellings.

The Primary Felling can be made the more effectively, the more numerous the standards are. Considering the circumstances in which those trees have grown, each one standing well away from the rest, and all possessing a spreading crown, it is obvious that none of them can be removed by this felling. Indeed, to obtain as much cover as is required after the Primary Felling has been made, there is no alternative but to preserve, besides all the standards, a goodly number of the poles of the underwood; for, otherwise the coupe would consist entirely of trees standing each one some distance from the next, the result being not such a Primary Coupe as is here required, with an all but complete leaf-canopy overhead, but a Compound Coppice Coupe, in which the exploited stools are sure to throw up shoots and the production of a pure seedling crop thus become a physical impossibility. The Primary Felling we require may hence be summarily described as follows:—Clearing the ground of all low bushy growth, extraction of all overtopped stool-shoots, lopping off of the low branches of poles, and sometimes even of formed trees, to raise their cover, and, lastly, the removal from the upper story of the leaf-canopy of trees possessing only a slight development of crown, these being selected one here, another there, and so on, so as to make small well-distributed lacunæ throughout the entire leaf-canopy. After such a felling, the soil ought to be quite clean and the view unobstructed, a characteristic which differentiates it from a well-executed Thinning; moreover, the circulation of the air should be unimpeded and the rays of the sun ought to reach the ground in small patches as if passed through a sieve. The seeds that fall from the trees above would then remain in a perfect state of preservation throughout the winter and germinate early enough in spring; while, thanks to the cover overhead, any oak and beech and even hornbeam seedlings that came up thus, would not only receive sufficient light to live on for years but also run no risk of being choked up by a rank crop of grass or by a strong regrowth from exploited stools. Such a Primary Felling (we may aptly term it a CANOPIED PRIMARY COUPE) can yield but a small outturn, and with respect to its execution it is both expedient and necessary to give complete latitude to the Executive Forest Officer, just as is done in the case of Thinnings. We thus see that the operation in question differs, and this in several respects, from the Dark Primary Felling, which finds its true place in a regularly constituted high forest. Here lies the very keystone of the whole conversion.

According to the prevailing climate the years of abundant seeding occur at longer or shorter intervals. Besides this, it is an established fact that every fall of acorns and beech mast, even the most abundant, frequently produces only a partial crop of seedlings. But the oak and the beech trees in a large forest bear no inconsiderable quantity of fruit almost every second year. The consequence is that in a Primary Coupe, that is not allowed to close up and form a complete leaf-canopy again, we find self-sown seedlings come up, at first few and far between, but increasing in number year after year, until they form a complete thicket. If then, after a few years, say, 5 or 6, the seedling crop has not produced itself with sufficient completeness, there ought to be no hesitation in restoring the state of the Primary Coupe, which must have by this time disappeared owing to the spreading out of the crowns of the standing trees. The operation which effects this consists in clearing the soil once more of brushwood and stool-growth, in cutting away poles bent down under their own weight, in pruning off all low epicorms, and, lastly, as the leaf-canopy is again complete, in opening it out here and there by the removal of some of the poles. After that one must have patience and wait.

But as soon as the soil is dotted over with seedlings of the principal species, it is necessary to begin a Secondary Felling. In the first of these Fellings the operation should be restricted simply to the bare isolation of the crowns of the trees or poles overhead. The reason for this is evident, for what is wanted is simply to open out the leaf-canopy sufficiently to enable seedlings already on the ground to maintain themselves and make their first effort of growth. Under the amount of cover thus produced, hornbeam seedlings are sure to come up, if they have not already done so ; and, besides this, stool-shoots and suckers, if any appear at all, will possess but little vigour, while it will be impossible for the softwoods and the birch to invade and get the upper hand of everything else. Hence the expediency of repeating the Secondary Felling from time to time, and of keeping down stool-regrowth by cutting back at least the more injurious shoots. Under this treatment the young forest of oak and hornbeam, or of beech, oak, and hornbeam, according to the prevailing soil, will form itself under the most favorable conditions, and this even if the oak plants in it are scattered, or are as much as 10 feet apart, provided always that the proportion of the associated species is large enough.

To these various positive justificatory reasons for acting gradually and with moderation in the execution of the Secondary Fellings, we will add that there is no advantage in operating in any other way, that is to say, in completing this class of fellings in one or two operations instead of in three or four. By adhering to the rule we have just been enjoining, the risks which a crop of young seedlings is exposed to, are obviated, the young seed-grown forest is advantageously composed of all the species spontaneous in the locality, and the merely apparent backwardness of the young seedlings is largely compensated for by the development of the trees composing the reserve.

As regards the Final Felling, it ought not to be undertaken until the new self-sown crop is of sufficient height to be beyond the reach of early frosts, so fatal to young oak and beech. And, indeed, to say the truth, the reserved oak trees that must be maintained until then, and which are still in more or less full growth, render an early Final Felling unnecessary. The oaks which may have been preserved at the previous coppice exploitations, because they were full of promise, should also be left untouched in the Conversion Fellings above the seedling growth below, which is necessarily less valuable than standards of no matter what class. To fell these trees, while they are still in full growth, would mean the increasing impoverishment of the forest in proportion as the conversion drew nearer to its conclusion, a result deplorable in itself and one that would belie the very object of the conversion itself. If conversions necessarily involved the premature extraction of trees in full growth standing in the compound coppice crops to be converted, there could not be the shadow of a doubt that it would be better to give up at once all idea of effecting the conversion.

Hence in conversion operations the Final Felling should be entirely restricted to the removal of the last coppice poles spared in the previous Regeneration Fellings. But hand in hand with this, it may be found expedient to execute another work of no little importance. In spite of all the possible care and foresight that may have been displayed in making the Regeneration Fellings, it seldom happens that the seed-grown portion of the young crop is not interfered with, or even overtopped, by abundant stool-shoots. To cut back these latter once for all is the best means of assuring the good growth of the former. But this must be done at the right time, viz., when the stool-shoots are on the point of spreading out laterally to meet their crowns and before they have reached the sapling stage, that is to say, as a rule, simultaneously with the extraction of the last poles of the original coppice crops. After such an operation, the new shoots that grow up from the stools cut back, being 10, 12 or 15 years behind their seed-grown neighbours, quickly fill up the interstices in the leaf-canopy left between these latter, and, where they are exposed enough overhead, catch them up in a few years, but this time without any longer being able to harm them before the First Thinning, which finally removes them, falls due.

In high forests already constituted as such, all the Regeneration Fellings are established volumetrically; this cannot, of course, be done in copses under conversion. In the latter case the Primary Fellings are naturally not required to furnish anything better than produce insignificant both as regards quantity and quality. It is, therefore, better to establish them by area, and to subject them to the condition that they shall pass through all the crops to be regenerated in a certain limited time, say, the first 12 or 15 years of the current Period. Hence it is only the Secondary Fellings that can be based on volume, and their yield is accordingly determined by dividing the total contents of the trees to fall in the crops undergoing regeneration by the number of years to run from the commencement of these fellings to the end of that Period. It is, of course, unnecessary to take into account the small coppice poles, some of which must fall in the Primary Felling; these will, on the whole, be a sort of set-off against the trees left standing in the last Secondary Felling.

SECTION III.

THE COMPOUND COPPICE FELLINGS.

The Compound Coppice Fellings to be made, while the Preparatory Cuttings and regeneration operations are in progress in other parts of the Working Circle, ought to be located on the basis of area and ought to be subjected to a long Rotation. The crops to be exploited as compound copse will, according as they belong to the Second, Third, Fourth or Fifth Blocks, be worked in this manner once, twice, thrice or four times before being put under the preparatory treatment for conversion and finally under direct conversion itself. It is hence necessary to direct the treatment and working of these crops in view of the final object, viz, their regeneration by seed, and consequently to get together in them, by the beginning of the Period fixed for their conversion, a reserve numerous enough to form that required in a Primary Coupe.

Hence it seems only natural that we should adopt a special set of rules for the Selection of the Standards in these exploitations. The further a crop is from the Period fixed for its regeneration, the less necessary is it to reserve in it large trees. This being so, the Aménagiste, in organising the conversion of a forest, might consider himself justified in prescribing or authorizing the fall of the standards of the second and higher classes in the Coppice exploitations made in the last Blocks, a procedure that would throw into the yield of the First Period produce at least as considerable as the total outturn of all the Coppice crops composing the newly organised Working Circle before its conversion was taken in hand. Such a step would be greatly to be deplored. Its result would be, that, during the preparation of the coppice crops for conversion, the material to reserve in the coppice exploitations would be less than what would be conformable with the general prescriptions of the Royal Edict promulgated for the working of the Forest Code. Now it is always tantamount to robbing the State and, therefore, the nation at large, to fell unexploitable timber, which has acquired neither its full sum of utility nor its highest money value. And more than this, by felling in the First Period not only all exploitable trees but also others which can become exploitable only during the following Periods, the Aménagiste would at one stroke, at the very beginning of his work, get rid of produce, which he would require afterwards in order to have some stock to fall back upon in order to preserve the necessary equilibrium between the yields of the various Periods, or, at least, to attenuate the difference between the yields of the First and last Periods.

In our own opinion the best rule to follow in selecting the standards and executing these Compound Coppice Fellings is that prescribed by Section 70 of the Royal Edict of 1827.

CHAPTER III.

A Sustained Yield in Conversion Organisations.

The question of a Sustained Yield in conversion organisations can be considered from two widely different points of view. The first is offered by the comparison of the outturn of the original crops and that of the forest organised for conversion. The second is to be found in the comparison of the outturns of produce to realize during the various Periods of the High Forest Rotation.

To take the case of any forest whatsoever, before its conversion was undertaken, that is to say, during the last Coppice Rotation that preceded the conversion, the revenue yielded by the forest was obviously derived partly from the sale of the large trees exploited. If the revenue furnished by the forest under the Coppice Régime was exaggerated by the exploitation of a large number of such trees, the effect thereof on the forest would have been its impoverishment. If, on the contrary, the selection of the standards was made in a liberal spirit, the former rate of outturn could only have been on a restricted scale. Here then we see an element altogether extraneous to the comparison to be made, and yet one which may have had the effect of causing the rate of outturn of the last years of the coppice exploitation to differ very materially from the figure of the mean anuual production.

However it be, the copse in question does, of course, contain some material. And further more, we expect the seed-grown forest, which is to take its place, to contain a known quantity and quality of stock, which must not only be more abundant but also more valuable than the existing material of the Copse. Hence, as we have before said, the only way to obtain this surplus over and above the actual capital represented by the standing copse, is to lay by, in the form of savings, a part of the annual production. As in all other financial undertakings, so in forest management, capital can be increased only by savings from income. Hence, as a general rule, and provided the compound copse does not contain any extraordinary number of standards, the revenue must necessarily for a time fall off as a consequence of conversion operations being undertaken. This falling off will be the less appreciable, the longer the Rotation is on which the copse to the converted has been hitherto exploited, and the greater the number of standards it contains. This being so, it is easy to understand the great utility of a long period of preparation. Thanks to it, the Rotation for the crops still to be exploited as copse can be lengthened if necessary, and the crops themselves enriched with a numerous reserve; while the maintenance and unchecked growth up to maturity of the underwood and formed trees included in the Block under preparation is the first step towards the realization of the savings put by in obedience to the exigencies of the conversion. Here is a resource not less valuable than the elements of certain regeneration itself.

The falling off in the revenue will be all the less appreciable, the greater the number of years over which the period of diminished receipts is spread, and actually this period is equal to the whole length of the new High Forest Rotation. In the majority of cases we see in this one reason the more, and that a powerful one, for avoiding all hurry in effecting a conversion, and for taking the full time necessary for the production of a complete seed-grown forest. The art of the Aménagiste offers him no other means of mitigating the difficulties inherent in the work of conversion; whatever help can be derived from a proper system of culture is always remote in its results.

There is often reason to fear wide fluctuations in the yield of a forest under conversion during the various successive Periods of the Rotation. For instance, if after comparatively productive exploitations during the First Period there ensued a sudden falling off in the yield, this *contretemps* might mean the ruin of the whole undertaking after it had been in hand for 30 or 40 years. The Organisation Project should provide against such a contingency.

The establishment of a Reserve Fund offers the first means to this end. It is clear that during the Preparatory Period no attention need be paid to this matter, for during its course savings are *ipso facto* hoarded up in the First Block, in which all that can be preserved is preserved, and often even in the coppice crops, the exploitation of which falls due at a more or less distant date. But during the following Period (the First Period, that is, of the conversion), the necessary provision has to be made by the establishment of a Reserve Fund, just as is done, as we have already seen, in the organisation of already constituted high forest. For the annual increment neglected in the estimation of the yield a full or partial compensation will be found in the promising oaks reserved at the exploitations, which trees will not, as a rule, be felled for a half century at least. It is, therefore, absolutely necessary, in establishing a Reserve Fund, to draw upon the actual stock.

If, moreover, during this same Period the large trees of the last Blocks are preserved in the coppice exploitations, if, in fine, the Second Block has been well provided for by the Organisation Project, and worked accordingly with a sparing hand, it is evident that the increasing richness of the forest will cover any threatened deficit. The same economical spirit observed in each and every exploitation, and the addition, whenever necessary and as they become available, of a few individuals from among the trees left standing in the Secondary Fellings will never fail to secure a sustained yield during the subsequent Periods.

We may, therefore, take it for granted that with the close of the Preparatory Period the essential basis of the conversion has been achieved, and that during the First Period of the actual conversion a decisive step has been made in a definite path clear of all difficulties and obstacles. Provided the cultural operations have been well executed and a spirit of economy has presided throughout the organisation as well as the treatment of the forest, the improvements realized will be found to be already extensive, and the success of the undertaking fully assured. An entire Block covered with a young seed-grown forest, another portion of equal extent well stocked with exploitable timber, and, lastly, the rest of the forest modified in the happiest manner by two coppice exploitations, that have left in it a numerous reserve of long-boled hardwood trees —such are the results accomplished. The stock and production of the forest have already undergone a complete transformation, and the elements for a successful conversion multiplied to the highest degree desired.

The results in the contrary case would be very different indeed. Conversion operations undertaken in crops insufficiently prepared for them, reproduction by seed compromised by the less or more unimpeded growth of shoots from the stool (due to the untimely exploitation of formed trees in the various exploitations), a material falling off in the yield manifesting itself from the very beginning of the Second Period, such are the manner and circumstances in which the work would be done; thus undertaken, the conversion of the forest would be all but impossible, and compound coppice crops would gradually be transformed into simple copses.

Time as well as economy is an element of the first necessity in conversions. And when the forest to be converted contains no large mass of compound copse sufficiently well constituted, both as regards the underwood and the reserve, to form, after a Preparatory Period, a convenient First Block, it would be wise to postpone the conversion. Coppice exploitations on a long Rotation and a judicious selection of standards would not be long in bringing about a better state of things.[1] Then again the adoption of a long High Forest Rotation has for immediate result the lessening of all existing difficulties. It restricts the area to be converted and the quantity of produce to be extracted during a given time; it affords the best guarantee that none but exploitable timber shall be cut during as well as after the conversion; it assures, of necessity, a sustained yield from the very beginning of the Second Period; it allows of the formation of a numerous reserve of well-grown trees in the coppice exploitations of the last Blocks; and, finally, it modifies in a favorable manner the standing stock by means of gradual improvements, without which a successful conversion would often be impossible. Regarded in the light of these observations, the conversion of a forest is unquestionably a work *de longue haleine*, requiring the aid of several

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1 It seems superfluous to insist once more on the results of a good selection of standards. In complete conformity with the prescriptions of the Royal Edict of 1827, it assures the progressive improvement of the coppice crops; in certain cases it may suffice to bring about the high forest state itself; it is obligatory, and the wealth it stores up is not savings clipped out of income. And yet, in the majority of cases, it is all that can be done in the interests of the future. The analysis of a Compound Coppice Felling given in the Appendix shows clearly how the results of a selection of standards can be appreciated in all its bearings.

generations of men. It is sometimes possible to attain the desired result in a shorter time, but then without that same degree of certainty. To enlist time on one's side in creating the seed-grown forest means to have all the natural forces in one's favour ; to run against time is to run counter to them.

Already we have in France some well-conceived Organisation Projects for the conversion of certain forests, which are in course of execution in a manner that leaves nothing to be desired. Thus, in the Department of the Ardennes, there is the State forest of Signy-l'Abbaye, which contains 7125 acres. Situated on an excellent forest soil formed of Oxford Clay, in which the silicious element is considerable, it is stocked chiefly with hornbean, the softwoods, and birch and oak. Trees of this latter species, rising up as standards above the underwood, attain a diameter of 40 inches in from 150 to 200 years. But, in consequence of the great fertility of the soil, the oak had already begun to disappear from this fine forest, which was then worked as Compound Copse on a Rotation of 25 years. Certain prescriptive rights, moreover, prevented Improvement Cuttings, that is Cleanings and Thinnings, from being made. The true remedy was a return to the High Forest Régime. Its conversion, ordered by Government, was organised, at the same time that the prescriptive rights referred to were commuted by transferring a portion of the forest in full proprietorship to the persons exercising those rights, and it has been in hand since 1868.

The forest was found to be naturally divided into 3 regions ; hence three High Forest Working Circles of about 2400 acres each. The Rotation adopted is one of 180 years. This is the space of time judged necessary to obtain from regular high forest growth trees 30 inches in diameter, and it is supposed to represent the probable longevity of canopied crops of oak. The Rotation has been divided into 5 Periods of 36 years each, that interval being considered long enough for obtaining the complete regeneration by selfsown seedlings of a whole Block. Each Working Circle is thus divided into 5 Blocks, which will be successively brought under conversion operations in their respective turns.

The broad lines of work being thus laid down, it was necessary to do nothing but what was certain to yield the desired results.

The only way to accomplish this was to make the most of the existing crops, and even to improve the composition and production of those constituted as compound copse. Accordingly, the Organisation Project prescribes a Preparatory Period of 36 years during which the following work is ordered for each Working Circle:—

(i) Strict conservation of the crops forming the First Block. This Block will thus find itself stocked in 30 years with an old copse aged from 61 years to 36 years at the least, well drawn up in height, well provided with standards, almost as well adapted for regeneration by seed as if they were real high forest crops, and in a position to yield at once a large quantity of valuable produce. During the whole Period the only operations to make in this Block are Thinnings every 12 years, Cleanings on a small scale, and the removal of trees that happen to decay.

(ii) The exploitation as compound copse every year of one-thirty-sixth of the area of the four remaining Blocks. The effect of this rule will be that the crops worked as copse will, for the first few years indeed, be felled when they are only 25 years old or not much older; but year by year they will naturally be of increasing age, until from the last year of the Period, a future far from remote, none will be cut that is not at least 36 years of age. The resulting advantages will be the realisation of produce of far higher value than if the Coppice Rotation were fixed at only 25 years, and a happy change in the condition of the standing stock. The unqualified reservation of all promising oaks and the execution of well-directed Improvement Cuttings will increase the proportion of that species in the copse and ameliorate the composition of the various crops in the highest degree possible.

Such are the essential provisions of this Organisation Project They place every thing at once on a certain basis, and will bear scrutiny from every point of view. Our immediate successors will receive the forest from us admirably prepared for conversion and, to speak absolutely, in a much better condition than it is in at the present day. Now it is poorly stocked; then, *i. e.* from the very beginning of the next century, it will be richly endowed with every element that goes to the making of a fine forest. But these excellent results cannot be obtained without keeping down the quantity to be worked out annually. The Aménagistes, whose work the Organisation Project is, have been guided throughout by the necessary spirit of economy. In former times, before the stock of standards was exhausted in the last century by the Benedictine proprietors of the forest, the exploitations yielded £9,400 annually. Now they will yield only £6,000 for the first few years; but this figure will go on increasing from year to year, from Period to Period, for the next two centuries, if the present respect for growing stock is perpetuated. The state of things was such that there was no choice left except between certain ruin on the one hand and uncompromising, but eventually fruitful, economy on the other. The Aménagistes chose without hesitation the better part. It is by work such as the organisation of this forest that our Department covers itself with honour, just as it is by labour and frugality that a nation amasses its wealth.

CONCLUSION.

Every tree, whether isolated or forming part of a canopied group, is a living entity possessing an individual existence. Its species, condition, age, habit, situation, and countless other details combine, to make it a tree different from all others.

The object to demand from forest trees being in a special manner the wood which they produce, the Forester's duty is obviously so to place promising trees, as to enable them to acquire the most desirable form, dimensions and qualities. At the commencement of their existence and during their early years, we can exercise a marked influence over the form of trees, either by growing them in complete isolation or in continuous leaf-canopy, or by removing some of their branches, or even by straightening them or, on the contrary, bending them to any shape we please. But once they become formed trees or reach the age of complete fertility, they possess a distinct form and habit of their own, which cannot be changed without ruining them. If the trees in question have grown up in complete freedom, with a full and unhampered crown, they must retain their large branches, or they will languish, contract unsoundness and blemishes, and be doomed to premature decay. Should they, on the contrary, have grown up in the midst of a full leaf-canopy, tall and lanky, they could not be isolated without running the greatest risks as respects their boles, their crowns and their root apparatus. The form they have actually assumed is here again their own, and it is beyond human power to alter it without destroying their vigour and soundness.

The action of the forester on the formed tree, a vegetable entity endowed with its own peculiar constitution and temperament, ought to be limited simply to placing it under the most favourable conditions for developing itself and acquiring its highest qualities, while maintaining it always in a sound state. This action may be exercised on the crown, the bole, and the roots—on the crown, by giving it the room in space and the amount of light it requires; on the bole, by protecting it by means of the neighbouring trees or the surrounding underwood; on the soil, by maintaining, by means of the same trees or underwood, cover overhead and shelter from the heat of the sun's rays, its covering of organic detritus, and a spontaneous growth of species adapted to the locality. Then again, in producing a change of condition, it is often possible to effect the transition with caution and judgment, so as to minimize its concomitant evil effects and thus obviate the deterioration and decay of the tree. But when we have said so much, we have said all, and in maintaining any tree under conditions favorable to its longevity, its growth, and the quality of its timber, we may be said to have done to it all the good of which we are capable. Only these conditions are not the same for one species as for another, and they differ also for one and the same species with the state of the individual tree and its surrounding circumstances, so that the task of the sylviculturist too varies with every tree that he has to deal with.

The work of organisation also is necessarily varied according to the forest concerned. All points of difference have, therefore to be noted and indicated, after the general rules applicable have been laid down. Every forest offers a real and living individuality. It differs from every other forest by its situation, its soil and component crops, by its area, the outline of the cantons which compose it, by the roads which intersect it, by the estates which surround it, and by the conditions under which it is at the time growing. There are no two forests, any more than two towns, exactly alike, and it would be a great mistake to suppose that the organisation of forests adjoining each other or situated in the same region can be built up on the same framework or pattern. The Amenagiste, if he laboured under so erroneous an impression would lack the very fundamental idea that should guide him, and instead of adapting himself to circumstances, would vainly endeavour to force circumstances to suit his silly imaginings.

A good Organisation Project ought to take into full account all the available resources of the forest concerned that constitute its actual value, of the existing factors of production on which its future value depends, of the distribution of the age classes on the ground, of its internal and external export lines, of all noteworthy facts peculiar to it that combine to distinguish it from all other forests. These facts must first of all be recognised, then the irrelative importance estimated, and the various special conditions resulting therefrom and influencing the organisation of the forest, combined and co-ordinated in the most advantageous manner; in the next place, what is accessory and contingent should be subordinated to what is principal and necessary; and, lastly, every point of detail should be taken into account to the desirable extent and all useful improvements foreseen, arranged for and accomplished as far as possible. This done, the result will be an Organisation Project well suited to the given forest, and, as a consequence, suited to that forest alone and to no other. Hence, however small and simply constituted that forest may be, its organisation will always be a complicated and difficult work.

It may be effected in a thousand different ways, each of these thousand ways being a more or less good one. Without going so far as to seek the very best one of these thousand possible solutions of the problem before us, we ought at least to avoid acting and deciding questions without any definite aim, and trusting everything to mere chance, as we would, for instance, do if we were to divide a high forest into 4 equal Blocks by means of two straight lines intersecting one another at right angles, or a copse into 25 coupes by means of perfectly parallel lines; if, in a word, we acted as if we had nothing more to do than trace out a few lines on a piece of blank paper, instead of being obliged to guide ourselves by what we find on the ground.

Suppose, to take an instance, there was a small wood of 250 acres, situated on level ground and composed of coppice crops from 1 to 20 yards old. What could be more simple than this forest, one would ask, and what difficulties could its organisation present? Well then let us take for granted that the essential points in this individual case are identical with those peculiar to the whole region in general in which this forest is situated. Let us also admit, for the sake of argument, that this wood ought to be treated as a compound copse, that the Rotation to adopt should be one of 30 years, and that the annual cuttings should pass over equal areas. But granting all this, is it not a fact, firstly, that the trees that are to be grown above the underwood are already represented by more or less numerous standards all short in the bole, and that this circumstance must be looked to and the present state of things modified, either by means of Thinnings or otherwise, when the age of exploitation is raised from 20 to 30 years? Then again, we have to enquire whether this raising of the age of exploitation to 30 years must be effected gradually, by beginning at once to fell one-thirtieth of the area every year, or whether the forest ought to be left untouched for the next 10 years, until the age of the oldest crop reaches 30 years, or whether any other plan ought to be adopted? Lastly, the question remains to be answered whether it is better to have 30 annual coupes of 8 acres, 1 rood, and 13 poles each, or only 15 biennial coupes of 16 acres, 2 roods and 27 poles each, or any other arrangement of coupes? Each of these three questions may be answered in several ways, but of these several answers only a comparatively small number will be found to suit the case of the forest in question.

The next thing to do is to divide off the forest into coupes and to open out bridle-paths and roads, following the configuration of the ground. Either there are existing roads sufficient for the purpose required, or new ones have to be made to suit the shape of the forest and to provide the necessary outlet for its produce. In the same manner one or more new bridle-paths forming division lines, straight or zigzagging as the case may be, may be required. All such other paths ought to be laid out with reference to the roads and to the form of the perimeter of the various cantons; it is not always advantageous to align them perpendicularly to the boundary-paths or parallel to each other. It may be found expedient to make the coupes more or less wide, and preferable to cut the boundary-paths in continuous straight lines instead of resorting to curves and sharp zigzags on the plea of making the areas of the coupes as equal as possible. Then again it might be desirable to let certain paths abut at an angle or on a foot-path. To insist once more on this subject, we cannot repeat it too often that roads and paths cannot be laid out without some intelligent plan, or only with the aid of a rough map: due attention must always be paid to the shape of the forest and the topographical features, to the most convenient lines for export, and to other peculiarities presented by the locality. Often indeed it is easy and also advisable to lay out the net-work of roads and paths in such a manner as to be an ornament to the forest and to facilitate inspection.

If, when we have simply a small plains forest to deal with, we have to reckon with so many facts of a special nature, what must it be, if, and this even in the slightest degree, the ground is undulating, the age classes mixed up, and the crops varied? The organisation of a forest, like every other question of a professional character, is thus always a complicated, difficult, and important operation, for the Aménagiste has to adapt it to the forest in question, to the locality in which his work lies and on which after the lapse of a few years his Organisation Project must leave a faithful impression of itself.

A danger to be avoided in work like this is preconceived ideas and foregone conclusions. After what we have just said, it is easy to understand that the idea one forms, in advance or from a distance, of any forest never corresponds to the reality, and that a personal knowledge of it is absolutely necessary for drawing up or for carrying out any project for its organisation. To guard oneself completely against all chance and uncertainty, one must moreover be intimately acquainted with the conditions prevailing outside the forest, and even with the manners and customs of the surrounding population. These facts, although external to the forest itself, exercise for good or for evil a powerful and lasting influence on it, and their disregard by the Aménagiste or the Executive Forest Officer may frequently sooner or later render the Organisation Project impracticable.

Foregone conclusions and stereotyped ideas may lead to further dangers. At the end of the last century the greater number of the compound copses belonging to the Communes of Eastern France were worked on a Rotation of 25 years. This rule of 25 years was adopted with the most uncompromising rigour whether it suited the forest in question or not. Whether the, copse was composed of oak, of hornbeam, of beech, of hazel, of alder, or of birch, whether the soil on which it was situated was rich or poor, moist or dry, deep or superficial, it was exploited at the age of 25 years. It is obvious that, however well this Rotation suited some forests, there were many others for which it proved disastrous; and it is quite possible that it is responsible, together with other causes of course, for the rarity of oak in so many of our Compound Copses. Every rigid system, refusing to yield to the varying requirements of different forests and localities, must be equally vicious; and more than this, it must infallibly result in its slaves overlooking some important facts and indispensable conditions.

Indeed, it is this very danger of carrying into effect preconceived opinions that justifies us in warning the Aménagiste against seeking any perfect solution of the problems before him, the realization of some impossible ideal, and in advising him to confine himself to doing his best to obtain the results required and no more. If imbued with this spirit, he knows the forest he is dealing with, if, moreover, he is careful to conform to the essential rules of forest organisation, and allows himself to be guided by the true principles of sylviculture by endeavouring to obtain from well-constituted crops and promising trees only such products as the soil can yield, he will scarcely ever fail to draw up good Organisation Projects.

APPENDIX.

Grazing in Forests.

In certain districts the organisation of a forest must take into account the grazing rights or privileges exercised there. In the broad-leaved forests of our plains, where wood is a valuable commodity and agriculture is in an advanced state, these rights and privileges are, as a rule, either too restricted to require any attention, or do not exist at all; the advanced farmer and stock-breeder there would care little for such a wretched way of feeding his cattle. Thus it is in the conifer forests of our mountain districts that forest grazing is chiefly resorted to.

Before every thing else it is necessary here to distinguish for grazing purposes the ovine class of animals, that is, sheep and goats, from the bovine and equine classes, viz., cows, bulls, horses, mares, asses, and mules. The grazing of the first class of animals is the most fruitful cause of the destruction of our mountain forests; and Sections 78 and 110 of the Forest Code accordingly prohibit it in a complete manner in forests managed by the State. Some exceptions, however, are made in favour of sheep alone, but they are all the more to be deplored for the reason that the grazing of sheep in forests yields smaller returns than even the slender profits derived from the similar grazing of cows. The area required to feed one cow is sufficient for only 5 sheep, whereas the money value of the 5 sheep is only one-third that of the single cow. Thus in the Alps the aggregate price of the former would be only 16 shillings, while the latter, even if only a small animal, would fetch 48 shillings. It is, therefore, a question of urgency, both in the interests of private individuals and of the community at large, to suppress the grazing of sheep in our forests. To think of maintaining it and providing against unnecessary damage to the forest by means of special restrictions would be futile, for mountain forests on the one hand and sheep on the other are two totally incompatible things.

The grazing of cows, profitless in forests of silver fir, in which grass can grow only in the blanks, is never of much value in pine forests, the soil of which is always unfertile and dry. It is always in the open forests formed by larch that rich pasture is found

But in any case the number of cattle allowed therein must be limited in proportion to the area; and in order to prevent the soil from being caked, beaten hard by the hoofs of the animals, and rendered bare of low vegetation, and to guard against the trees themselves being attacked after the grass has been completely browsed down, it must be made a rule never to let in more than one cow for every $2\frac{1}{2}$ acres in those portions of a forest, in which the standing crop has grown up out of the reach of cattle and is composed of stems sufficiently thick to resist being bent down. This precautionary measure must be adopted both in the interests of the cattle and of the forests.

No forest crop is safe against cattle until it has reached the pole stage. In other words, cattle may not be admitted into a high forest before it is at least 40 years old. And more than this, cantons stocked with old timber ought also to be closed against grazing, say 10 years before they are felled. This precaution is necessary to enable the soil to regain its original freeness and thus become fit for the reception of seed. Hence the Rotation for forests, in which grazing is permitted, ought to be long. Allowing 50 years for each canton to be kept closed, that is, closed against cattle, it would remain open for grazing for only 50 years during a Rotation of 100 years, 100 years during a Rotation of 150 years, and 150 years during a Rotation of 200 years, the portion of the forest kept open for grazing being respectively one half, two-thirds and three-fourths.

What we have said with reference to high forests applies, it will be perceived, also to those copses, in which, as an exceptional measure, grazing is permitted. It is not only during the first 10, 12 or 15 years of the life of the underwood that cattle must be kept out at all hazards, but also during the last 3, 4 or 5 years immediately preceding its exploitation. If this rule were neglected, seedlings of the valuable species would have no chance of coming up and the forest would go on steadily deteriorating. Closing any portion of a forest against grazing can only be effective, if that portion has proper boundaries, such as ravines, ditches, walls or any other kind of fence. Hence it is very necessary in those high forests in which grazing is allowed, to form the Blocks each in one piece, and to enclose them with good boundaries In the absence of natural boundary lines difficult for cattle to get over, the Organisation Project ought to provide for the making of ditches, walls, or earthworks. These precautions are equally necessary in forests, themselves closed against grazing, but adjoining others in which that privilege is exercised.

Blanks, or such portions of a forest as are in a bad state, cannot be re-stocked or restored as long as they are kept open to grazing. Indeed, grazing is in most cases itself the cause of the existence of blanks, and nothing can be worse for a forest than to allow men and cattle the free run of it. It is, therefore, necessary to close, in a permanent manner, against both man and beast, such cantons as have naturally become blank or are placed under unfavorable conditions for close forest growth, where, for instance, the slopes are abrupt, where hard rock crops up in every part, where the elevation is great, &c. To close such places could mean no loss to the grazier.

Cattle cannot be allowed into forests worked by Selection, for in such forests every canton may be said to be continually under regeneration, and all the age-classes are necessarily mixed up in the most confused manner. Here is an unanswerable reason for abandoning the Selection System for the Natural Method, whenever that is practicable, in forests in which grazing cannot be stopped. When this change is impracticable, there is only one course left open, viz. to divide the forest into two portions, abandoning one, containing of course, the best soils, completely to the grazier, and reserving the other for treatment by Selection, free for ever of all rights and protected by means of good boundaries. With any other arrangement the forest is bound to disappear.

The creation and maintenance of what we may term *grazing forests*, the salvation of the Alps, requires the same precautionary measures as those described for timber forests, viz., effective closing, by means of ravines chosen as boundaries, or of fencing and earthworks, during a sufficiently long period; the substitution of cows for sheep; restriction of the number of head of cattle admitted; and, lastly, temporary rest for the soil and herbage from time to time.

Forest Fires.

The pineta of the Landes and the forests of the Maures and Esterel are constantly ravaged by that plague—FIRE. In organising those forests, whether with a view to the production of resin or of cork, the first care of all should be to suggest efficacious measures for their protection against fire. The leaf-canopy in those forests being never complete, the soil is always more or less covered with brushwood, and the pine trees, gorged with resin, are constantly dropping on it highly inflammable matter. It is with the brushwood and the pine trees that the fires originate, and it is, therefore, with them that we must begin, if we wish to keep them out.

Everywhere in France the means adopted for protection against fire and for preventing it from spreading consists of fire-paths or shelter trenches cut through the forest at regular distances, and in keeping the soil clear of brushwood. Indeed, these measures constitute the only effective procedure for preventing and checking forest conflagrations. But the paths, although absolutely necessary to facilitate the circulation of the establishment and to form protective lines, are by themselves insufficient to check the progress of fire; while as regards the clearing away of the brushwood, that operation necessitates an outlay and an amount of labour which are altogether prohibitory in the vast areas we have to deal with; and besides this, the removal of the brushwood is unfavorable to the growth of the forest itself. But it is always possible to combine the two systems, in the right proportion, by employing a limited network of protective paths and partial clearing of the brushwood, and taking the further precaution of planting belts of trees which lend themselves less than the pine to the kindling and progress of fire.

The method of procedure in each case must depend on the character of the district and forest concerned, on the means at one's disposal, and on the object sought. Thus the private owner of a small forest can keep the entire length of its boundary clear of bushes over a considerable width, and even go so far as to extend the clearing to the whole area of the forest. But when it comes to protecting vast surfaces, the first of those two methods is not effective enough, while the second ceases to be practicable.

In the wooded dunes belonging to the State, the forests, consisting of the Cluster Pine, are intersected by two series of parallel protective paths cleared one kilometre (about $\frac{5}{8}$ mile) a part and cutting one another at right angles, thus forming squares of about 250 acres each. This system is to be commended, since it is easy to clear and keep free of dead leaves a path of from 17 to 20 feet wide, which is constantly used by the establishment and others, and thus kept in a well-beaten state. It is no less easy to remove from along the boundary also all heather bushes over a width of from 130 to 170 feet, a width which will, as a rule, be found amply sufficient. But as the pines are continually dropping and strewing the soil with their dead needles, the best aliment the fire can have, and feeding the conflagrations, once these have begun, with large pieces of bark full of resin and light enough to be carried in a blazing state by the wind over great distances, every pine tree ought to be removed from this protective zone. Only instead of letting it remain bare, it is much better in every respect to raise on it a belt of the peduncled oak. This is effected by planting out young seedlings of that species under the pines, so thinned out as to form a sort of Primary Felling for the oak. As these latter grow up, the pines should be gradually cleared away until only a belt of pure oak remains. When this work is complete, the pinetum will be found divided off into squares by bands of high forest of oak, which occupy in the aggregate about a tenth of the whole area. Under these open belts of oak, with the soil kept free from brushwood and the protection-paths along its middle maintained perfectly clear like regular avenues, fire can make but little progress, the work of protection is thereby rendered easy, and the regular establishment of guards and labourers will in most cases be found quite sufficient to carry it out successfully.

The protective measures, which we have just described, seem to us to be all that can possibly be adopted at the present day in the *dunes* and in the similarly wooded *landes* of Gascony. Later on, if the population in the Landes increases and cultivation extends, it will be possible to separate the various forest cantons from each other by means of lines of fields, themselves dotted over with large oak. In any case, the penduncled oak, which is indigenous and grows well in that district, ought to form a valuable element of those forests: We cannot continue to neglect its cultivation except at the risk of extensive injuries and heavy loss.

In the Maures and Esterel the conditions as regards soil and l imate are of an entirely different character, and the cork oak is the most important and abundant of the broad leaved denizens of the forest. There roads and paths, without which access to and inspection of the forests would be impossible, and their management, as it were, get out of hand altogether, could not be run in straight lines or be cleared at equal distances apart. They must before everything else, be laid out in accordance with the lie of the ground and be given just sufficient width (say, from 7 to 10 feet for carts, and only 3 feet for men on foot), so as to admit of a large number of them being made. But, as before, the sides of these roads and foot-paths should be cleared of brushwood over an aggregate breadth of from 130 to 170 feet. Within these belts all ling and other bushes, offering easy access to fire must be rooted out; arbutus, lentisks and other shrubs with broad fleshy leaves, which cover the soil and do not become dry and combustible, should be preserved. Pines growing on these belts should be felled to enable cork oaks, whether self-sown or artificially introduced, to push up, so as to destroy all connection for the spread of fire between adjacent insulated blocks of the forest. Often the protective belts may even be planted up with the sweet chestnut, the thick foliage of which keeps the soil moist and kills out all low vegetation. Such canopied belts of chestnut would present an impassable barrier to the progress of fire, provided that at the end of every winter the soil was swept clear, at least partially, of the dead leaves covering it.

We thus see that the same method of fire protection as before is applicable here, with differences only of practical detail. It is of a more complex character in the Maures, modifications being necessary in going from one slope to an adjacent one; but its essential characteristic of being based on the establishment of roads, tracks and paths in accordance with the nature of the soil and topography always remains unchanged. Thus the economical construction of this network of export and communication lines, which are as indispensable for creating a market for the produce of those forests as for protecting them, constitutes the most important question involved in their organisation. But protection against fire is at the same time a necessary condition imposed by Sylviculture, which art here again as elsewhere cannot be dissociated from its sister and handmaid, the Organisation of Forests.

ANALYSIS

OF

Coupe No. 8, Communal Forest of Velaine-sous-Amance

to be exploited in 1876.

Area 5a. 0r. 34p; age 52 years.

Estimated quantity and net value of stock to be removed.

TIMBER (OAK).

DIAMETER in inches.	NUMBER of trees.	AGGREGATE length.	CONTENTS in cubic feet per running foot.	CONTENTS in cubic feet.	TOTAL contents in cubic feet.	RATE s. d.	NET value. £	s.	d.
6	46	613	0·156	96	96	0 4¼	1	14	0
8	46	920	0·278	256					
10	9	180	0·432	78	451	0 5¾	10	16	1¼
12	8	187	0·625	117					
14	7	187	0·839	159					
16	7	187	1·096	208	493	0 11½	23	12	5½
18	3	90	1·388	126					
20	2	60	1·736	104	104	1 2½	6	3	6
22	0	0	2·101	0	0				
24	0	0	2·500	0	0				
26	1	30	2·932	88	88	1 5¼	6	10	2
					1,232		48	16	2¾

FIREWOOD.

The Standards.	£	s.	d.
980 stacked cubic feet of oak @ 20 s. per 100 c. ft.	9	16	0
210 „ „ „ „ hornbeam @ 33s. per 100 c. ft.	3	9	3
Total	13	5	3
Total estimated net value of standards	62	1	5¾

The Underwood.			
735 stacked cubic feet of hardwoods @ 26 s. per 100 c. ft.	9	11	1¼
735 „ „ „ „ softwoods „ 20 s. „ „ „ „	7	7	0
2,500 faggots @ 20 s. per 100	25	0	0
Estimated net value of underwood ...	41	18	1¼
Total estimated net value of all produce	103	19	7
Hence estimated net receipts per acre	19	19	1½

Estimated quantity and net value of stock to be reserved.

TIMBER.

First Class Standards.	£	s.	d.
79 oak @ 3 d	0	19	9
84 other species @ 3 d	1	1	0

Second Class Standards.

96 oak, average contents 7 c. ft., total 672 c. ft. @ $6\frac{3}{4}$ d	18	18	0
5 other species average contents 7 c. ft., total 35 c. ft. $1\frac{1}{2}$ d.	0	4	$4\frac{1}{2}$

Third Class Standards.

DIAMETER in inches.	NUMBER of trees.	AGGREGATE length.	CONTENTS in cubic feet per running foot.	CONTENTS in cubic feet.	TOTAL contents in cubic feet.	RATE. s.	RATE. d.	NET value. £	s.	d.
14	20	533	0·839	447						
16	6	160	1·096	175	1,122	0	$11\frac{1}{2}$	53	15	3
18	12	366	1·388	500						
20	6	180	1·736	312						
22	1	30	2·101	63	375	1	$2\frac{1}{4}$	22	5	$3\frac{3}{4}$
					1,497			76	0	$6\frac{3}{4}$

FIREWOOD.

1,960 stacked cubic feet @ 20 s. per 100 c. ft. ..	19	12	0
Total estimated net value of stock reserved ...	116	15	$8\frac{1}{4}$
i. e. per acre	22	8	$3\frac{3}{4}$

ESTIMATED NET VALUE OF ENTIRE STOCK IN 1878.

Value of prod··ce to be removed ...	103	19	7
„ „ stock „ reserved ...	116	15	$8\frac{1}{4}$
Total ...	220	15	$3\frac{1}{4}$
Value per acre	42	7	$5\frac{1}{2}$

Probable value of the coupe 25 years hence, *i. e.* in 1903.

The standards of the first class, about 10 per cent. of which die on being isolated at the exploitation of the coppice, scarcely attain a diameter of 8 inches by the end of the second rotation. But the standards of the second and higher classes put on average diametral increment of 6 inches during each Rotation of 25 years. The trees now reserved will, therefore, be worth as follows in 1903 :—

Second Class Standards.

	£	s.	d.
71 oaks of 8 inches diameter, average contents 3½ c. ft., total 248½ c. ft. @ 5¾ d.	5	19	1¼
76 other species, average csntents 9 stacked cubic feet, total 684 c. ft. @ 33 s. per 100	11	5	8¾

Third Class Standards.

96 oaks of 16 in. diameter, average contents 21 c. ft., total 2,016 c. ft. @ 11½ d	96	12	0
5 others, average contents 35 stacked cubic feet, total 175 c. ft. @ 33 s. per 100	2	17	7

Veterans (Timber).

Diameter in inches.	Number of trees.	Aggregate length.	Contents in cubic feet per running foot.	Contents in cubic feet.	Total contents in cubic feet.	Rate s.	Rate d.	Net value £	Net value s.	Net value d.
20	20	533	1·736	925						
22	6	160	2·101	336	2,161	1	3¾	141	16	3¾
24	12	360	2·500	900						
26	6	210	2·932	616	718	1	6½	55	6	11
28	1	30	3·403	102						
					2,879			197	3	2¾

Veterans (Firewood).

4,620 stacked cubic feet @ 20 s. per 100 ... ... 46 4 0

The underwood.

Half the value of the present underwood 20 19 0½

Estimated total net value per acre in 1903 ... 381 0 8¼

Estimated net value per acre in 1903... 73 2 8¼

It is easy to deduce from the above figures the total increment added during the rotation from 1879 to 1903. Expressed in money it is £ 381 0s. 8¼d.—£ 116 15s. 8¼d.=£ 264 5s; *i. e.* £ 50 14s. 4¾d. per acre for the whole rotation, or very nearly £ 2 0s. 6d. per acre per annum. Expressed in cubic feet the increment per acre per annum is as follows :—

Oak timber ...	...	... 22	c. ft. approximately
Fuel from standards ...		... 17	„ „ „
Fuel from underwood ...		... 12	„ „ „
	Total	... 51	

Again the figures of the preceding exploitation of 1853 are available, and reference to them will show that whereas only 10 standards having a girth of 14 inches and upwards were probably left in that year, 45 are to be spared in 1878, and as the net value of these trees alone will have increased by as much as £ 200, it is in their reservation that we must recognise the chief merit of the coppice proposals for 1878.

The preceding analysis, which is only a skeleton of what such analyses should be, suffices to show how we may interrogate the future of any coupe or crop and correctly forecast from a financial point of view the probable results that may follow from a given operation.

TABLE FOR COMPUTING PRESENT VALUE OF A PERPETUAL INCOME.

On page 104 the formula

$$C = \frac{R}{(1+i)^n - 1}$$

was explained. In the following table are given the value of the expression $\frac{1}{(1+i)^n - 1}$ for different values of i and n. Hence to find out what capital will produce a given periodically recurring income we have only to multiply the amount of that income by the coefficient taken from this table and corresponding to the rate of compound interest and the number of years in the period in question.

Number of years in the period.	RATE OF COMPOUND INTEREST PER CENT.				
	3	3½	4	4½	5
1	33·3333	28·5714	25·0000	22·2222	20·0000
2	16·4204	14·0400	12·2549	10·8666	9·7561
3	10·7843	9·1981	8·0087	7·0838	6·3442
4	7·9666	6·7786	5·8872	5·1943	4·6402
5	6·2785	5·3280	4·6157	4·0620	3·6195
6	5·1532	4·3619	3·3862	3·3084	2·9403
7	4·3502	3·6727	3·1652	2·7711	2·4564
8	3·7485	3·1565	2·7132	2·3691	2·0944
9	3·2811	2·7556	2·3623	2·0572	1·8138
10	2·9077	2·4355	2·0823	1·8084	1·5901
11	2·6026	2·1740	1·8537	1 6055	1·4078
12	2 3515	1·9567	1·6638	1·4370	1·2565
13	2·1343	1·7732	1·5036	1·2950	1·1291
14	1·9509	1·6163	1·3667	1·1738	1·0205
15	1·7922	1·4807	1·2485	1·0692	0·9268
16	1·6537	1·3624	1·1455	0·9781	0·8454
17	1·5318	1·2584	1·0550	0·8982	0·7740
18	1·4236	1·1662	0·9748	0·8275	0·7109
19	1·3271	1·0840	0·9035	0·7646	0·6549
20	1·2405	1·0103	0·8395	0·7084	0·6048

Number of years in the period.	Rate of compound interest per cent.				
	3	3½	4	4½	5
21	1·1624	0·9439	0·7820	0·6578	0·5599
22	1·0916	0·8838	0·7300	0·6121	0·5194
23	1·0271	0·8291	0·6827	0·5707	0·4827
24	0·9682	0·7792	0 6397	0 5330	0·4495
25	0·9143	0·7335	0·6003	0·4986	0·4190
26	0·8646	0·6916	0·5642	0·4671	0·3913
27	0·8188	0·6529	0·5310	0·4382	0·3658
28	0·7764	0·6172	0·5003	0·4116	0·3424
29	0 7371	0·5841	0·4720	0·3870	0·3209
30	0·7006	0·5535	0·4457	0·3642	0·3010
31	0·6666	0·5250	0·4214	0·3432	0 2826
32	0·6349	0·4983	0·3987	0·3236	0·2656
33	0·6052	0 4735	0·3776	0·3054	0·2498
34	0·5774	0 4503	0·3579	0·2885	0·2351
35	0·5513	0·4285	0·3394	0·2727	0·2214
36	0·5268	0·4081	0·3222	0·2579	0·2087
37	0·5037	0·3889	0 3060	0·2441	0·1968
38	0·4820	0·3709	0·2915	0·2311	0·1857
39	0·4615	0·3539	0 2765	0 2191	0·1753
40	0·4421	0·3379	0·2631	0·2076	0·1656
41	0 4237	0·3228	0·2504	0·1969	0·1564
42	0 4064	0·3085	0 2385	0·1869	0·1479
43	0·3899	0·2950	0 2272	0·1774	0·1399
44	0 3743	0·2822	0·2166	0·1685	0·1323
45	0·3595	0·2701	0·2066	0·1600	0·1252
46	0·3454	0·2586	0·1970	0·1521	0 1186
47	0·3320	0·2477	0·1880	0·1446	0·1123
48	0·3193	0·2373	0·1795	0·1375	0·1064
49	0·3071	0·2275	0·1714	0·1308	0·1008
50	0·2956	0·2181	0·1637	0·1245	0·0955
51	0·2845	0 2092	0·1565	0·1185	0·0902
52	0·2739	0·2007	0·1495	0·1128	0·0859
53	0·2638	0·1926	0·1430	0·1074	0·0815
54	0·2542	0·1849	0·1352	0·1023	0·0773
55	0·2450	0·1775	0·1308	0·0[illegible]75	0 07[illegible]3

Number of years in the period.	Rate of compound interest per cent.				
	3	3½	4	4½	5
56	0·2361	0·1705	0·1251	0·0929	0·0696
57	0·2277	0·1638	0·1197	0 0885	0·0661
58	0·2196	0·1574	0·1146	0·0844	0·0627
59	0·2119	0·1512	0·1097	0·0805	0·0596
60	0·2044	0·1454	0·1050	0·0768	0·0566
61	0·1973	0·1398	0·1005	0·0732	0·0537
62	0·1900	0·1344	0·0964	0·0698	0·0510
63	0·1839	0·1293	0·0923	0·0666	0 0485
64	0·1776	0·1244	0·0884	0·0636	0·0461
65	0·1715	0·1197	0·0847	0·0607	0·0438
66	0·1657	0·1151	0·0812	0·0579	0·0416
67	0·1601	0 1108	0·0779	0·0553	0·0395
68	0·1547	0·1067	0·0746	0·0528	0·0376
69	0·1495	0·1027	0·0716	0·0504	0·0357
70	0·1445	0·0989	0·0686	0·0481	0·0340
71	0·1397	0·0952	0 0658	0·0459	0·0323
72	0·1351	0·0917	0·0631	0·0439	0·0307
73	0·1307	0·0883	0·0605	0·0419	0·0292
74	0·1264	0·0851	0·0581	0·0400	0·0278
75	0·1223	0·0820	0·0557	0·0382	0·0264
76	0·1183	0·0790	0·0535	0·0365	0·0251
77	0·1144	0·0761	0·0513	0·0349	0 0239
78	0·1107	0·0733	0·0492	0·0333	0·0227
79	0 1072	0·0707	0·0472	0·0319	0·0216
80	0·1037	0·0681	0·0453	0·0305	0·0206
81	0·1004	0·0657	0·0435	0·0291	0·0196
82	0·0972	0·0633	0·0418	0·0278	0·0186
83	0·0941	0·0610	0·0401	0·0266	0·0177
84	0·0911	0·0589	0·0385	0·0254	0·0169
85	0 0882	0·0568	0·0370	0·0243	0·0167
86	0·0854	0·0547	0·0355	0·0232	0·0153
87	0·0827	0 0528	0·0341	0·0222	0·0145
[illegible]	[illegible]	[illegible]0509	0·0327	0·0212	0·0138
[illegible]	0·07[illegible]	[illegible]0491	0·0314	0·0203	0·0132
[illegible]	0·0[illegible]	[illegible]474	0·0302	0·0194	0·0125

Number of years in the period.	Rate of compound interest per cent.				
	3	3½	4	4½	5
91	0·0728	0·0457	0·0290	0·0185	0·0119
92	0·0706	0·0441	0·0278	0·0177	0·0114
93	0·0684	0·0425	0·0267	0·0170	0·0108
94	0·0662	0·0410	0·0256	0·0162	0·0103
95	0·0642	0·0396	0·0247	0·0155	0·0098
96	0·0622	0·0382	0·0237	0·0148	0·0093
97	0·0603	0·0368	0·0228	0·0142	0·0089
98	0·0584	0·0356	0·0219	0·0136	0·0084
99	0·0566	0·0343	0·0210	0·0130	0·0080
100	0·0549	0·0331	0·0202	0·0124	0·0077
101	0·0532	0·0320	0·0194	0·0119	0·0073
102	0·0516	0·0308	0·0186	0·0113	0·0069
103	0·0500	0·0298	0·0179	0·0109	0·0066
104	0·0485	0·0287	0·0172	0·0104	0·0063
105	0·0470	0·0277	0·0165	0·0099	0·0060
106	0·0456	0·0268	0·0159	0·0095	0·0057
107	0·0442	0·0258	0·0152	0·0091	0·0054
108	0·0428	0·0249	0·0147	0·0087	0·0052
109	0·0415	0·0241	0·0141	0·0083	0·0049
110	0·0403	0·0232	0·0136	0·0079	0·0047
111	0·0391	0·0224	0·0130	0·0076	0·0045
112	0·0379	0·0217	0·0125	0·0073	0·0042
113	0·0367	0·0209	0·0120	0·0070	0·0040
114	0·0356	0·0202	0·0116	0·0067	0·0038
115	0·0346	0·0195	0·0111	0·0064	0·0037
116	0·0335	0·0188	0·0107	0·0061	0·0035
117	0·0325	0·0182	0·0103	0·0058	0·0033
118	0·0315	0·0176	0·0099	0·0056	0·0032
119	0·0306	0·0170	0·0095	0·0053	0·0030
120	0·0297	0·0164	0·0091	0·0051	0·0029
121	0·0288	0·0158	0·0088	0·0049	0·0027
122	0·0279	0·0153	0·0084	0·0047	0·0026
123	0·0271	0·0147	0·0081	0·0045	0·0025
124	0·0263	0·0142	0·0078	0·0043	0·0024
125	0·0255	0·0139	0·0075	0·0041	0·0022

Number of years in the period.	Rate of compound interest per cent.				
	3	3½	4	4½	5
126	0·0248	0·0133	0·0072	0·0039	0·0021
127	0·0240	0·0128	0·0069	0·0037	0·0020
128	0·0233	0·0124	0·0066	0·0036	0·0019
129	0·0226	0·0120	0·0064	0·0034	0·0018
130	0·0219	0·0116	0·0061	0·0033	0·0018
131	0·0212	0·0112	0·0059	0·0031	0·0017
132	0·0206	0·0108	0·0057	0·0030	0·0016
133	0·0200	0·0104	0·0055	0·0029	0·0015
134	0·0194	0·0100	0·0052	0·0027	0·0014
135	0·0188	0·0097	0·0050	0·0026	0·0014
136	0·0183	0·0094	0·0048	0·0025	0·0013
137	0·0177	0·0091	0·0047	0·0024	0·0012
138	0·0172	0·0087	0·0045	0·0023	0·0012
139	0·0167	0·0084	0·0043	0·0022	0·0011
140	0·0162	0·0082	0·0041	0·0021	0·0011
141	0·0157	0·0079	0·0040	0·0020	0·0010
142	0·0153	0·0076	0·0038	0·0019	0·0010
143	0·0148	0·0074	0·0037	0·0018	0·0009
144	0·0144	0·0071	0·0035	0·0018	0·0009
145	0·0139	0·0069	0·0034	0·0017	0·0008
146	0·0135	0·0066	0·0033	0·0016	0·0008
147	0·0131	0·0064	0·0031	0·0015	0·0008
148	0·0127	0·0062	0·0030	0·0015	0·0007
149	0·0124	0·0060	0·0029	0·0014	0·0007
150	0·0120	0·0058	0·0028	0·0014	0·0007