F. de Liocourt

De l'amenagement des sapinières

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On the amelioration of fir forests

English translation 2001 by Maria Nygren
Technical review by Pekka Nygren and David R. Larsen
The School of Natural Resources
University of Missouri-Columbia

This paper is our translation of the original French text. We have made some modifications to improve the readability and understanding of the ideas that we believe are in the original text. We comment on these modifications in the Notes at the end of the paper.

Excluding some forests that cannot be treated otherwise than by restricted silviculture[1], because of their steep slope, their altitude or other particular circumstances, and some particular woods which, considering their small area, are not subject to any regular management, the coniferous forest of fir and spruce are improved either according to the volume yield silviculture[2] or as normal forest[3].

That latter method, admitted as the principle that excludes any other, has been later abandoned in a large number of fir forests, and replaced by volume yield silviculture. The sharp turn in favor of this is emphasized every day.

The sharp turn is caused by the lack of exactitude of the normal forest improvement methods and the insufficiency of the results obtained, which is the inevitable consequence.

The idea of rotation time, admitted as the key issue of the improvement of the normal forest, is without any precision. It is difficult to know the exact age of a tree that has reached the targeted timber harvest dimensions; and, as we will see further, in a considerable number of young woods, only some trees reach the normal age, while all the others, in too large numbers to be considered as waste wood, are harvested for intermediary products.

The principle of equal volume in each timber harvest is not exact, because of differences in the soil fertility, which can only be corrected arbitrarily, by using the fertility coefficients. Besides, nothing proves that all age classes have to cover distinguished and rigorously equal areas, like we admit today. Let's assume that in forest amelioration a normal forest is formed during 150 years in periods of 50 years each. Theoretically, the stands[4] of 1 to 50 years should cover a third of the area; those of 50 to 100 another third, and those of 100 to 150 the last third. We conceive that in fact it may not be impossible that the populations were grouped as follows: on a half of the area, populations of 50 to 100 years old; on the other half, populations of 100 to 150 years, with an understory of the pre-existent seedlings of 1 to 50 years. The truth is without doubt not exactly as in this hypothesis, because of the canopy closure of most of the 100 to 150 year old populations, which would not let the young seedlings to emerge and develop in a convenient way in the understory; it is probably in between the two. In other words, without being able to state anything exact on the subject, in a normal high forest of three periods, the class of the old stands must normally cover an area bigger than a third of the forest holding, and consequently include a bigger volume than if it would cover only a third.

There is no precise rule to calculate the possibility for harvesting the intermediate products, which however is very important. We are restricted, in order to prevent a possible impoverishment of material, to methods the significance of which we do not know, such as the estimation of whole or partial stock of these intermediate products, but ignoring more or less completely their growth. The latter is much more difficult to know because the harvest time of the intermediate products is not determined.

All this result in, most of the time, an almost complete lack of realization of the amelioration predictions.

In the operations not included in the rotation, the stands remain very irregular, despite the often-considerable amount of material that has been harvested. The irregular state has persisted harvests determined by the rotation, excluding some absolutely regular populations, where the future, towards the age of 80 years, often seems compromized. We are more than once very surprised when we review the amelioration at the end of the first period, to notice that the material harvested, which should be approximately nil in volume, is so high, many times even higher than at the beginning of the period. This prompted a forester from the Vosges to say when he was showing the first timber harvest of a forest: "Here is the first harvest; it will always be the first harvest."

This irregularity in the regeneration operations is, besides, much more accentuated, when bigger areas are marked for harvesting a specified volume and when the period is longer, because the age differences in the young stands are higher, and the inequalities in size only become stronger with time.

In one word, in the fir forests managed as normal forest, the maintenance of the managed status has been the result of, if not generally but at least predominantly, the past operations.

Thus, the natural method has not has resulted in a well determined regular stand characteristics by which we pretended to distinguish it from silviculture, and it is not possible to say where the managed woodland[5] ends and the normal high forest starts. This latter must, in reality, be considered not as a distinguished method, but as a derivation, or if we want it, as a more perfect form of the former.

On the other hand, the situation of the fir forests, such as they are everywhere managed, is without doubt excellent. These forests are generally well stocked and present a very satisfactory condition; however, because that condition is eminently irregular, it is rational to give the name of silviculture for the management method that reigns in them; especially because in this method, such as it is actually applied almost everywhere, the operations are conducted absolutely as in the natural method, more or less intensively as desired and approaching the natural method if the circumstances so require. These operations include the regeneration and the liberation of the future stocks by thinning and cleaning, and by removal of the dead and dominated[6] wood.

But it is not enough that the practices are well done; a precise method for the calculation of the possibilities is necessary for securing sustained yields[7], which is one of the characteristics of the managed forest. Or, the procedures actually used for this calculation absolutely do not permit one to estimate if we are harvesting too much or too little from a forest. Until now when the fir forests were, for the most part, understocked, there were only advantages to gain when using conservative methods, such as the pre-estimation or total or partial underestimation of growth, were applied, while yield[8] calculations presented difficulties. In every amelioration review, the increasing yields were, and still mostly are, noticed; but these increases cannot renew themselves indefinitely. When the forests have reached, or at least are approaching, the maximum stocks that they can contain, a time will arrive, which may not be far away, when we will be inevitably exploiting too much material, after which the possibilities will abruptly go down for a longtime. It is a danger on which we could not emphasise too much.

Thus, it is important to apply to the yield calculation a method that permits harvesting, in a given forest, the normal material, to conserve it and, consequently, secure the sustained yields.

Let's emphasize, at the beginning, that the numerical data that we will find in this study are not exact. For that, a series of observations would have been necessary, but our time was too short. We are restricted to summarize some observations on a very limited number of subjects, with the only goal to show what could be drawn from these data once they were well determined by an in-depth study.

A managed normal forest must include, when fully stocked, all diameter classes; the smaller the diameter the larger the number of trees in this class. This results in natural mortality in each class[9].

In addition, the distribution so obtained must be extended to such a maximum diameter that the estimated capital, multiplied by the corresponding rate of replacement between classes, gives the maximum product. This principle of maximum revenue is undisputable for the state forests, because if the state disregarded it, it would dry up a part of the public revenues. The same reasoning is applicable to the counties, the wealth of which is dependent on the state's revenues.

We will go even further and say that it equally holds for private forests. In fact, if these are understocked[10] due to the choice of a too short rotation, it is always a part of the national soil that stays unproductive[11], and the public wealth is diminished.

It is reasoned that the private forest owners are generally interested in putting their capital to work at maximum rate; but, as their interest, when it is a question of forests, is opposed to the public interest, we do not have to deal with the rules that follow from the choice of short rotations. We just mention that the motive of the elevated replacement rate, which is claimed in this case, is often nothing else than a pretext for justifying the cashing of the capitals that the owners may need. Much has been written on this question; but it is our opinion that for those who want to eat their goods, it is not necessary to indicate how to do so.

We will first study what is the natural diameter distribution in a managed normal forest.

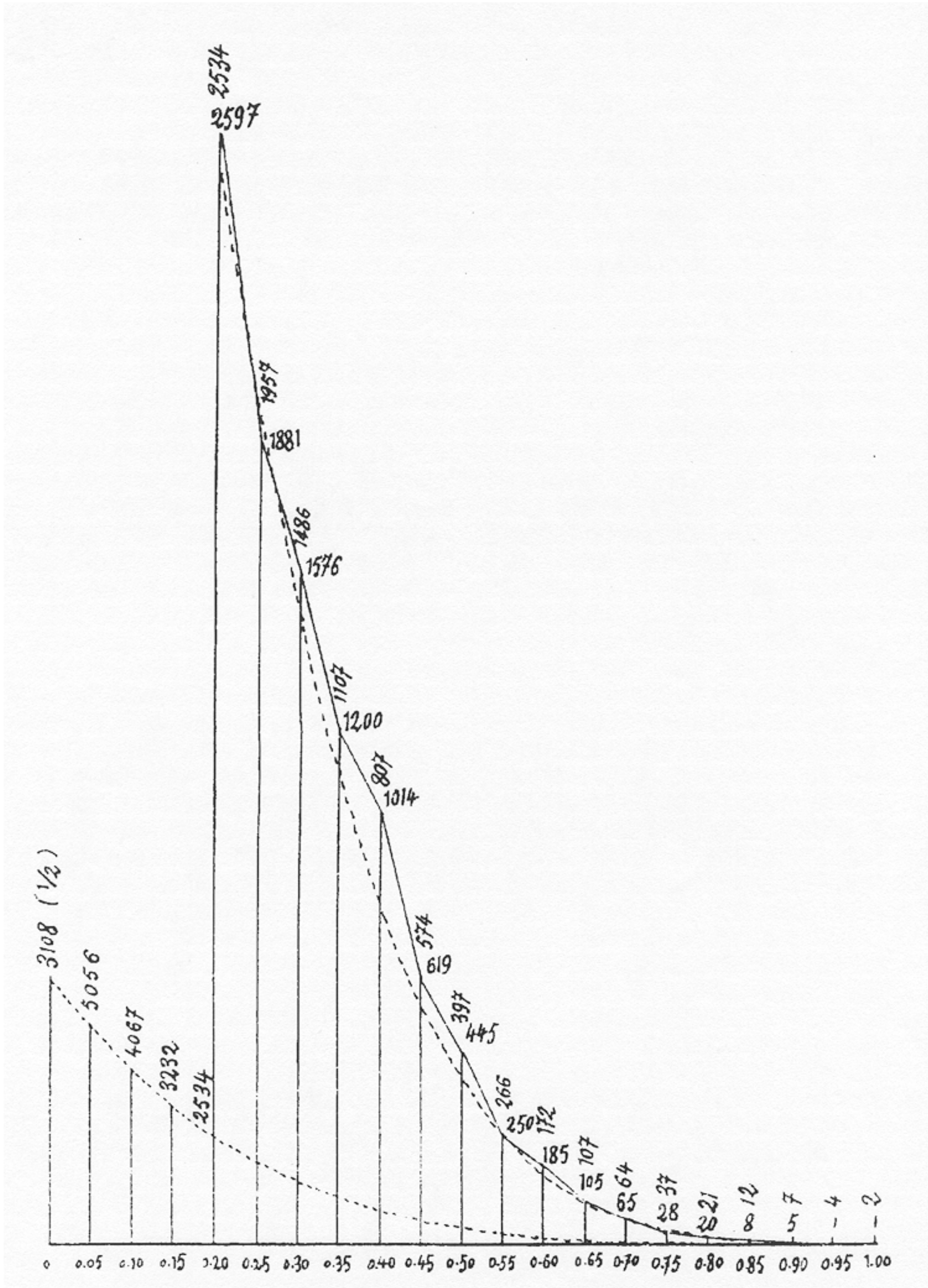
In the forests of Gérardmer, where our observations were made, as in all the fir forests under silvicultural management, the logging operations can be summarized in one word: they have the goal to carry as large number of the small trees as possible all the way to the most elevated dimensions, successively eliminating all those that die, are seriously depressed and which the silvicultural interest in general demands.

Without doubt, the fir forests have neither normal density nor normal diameter distribution as such as they are managed, because of the inaccuracy of the yield estimates, but at least they offer, due to the way of which the operations are conducted, enough reference points for deducting the natural and normal diameter distribution.

For determining the distribution, we have revealed the stem frequency distribution series for several forests where amelioration reviews have been carried out. These series have been normalized to the uniform number of 10,000, from the diameter of 0.20 m to the highest dimensions, as shown in the table below.

Diameter at 1.50 m	Corcieux	Lièzey	Vologne					Mean
			1st	2nd	3rd	4th	5th series	
0.20 m	2,500	3,220	2,783	2,570	2,748	2,181	2,176	2,597
0.25	1,988	1,554	2,053	1,973	1,992	1,955	1,655	1,881
0.30	1,572	1,486	1,510	1,559	1,494	1,605	1,810	1,576
0.35	1,179	1,148	936	1,156	1,162	1,416	1,406	1,200
0.40	1,125	1,062	925	1,098	868	987	1,035	1,014
0.45	590	574	545	585	640	686	712	619
0.50	463	446	414	390	426	471	502	445
0.55	251	197	258	201	267	283	291	250
0.60	174	161	231	197	177	169	188	185
0.65	91	57	141	112	106	116	109	105
0.70	45	42	106	81	60	61	60	65
0.75	9	25	43	27	30	33	29	28
0.80	10	16	36	26	18	20	15	20
0.85	1	8	11	10	7	9	7	8
0.90	2	4	5	9	4	5	3	5
0.95			1	3	1	2	1	1
1.00			2	3		1	1	1
	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Volume per hectare	354 m^3	363 m^3	348 m^3	318 m^3	339 m^3	412 m^3	375 m^3	

In order to not to complicate the figure, we have not represented the graphics on these counts in the table that follows. They differ very little from each other's and are often merged. We have only graphed, by a solid line, the mean of these counts. The corresponding numbers have been written horizontally.



This figure has let us to trace a dotted line, as whole little different from the first, as we notice, which can be considered to represent an approximation of the normal diameter distribution in a managed forest. The corresponding numbers have been marked vertically. This curve has been constructed on such a way that the differences between ordinates follow a uniformly decreasing gradient, as the following table shows. The same rule has been followed for the trees below 0.20 m, the minimum dimension for the stem frequency distribution series. The volume of these trees is insignificant and the estimation error committed cannot have any importance.

0 to 0.05	3,108 (1/2)					
		1,161				
0.05	5,056		172			
		989		18		
0.10	4,067		154		1	
		835		17		0
0.15	3,232		137		1	
		698		16		0
0.20	2,534		121		1	
		577		15		0
0.25	1,957		106		1	
		471		14		0
0.30	1,486		92		1	
		379		13		0
0.35	1,107		79		1	
		300		12		0
0.40	807		67		1	
		233		11		0
0.45	574		56		1	
		177		10		0
0.50	397		46		1	
		131		9		0
0.55	266		37		1	
		94		8		0
0.60	172		29		1	
		65		7		0
0.65	107		22		1	
		43		6		0
0.70	64		16		1	
		27		5		0
0.75	37		11		1	
		16		4		0
0.80	21		7		1	
		9		3		0
0.85	12		4		1	
		5		2		0
0.90	7		2		1	
		3		1		
0.95	4		1			
		2				
1.00	2					

This curve could be obtained much more simply and with a sufficient exactitude by just observing that it has a regular appearance deviating as little as possible from the solid line.

The dotted line in the bottom of the figure is nothing else than a reproduction of the one above reduced to one tenth for allowing the representation of the trees from 0 to 0.15 m, the ordinates of which would have passed the scale of the figure.

Without doubt, the curve obtained must present more or less pronounced variations according to the region and even according to individual forest stands, especially in the Vosges, where the stands have very unequal aspects, due to the different locations[12]. In the Jura region, where the fir forests are much more homogenous, the variations will certainly be much less pronounced and applicable to several stands[13].

Let's study now what is the maximum volume that should be found in one hectare that includes the complete age distribution, up to the largest dimensions, which cannot be considered to pass one meter of diameter.

The examination of several counting notebooks indicates that 500 m^3 ha^{-1} represents a completely closed stand, because it is never exceeded except in the stands where the old trees dominate and where the young trees are missing or are few in number.

It will be advisable to control or to rectify this number according to the observations made in adequately chosen experimental areas, where the stand is closed, has a sufficiently irregular aspect and includes trees of the largest dimensions.

For calculating the number of stems and the volume per hectare, we do not have to do anything but reduce proportionally to 500 m^3 ha^{-1}, the assumed control, the data in the dotted line, which must hold because it has been established after the counts conducted in forests of very different densities, varying from 300 to 400 m^3 ha^{-1}. This indicates that the age distribution is independent of the stand density, at least within our limits. Thus, we get the following numbers:

		Data on dotted line		Reduced value per hectare	
Diameter at 1.50 m [m]	Unit volume [m^3]	Stem count [n ha^{-1}]	Volume [m^3 ha^{-1}]	Stem count [n ha^{-1}]	Volume [m^3 ha^{-1}]
0 to 0.05	0.002	3,108	6	140	0
0.05	0.02	5,056	101	228	4
0.10	0.05	4,067	203	183	9
0.15	0.2	3,232	646	146	29
0.20	0.3	2,534	760	114	34
0.25	0.5	1,957	979	88	44
0.30	0.8	1,486	1,189	67	53
0.35	1.1	1,107	1,218	50	55
0.40	1.5	807	1,211	36	54
0.45	1.9	574	1,091	26	49
0.50	2.4	397	953	18	43
0.55	2.9	266	771	12	35
0.60	3.6	172	619	8	29
0.65	4.2	107	449	5	21
0.70	5.0	64	320	3	15
0.75	5.8	37	215	2	11
0.80	6.7	21	141	1	6
0.85	7.6	12	91		
0.90	8.6	7	60		
0.95	9.6	4	38		
1.00	10.7	2	21		
		25,017	11,082	1,128	500

If we now harvest annually on this hectare the annual increment, letting us be guided by the silvicultural needs only, the forest will remain constant in both volume and diameter distribution.

To know that increment, we will calculate the increment of each diameter class in the following way:

We will choose, in each diameter class, a certain number of logged trees, and we will determine the mean age corresponding to each of them.

For example, if a tree of 0.30 m class with volume of 0.8 m^3 is 60-years-old, and a tree of 0.35 m class with volume of 1.1 m^3 would be 70-years-old, a tree of 0.30 m class grows 0.3 m^3 in 10 years, or 0.03 m^3 in a year; thus, one cubic meter of the 0.30 m class grows in a year 0.03/0.8.

The very summarized and insufficiently exact experiments that we have done gives the result that

1 m^3 of the trees	from 0 to 0.05 m	grows in a year	0.20 m^3
	from 0.05 to 0.10		0.12 m^3
	from 0.10 to 0.15		0.10 m^3
	from 0.15 to 0.20		0.08 m^3
	from 0.20 to 0.25		0.06 m^3
	from 0.25 to 0.30		0.04 m^3
	from 0.30 to 0.35		0.03 m^3
	from 0.35 to 0.40		0.02 m^3
	from 0.40 to 0.45		0.018 m^3
	from 0.45 to 0.50		0.016 m^3
	from 0.50 to 0.55		0.016 m^3
	from 0.55 to 0.60		0.015 m^3
	from 0.60 to 0.65		0.014 m^3
	from 0.65 to 0.70		0.014 m^3
	from 0.70 to 0.75		0.014 m^3
	from 0.75 to 0.80		0.013 m^3
	from 0.80 to 0.85		0.013 m^3
	from 0.85 to 0.90		0.012 m^3
	from 0.90 to 0.95		0.012 m^3
	from 0.10 to 0.15		0.011 m^3
	over 1.00 m		0.011 m^3

It only remains, for calculating the yield, to multiply the stem count of each diameter class by the volume of the corresponding class and make the total.

$0 \times 0.20\ m^3 = 0.00\ m^3$
$4 \times 0.12\ m^3 = 0.48\ m^3$
$9 \times 0.10\ m^3 = 0.90\ m^3$
$29 \times 0.08\ m^3 = 2.32\ m^3$
$34 \times 0.06\ m^3 = 2.04\ m^3$
$44 \times 0.04\ m^3 = 1.76\ m^3$
$53 \times 0.03\ m^3 = 1.59\ m^3$
$55 \times 0.02\ m^3 = 1.10\ m^3$
$54 \times 0.018\ m^3 = 0.97\ m^3$
$49 \times 0.016\ m^3 = 0.78\ m^3$
$43 \times 0.016\ m^3 = 0.69\ m^3$
$35 \times 0.015\ m^3 = 0.53\ m^3$
$29 \times 0.014\ m^3 = 0.41\ m^3$
$21 \times 0.014\ m^3 = 0.29\ m^3$
$15 \times 0.014\ m^3 = 0.21\ m^3$
$11 \times 0.013\ m^3 = 0.14\ m^3$
$6 \times 0.013\ m^3 = 0.08\ m^3$
$9 \times 0.012\ m^3 = 0.11\ m^3$

Total 14 m^3

We just studied the composition of a hectare in the case that the diameter distribution extends to the highest dimensions, and determined its annual yield.

Now we need to study if the distribution must not stop to an inferior category and which this category must be so that the maximum revenue would be reached, because it is one of the conditions of the normal managed forest. It is necessary, for this reason, to proceed by feeling one's way.

Let's stop, at the beginning, the formation of our hectare at the diameter 0.60 m, and let's see how the stand will be composed in this case. The trees will be grouped form 0 m to 0.60 m in the proportion determined by our dotted line, because it is the natural distribution. Their volume will be superior to 438 m^3, a number that was obtained by deducting from 500 m^3 the volume of the trees from 0.65 to 1 m. These trees will be replaced by a certain quantity of trees of diameter from 0 to 0.60 m, which will be added to each diameter class in the normal proportion determined by the larger diameter classes.

To know exactly this volume, it is necessary to proceed as we have proposed to do in order to control the number of 500 m^3: by making observations either with the help of the [stem] count notebooks[14], which are the real observation registers, or by studying well established experimental areas, which have closed stands, sufficiently irregular aspect and do not include trees of a diameters superior to 0.60 m.

The research will be guided by the remark that the volume to be found must be superior to 438 m^3.

After determining the volume per hectare, we will only have to deduct from it, with the help of the data established earlier, the number of stems by diameter class and their volume, which, multiplied by the growth rate, will give the annual revenue.

Studying this way stands with three or four different maximum diameters and comparing the results, we will have the data on maximum revenue and we will know which diameter class the stand should not exceed.

When we have a forest to be improved, the first thing to do is to study if it is normal.

If it is, the growth will be estimated as we just indicated; it will be the [cutting] possibility[15].

But the normal forest is an exception.

Thus, we must examine the different cases, which will be encountered and which can be reduced to the following two:

We could determine in which of these two cases the forest to be improved belongs by overlaying in the same graph the curve of the normal stand, as we constructed it, and the curve of the existing stand, and comparing the data on how stem number and volume are related.

1st The material is inferior to the target volume[16]. A certain percentage of the stand growth may be taken as [logging] possibility, based on the needs of the owner, specifying that the possibility so fixed should be obtained from the diameter classes exceeding [target distribution][17].

2nd The material is higher than the target volume. We will take as possibility the total growth, to which we will add a certain percentage, in order to decrease more or less brutally, according to the silvicultural requirements and the owner's needs, the volume to the target level.

As in the first case, the possibility so fixed should be obtained from diameter classes exceeding [the target distribution].

The review of the logging possibility of all forests must be done within the time frame varying from 10 to 20 years. It will permit to observe how the desired results have been achieved, and to predict when the set goal will be reached, by the comparing the curves of the old and the new stand condition.

Above, we have not intentionally spoken of the logging from the silvicultural point of view. As we noted, in fact all the diameter classes are welcome, which sufficiently shows, at our opinion, that the operations such as they invariably are practiced in the fir forests, are good and that, continuing so, the normal curve must stay constant, excluding modifications that we must make it undergo, due to changes in stand density resulting from the more or less complete disappearance of a secondary component, for example beech or pine, or from variations in the fir and spruce proportions.

This curve can equally undergo modifications, as well as the volume measurements in the growth and yield tables, if we judge it useful to blaze the stand in a way approaching to the regeneration operations in the regular high forest, or even, if we attempt to try a new method with the goal of obtaining higher revenue.

The comparison of the curve and the final data with those established in the theory will permit to observe if the deviations are advantageous or, if on the contrary, they must be abandoned.

In summary, these comparisons will allow making, in each amelioration review, more and more accurate observations, and in all knowledge of cause we will be able to draw justified conclusions for the future.

It will perhaps be said that the procedures that we propose to employ are very complicated; but it will be admitted that the question itself is complicated and only numerous experiments, most of them very delicate, using a rational and well defined methodology, may resolve the question in a satisfactory way.

Notes

[1] De Liocourt uses the word “jardinage”, which literally means “gardening”. The context of this word in most places where it is used implies the meaning of the modern English word “silviculture”.

[2] De Liocourt uses the expression “jardinage avec possibilité par volume” or “silviculture with volume possibilities”.

[3] De Liocourt uses the term “futaie régulière” or “regular forest”.

[4] De Liocourt uses the word “peuplement”, which exactly means “population”. This word is translated as “stand” when the forest management context is clear, and “population” when the context is more ecological. The original reference to tree “populations” determined by age, i.e. age classes, is maintained in the English translation.

[5] The original expression is “futaie jardinée” or “forest subject to gardening”.

[6] De Liocourt uses the word “malvenant” or “without expectations”. The term is interpreted in this context to refer to trees or saplings without growth expectations due to their dominated position in the forest.

[7] The term “rapport soutenu” of de Liocourt is translated as “sustained yield”.

[8] De Liocourt uses the word “possibilité”, e.g. “calcul de possibilité” or possibility calculations. These “possibilities” clearly refer to the cutting possibilities or yield. The English word “yield” is consistently used in this context.

[9] De Liocourt uses the expression “déchet naturel afférent à chaque catégorie” which literally means “natural waste pertaining to each category”.

[10] De Liocourt uses the expression “incomplètement constituées” or “incompletely formed”.

[11] De Liocourt uses the much stronger wording “frappée de stérilité” or “hit by sterility”.

[12] The original word is “exposition”, which refers to “location with respect of something”; thus, the location here refers probably to slopes with different orientation. In a mountain region, the slope orientation is the main site variable determining the forestry options.

[13] The translation here is ambiguous. De Liocourt uses the word “massif”, which may refer to “a group of trees”, i.e. stand as we have translated the word, or to “a mountain”.

[14] The original expression is “calepins de comptage” or “count notebooks”; stem count is implied.

[15] Cutting is only implied in the original text.

[16] De Lioucourt uses the expression “volume normal” or “normal volume”. The expression is translated as “target volume” in order to avoid reference to “normal forest” as known in German silviculture, or to any stem distribution series that follows the statistical normal distribution.

[17] The original wording is “les catégories de diamètre exedent” or “surplus diameter classes”.