



## CONCERNING THE QUESTION OF THE ROTATION PERIOD IN FORESTRY

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During the years immediately prior to World War I, there was a discussion in Sweden about the profitability of forestry with particular regard to the most adequate rotation period. On the whole, this discussion represented a struggle between three different approaches, namely:

- 1) the principle of highest yield,
- 2) the land rent principle, in Swedish called the monetary profitability principle, and
- 3) Professor Tor Jonson's "principle for the greatest profitability".

I will very briefly describe the first-mentioned principle, the highest yield principle, which has increasingly lost ground. It demands the highest possible net yield from forestry and pays no regard to the size of fixed capital, i.e., it stand in opposition to the demand for profitability.

Assume a sustained-yield forestry being run on an area of 120 hectares. With a rotation period of 120 years, each stand will cover one hectare. However, with a rotation period of 60 years, each will cover two hectares. If the cutting value of the 120 year-old stand is  $\frac{A_{120}}{120}$ , after all general exploitation costs are excluded, and the 60 year-old stand is  $\frac{A_{60}}{60}$  SEK, the principle of highest yield satisfies itself with the requirement that  $\frac{A_{120}}{120}$  shall be larger than  $\frac{A_{60}}{60}$  without taking the long rotation period of the first cutting (60 years later) into consideration, and therefore  $\frac{A_{120}}{120}$  should corre-

spond to  $\frac{A_{60}}{60}$  with a compound interest over 60 years<sup>1</sup>.

In my opinion, no acceptable reason is produced for why the claim of profitability should be abandoned. To use Professor Heckscher's words, "one can ask why our country should try to obtain the largest possible forest production but not grain, hay, milk, iron, copper, silver or gold production"<sup>2</sup>.

## LAND RENT PRINCIPLE

According to the land rent theory, the rotation period that maximizes the land value and the land rent is the economically correct one. When the interest on the land value, i.e. the land rent, is simply the net gain minus general expenses, there seems to be no doubt about the correctness of the above sentence. It is, therefore, surprising that the correctness of the land rent principle is even questioned. Presumably, the explanation is that, in many respects, it has not been easy to grasp the consequences of this principle. Indeed, in many cases incorrect consequences have been presented, which has led some critics to consider that the land rent principle is untenable. In the light of this situation, it would seem to be important to make the fundamental meaning of the principle clear.

Significant for the land rent principle are its profitability requirements, in contrast to all other principles. The fixed capital of forestry should yield interest according to a normal rate of interest, with due regard to safety etc. The view that forestry holds an exceptional position within commerce and industry, and that its capital does not have to yield interest (the direct consequence of this view is the principle of highest yield) is completely inconsistent with the foundation of the land rent principle: profitability requirement<sup>3</sup>.

<sup>1</sup> If  $A_n$  is the cutting value of an  $n$ -year old stand covering the complete acreage, the highest yield principle will be  $\frac{A_n}{n} = \text{maximum}$ .

<sup>2</sup> "The profitability of forestry", *Ekonomisk Tidskrift*, 1912. Those interested in detailed criticism on the highest yield principle are directed to this paper.

<sup>3</sup> Both the principle of highest yield and the land rent principle hold a consistent position in the question of profitability which, on the other hand, is not the case and *cannot be* the case with regard to other principles.

Consequently, the task is largely to analyse the meaning of the profitability requirement, with respect to the determination of the forest's rotation period. However, although this seems to be simple, opinions have been divided even among the supporters of the land rent theory. One group has put forward a criterion concerning the economically right rotation period, whereas another group has advocated a different criterion, and so on. On the whole, one can say the meaning of the land rent theory is to investigate, partly each yearly stand individually in a sustained-yield forestry and, partly, a sustained-yield forestry seen as a whole. Since there is a very close connection between these two questions — a single stand merely occurs as part of a more or less sustained-yield forestry — there is reason to keep them apart to start with, to prevent possible misunderstandings from arising. Thus, unless the contrary is stated, all discussion concerns one single stand and the land on which it is growing.

In the paper mentioned above, "The profitability of forestry", Professor Heckscher has contributed to this question. He finds that the profitability requirement means that the yearly increment of each stand has to correspond at least to the rate of interest of its cutting value and that the economically right rotation period, i.e. the period that maximizes the land value, will be obtained when the increment of the oldest stand corresponds to the rate of interest<sup>4</sup>.

If the cutting value of a 59 year old stand is 1,000 SEK and after one year is assumed to amount to 1,050 SEK and another year later to 1,100 SEK, the stand should be cut at 60 years of age, since an increasing value of 50 SEK during the 61st year is not a normal rate of interest on 1,050 SEK.

This derivation of the land rent principle will probably not be completely valid. If a 60 year-old stand is being cut, there is not only the advantage of interest yield on the cutting value, but also the fact that the forest land can be used for a new stand one year earlier. Thus, the increase in value between the 60th and the 61st year should make up for the advantages lost, i.e. compensate for not only the rate of interest on the net cutting value, but also for the rate of interest on the land value.

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<sup>4</sup> The stands are cut at the time when their yearly increment corresponding to the rate of interest.

Forewarned by numerous examples of false conclusions in connection with interest calculation on the basis of land value and other capitalization values, I have tried to mathematically verify the above mentioned argument. Such verification seems to be highly justified given that one of the reasons for the deficiency of the earlier discussion was the large number of concepts used, which often led to their misuse and confusion.

In just such cases, expressing the argument in mathematical terms usually offers some advantages, since it partly implies a distinct definition of a concept and, partly, forces economy in the number of concepts used, whereas in ordinary writing and even more so verbally, one is free to use a great variety of general expressions.

The problem of determining the economically right rotation period must be just the same for well-managed forests as for unmanaged forests. Such being the case, the unassignable indirect costs of forestry will not be taken into consideration in the mathematical presentation. An addition of this type would not present any difficulties, but it would not be of any great interest, as it would not involve any essential change in the problem. Assume the cutting value of a standing forest is  $f(n)$  after  $n$  periods and the interest rate is  $p$  per period.

The stand's land value is

$$M = \frac{f(n)}{(1+p)^n - 1}$$

or, if a continuous interest is assumed in order to be able to use infinitesimal calculus:

$$(1) \quad M = \frac{f(n)}{e^{pn} - 1}$$

The rotation period that maximizes the land value is the right one; because the land rent represents the net profit of forestry (after the interest on capital invested has been discounted) and, of course, the net profit ought be made as

large as possible<sup>5</sup>. By a simple derivation, we get from this condition

$$(2) \quad f'(n) = f(n) \frac{pe^{pn}}{e^{pn} - 1}$$

With the help of (2), I shall now verify that the yearly increment of a stand should be at least of the same proportion as the interest on the cutting value and land value taken together, in order to make it profitable to let the stand grow. This can be stated

$$\left[ \frac{f(n)}{e^{pn} - 1} + f(n) \right] p \Delta n = f(n + \Delta n) - f(n)$$

The left side of the similarity expresses the interest on the land value and the cutting value during the period  $\Delta n$  and the right side expresses the increment during the same period. We get

$$f(n) \frac{pe^{pn}}{e^{pn} - 1} = \frac{f(n + \Delta n) - f(n)}{\Delta n}$$

i.e., when  $\Delta n$  approaches 0.

$$(3) \quad f(n) \frac{pe^{pn}}{e^{pn} - 1} = f'(n)$$

As (3) is identical with (2), the statement is confirmed.

As far as I can see, this reasoning proves that the yearly increment of the oldest stand will be equivalent to its cutting value and to the value of the land made available, or rather, that a stand is ripe for cutting when its annual increase in value meets this condition.

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<sup>5</sup> It is a completely different matter if one or two foresters come into possession of company profits as consequence of good luck or specific good management, or similarly if yet another forester sustains a company loss. In general, these differences usually even each other out.

However, so far the overhead costs of forestry have not been taken into consideration. The particular felling and transport costs have been deducted from the value of the stand's market quantity. Thereby we get the felling and stumpage value; but still administration costs, taxes, land improvement costs etc. have not been touched upon, despite their influence on the proceeds of the operation.

These unassignable indirect costs are, to some extent, fixed costs because they consist of interest on fixed capital invested in forestry, e.g. in drainage work, improvement of roads and float ways etc. Such capital investments are strongly integrated in the land, itself — they can hardly be separated from the pure land value<sup>6</sup>. It is usually hard to determine how much of the yield is interest from paid-up capital and how much is land rent.

The difficulty to differ entirely between the original "pure" value and some fixed capital investments makes it advisable to deal with these two categories as "land capital". Such a combination is also justified in terms of profitability; the sustained-yield forestry is profitable as soon as the land capital yields more than a slight net income, even if it does not amount to the rate of interest on the capital expenditure, i.e. even if the pure land rent is negative.

As long as a net profit remains when all variable costs have been covered, it is much more economically favourable to continue with forestry, than to move capital to another industry.

The aim of forestry then is: to obtain the highest possible yield on land and fixed capital, i.e. "land capital"<sup>7</sup>. For simplicity, this interest on the land capital is called land rent in the following discussion.

It is impossible to generally determine which capital investments should be considered fixed. It all depends on the length of the time period in view. If the time span covers a couple of decades, buildings of different kinds are often "fixed" but if the period cover generations or centuries, they

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<sup>6</sup> A purchaser of forest land takes little interest in whether or not the land's earning capacity depends on earlier capital expenditure. To him the total net yield is land rent.

<sup>7</sup> Of course, this maximum will shift in accordance with new fixed capital investments.

are often “flexible”. Hence, there is no absolute limit, but rather the extent of flexibility has to be considered in each specific case. However, very often the costs may probably be divided well enough into fixed — costs belonging to the land capital — and more or less flexible ones, such as administration costs, taxes etc.

These flexible and half-fixed general costs must, in some way, be distributed among the different stands. There are, however, no valid objective norms available, so the division has to be random or according to the specific case. One possible alternative is to regard these costs as exploitation costs<sup>8</sup>. The majority of the costs are related to felling (prelogging and final felling) and transport. The forest tax depends on the quantity felled, etc. Even the regeneration costs can be considered as exploitation costs, since legislation<sup>9</sup> enjoins the forest owner to ensure the continued growth of the forest. Despite the fact that it is open to question to regard these costs as wholly exploitation and transport costs<sup>10</sup>, it may be justifiable as there do not appear to be any generally applicable and, in practice, useful grounds for a proper distribution also between the growing stands. It is not worth trying to distribute the costs since this would lead to mistakes, perhaps no less risky than the deliberate approximation<sup>11</sup> mentioned. Through this approximation, the stands’ stumpage values will be somewhat low, hence, the profitability requirements based on these stumpage values or values of cutting operations are minimum demands.

Thus, the result of the above discussion is that during the stand’s last “year of life” the increment of each stand will correspond to the rate of interest on its cutting value and its land capital.

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<sup>8</sup> See e.g. E. Anderson, *Economic principles for the economic arrangement of forestry*, 1913.

<sup>9</sup> If any investments in regeneration have already been made, they must be considered as once and for all land capital investments.

<sup>10</sup> For example, book-keeping expenditures and costs apparently ought to affect the whole stand.

<sup>11</sup> If one would like to divide the general costs, in some way or another, and decrease the increment of a stand on its appropriate share, one will get *the net increment* of the stand, which, in that case, should be the term to use instead of increment.

However, this formulation is not very suitable for the determination of the rotation period. The land capital is one of the unknown magnitudes; it is nothing but the capitalized net yield<sup>12</sup> and thereby varies in accordance with different rotation periods. The greater the land capital one can get, the better, according to the basic rules of the land rent theory. The problem then is to make the stand's capitalized value as high as possible, by means of the difference between the yield of the oldest stand and the rate of interest on its cutting value. When choosing an  $n$ -year-old rotation period, one comes into possession of this difference every  $n$ -year, but with an  $(n + 10)$ -year rotation period only every  $(n + 10)$ -year. Consequently, to obtain a profitable extension of the rotation period, the difference, i.e. the net profit, must not only increase, but also compensate for the fact that a profit is made more seldom. Thus, the only way to investigate which rotation period will maximize the land capital is by means of figures for different rotation periods.

The problem in practice, is often confined to establishing that the increment corresponds to the rate of interest on the cutting value. This is because, on one hand, of the insignificance of the land capital in relation to the stand's cutting value and, on the other, of the typical quality for all maximizations that fairly important variations around the maximum level of the independent variable — in this case the rotation period — only bring about relatively insignificant variations in the net profit.

The signification of the demand for profitability referring to a specific stand's average increment is, on the whole, the same for the specific trees within a stand. This is of considerable practical importance. Even if a 70year rotation period is decided on, the time for felling is, nevertheless, not sufficiently determined. It is true that, on average, the felling age of the trees will be about 70 years. However, as trees grow very differently, it will be profitable to fell some of them at 65 while others will be allowed to grow until they are 75. The determining factor in this respect is the question of how long the increment will correspond to the rate of interest on cutting value and land capital. It may be the

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<sup>12</sup>  $\frac{\text{Net yield}}{(1 + p)^{n-1}}$



case that trees in one area may comply with this condition at a far more advanced age (than the trees in another area) and, thus, should be allowed to grow longer.

If the trees' and stands' cutting ages are determined in this way, the land rent is maximized. However, nothing is said about whether a *positive* land rent is obtained, i.e. whether the silviculture is profitable or not. If the general costs, the regeneration expenses and other felling costs are high, it may happen that the calculated cutting value will never be positive and, consequently, the land capital will be negative<sup>13</sup>. However, it is still correct that the land capital obtains its maximum value with this rotation period. In this case, the inevitable loss is the smallest possible, *if forestry should be undertaken at all*.

As far as I can see, the above discussion answers the question about a fixed rotation period with regard to static forestry. To further illustrate this point, a few words may be said concerning the calculation of the profitability of forest production, as the answer to this problem has been sought using similar calculations.

First, however, I will cite one remark contradicting the consequences of the profitability requirement for the increment of the specific stands and trees. Professor Jonsson considers it to be of absolutely vital importance to note the following. He writes: "Regardless of how the capital is determined, there is always a risk for some rotation periods to be attended by losses, despite the fact that each single tree and stand is growing completely satisfactorily". "The older and middle-aged stands, which are less profitable calculated as a percentage, are often needed in the forest as long as they bring about a high absolute production. This is in order to give the enterprise sufficient breadth and comprehensiveness to distribute and meet necessary administrative costs, arrangement of transportation routes etc. or, in other words, to utilize the yield in an economically more favourable way"<sup>14</sup>. Further on he asks whether "forestry can obtain its most profitable use if the decreasing increment

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<sup>13</sup> If the regeneration expenses are not considered to be felling costs, this means that the cutting value does not amount to the regeneration expenses with compound interest.

<sup>14</sup> Skogsvårdsföreningens tidskrift 1913, p. 283.

percentage of the individual trees were to force a rotation period that is so short that, on the whole, there would be no profit from forestry, but only costs”<sup>15</sup>.

Apparently, in this context, the calculation of the increment of the individual trees is not expected to take the general costs into consideration. As I attempted to show above, either a particular share of these costs must be subtracted from the increment and the net increment thus obtained must be related to the cutting value and the land capital, or, preferably, the general costs must be considered totally as exploitation and transportation costs. Which ever way is chosen, one has guarded oneself against Professor Jonson’s objection as this does not affect the profitability requirement, even though his objection cannot be denied a certain justification in relation to the Heckscher formulation.

Stumpage value <sup>I</sup>	General costs	Stumpage value <sup>II</sup>	Regeneration costs, current value <sup>II</sup>
40 year 10,000	8,000	2,000	2,000
50 year 15,000 * $\frac{4}{5}$ = 12,000	8,000	4,000	3,400
60 year 21,900 * $\frac{4}{6}$ = 14,600	8,000	6,600	5,600
70 year 28,700 * $\frac{4}{7}$ = 16,400	8,000	8,400	9,000
80 year 38,000 * $\frac{4}{8}$ = 19,000	8,000	11,000	15,000

<sup>I</sup> To the same extent as the rotation period increases, so decreases the area belonging to each stand.

<sup>II</sup> Compare with note 13 on the previous page.

The first column shows that the calculated stumpage value (sales value minus expenses only for cutting, round trips etc.) leads to a rotation period of 40 years. This is because the increment during the next 10 years will not correspond to an interest of 5% on the stumpage value<sup>16</sup> and, thus, even less if any land capital is taken into consideration. However, this rotation period yields no profit<sup>17</sup> at all

<sup>15</sup> Ibid. p. 305.

<sup>16</sup> After 10 years 10,000 SEK will amount to 16,300 SEK.

<sup>17</sup> The regeneration expenses are assumed to amount to 300 SEK, which in 10 years will rise to a bit more than 2,000 SEK. Adding the overhead costs, 8,000 SEK, will make 10,000 SEK (the cutting value in the first column).

and accordingly the land value is 0, despite the fact that it should have been the highest possible given this rotation period, according to the land rent principle. If, on the contrary, the overhead costs are taken into account, e.g. by considering them as felling costs, the stumpage value will correspond to the figures in the third column and, thus, to a rotation period of 60 years and to a net profit of 1,000 SEK, i.e. a land capital of 20,000 SEK for the forest as a whole.

#### CALCULATIONS OF THE PROFITABILITY OF FORESTRY

Now, I will pass on to a brief discussion of the problem concerning the calculation of the profitability of forestry. The first thing to do, is to make the meaning of invested or fixed capital in forestry clear, because this is the basis on which the calculation of profitability must be made. Which capital term is referred to? The capital invested, the sales value or some other capital term? Which one is the forest's 'true value'?

The value of a production object is completely depending on its yield. If the yield is good, the value of the object is high, if, on the contrary, the yield is poor, the value of the object is low. By capitalizing the annual yield its capital value is obtained, which is equal to the value of the production object. If  $A$  annually yields  $k$ , its value is  $\frac{k}{p}$ , provided it remains in that use.

Consequently, the value of a forest can be nothing more than the amount obtained by capitalization of the annual yield. Since the forest consists of partly the land, partly the different stands, the value of the entire forest must be equal to their combined value. In other words, the value of the forest can be divided into land capital and stand capital, provided the latter means the sum of the values of the stands.

If the cutting value of an  $n$ -year-old stand is written  $f(n)$ , the value of the entire forest is

$$(4) \quad \frac{f(n)}{p}$$

and the land capital, in accordance with the above, is

$$(5) \quad \frac{nf(n)}{e^{pn} - 1}$$

So, what is the value of a  $(n-1)$ -year-old stand? Of course, it is equal to an amount which, in addition to the stand's share of land capital, has after one year reached the level of the  $n$ -year-old stand's value increased by its share of land capital. The difference between the two stands' values is then equal to the interest on the  $(n-1)$ -year-old stand's value and its land capital. In other words, the value of an  $(n-1)$ -year-old stand is obtained by discounting the value of an  $n$ -year-old stand by 1 year and subtracting the interest on the land capital. In the same way the value of an  $m$ -year-old stand is equal to the value of an  $n$ -year-old stand discounted  $(n-m)$  years ahead and with the interest on the land capital subtracted, i.e.

$$(6) \quad \frac{f(n)}{e^{pn} - 1} (e^{pm} - 1)$$

The value of a not fully matured stand as a part of a sustained-yield forestry, i.e. its value as a production object—its net present value—must, according to the general principle, be determined by its yield. Consequently, this will be a derivation of the value of the stand when mature.

If the net present values of all the stands are summed up, i.e. (6) is integrated for  $(m = 1 \dots)$ , and the land capital

is added,  $\frac{f(n)}{p}$  is obtained—the value of the entire forest.

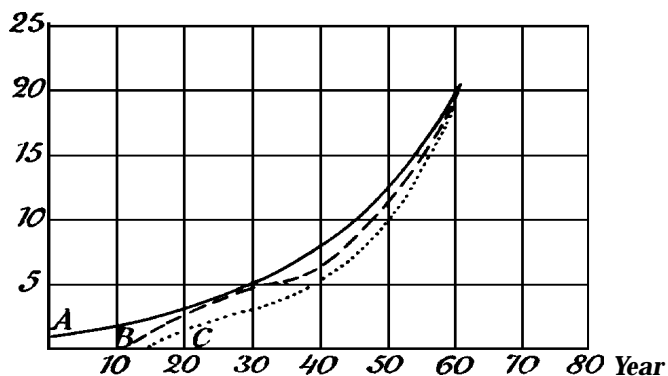
Considering that it is obvious that the only way to obtain the value of a stand is by discounting its future cutting value at cutting age, it is astonishing this fact has ever been contested. The cutting value of the stand *before* maturity is of no importance since it is lower than the net present value of the stand and, thus, immediate felling is out of the question. That the net present value exceeds the cutting value is true as long as the increment more than compensates for the interest on the cutting value and the land capi-

tal. Not until the increment exactly corresponds to the interest on the cutting value and the land capital will the net present value coincide with the cutting value; which is the right time for cutting. Accordingly, it does not matter to the value of the forest whether the cutting values of the stands which are not mature are high or low. This depends exclusively on the annual net yield, i.e. the cutting value of the mature stand and the exploitation costs. This is illustrated by the diagram below.

Regardless of whether the cutting values of the stands in different ages follow the *B* or the *C* curve, their net present values follow the *A* curve.

The net present value calculated in the above way corresponds to the value of all production factors used; work, capital and land with compound interest from the day of use, i.e. the value of saved labour and land value. From this it is clear, among other things, that the costs of the production factors must be exactly covered by the income when the net profit is regarded as compensating for the disposition of the land, i.e. when neither profit nor loss exists.

The correspondence of the annual profit with the rate of interest on land and stand capital apparently means that the annual profit, in relation solely to the stand capital, constitutes more than the common rate of interest unless the land capital is 0, which would result in a normal rate of interest. When the stands' cutting value is lower than their net present value, the annual yield obviously must constitute *more than a normal rate of interest on the cutting value* to



A. Net present value. B and C. Cutting value.

make the forestry profitable. It is impossible to generally determine how much higher this should be, since it is dependent partly on the maximum land rent, and partly on the relationship between the cutting value and the net present value, and this relationship varies from case to case.

From another point of view, the requirement for a higher than normal rate of interest on the total cutting value of the stand appears if the younger stands' increment, as a percentage of their cutting value, is very high, to begin with perhaps 100%. This decreases more and more with the rising age of the stands, apart from possible occasional deviations. Since it can not be profitable to let the stands grow longer than to the point where their increment corresponds to a normal rate of interest on the cutting value and on any land capital (the land capital should be estimated at the highest rate it can obtain in any rotation period), the stands' *average* increment as a percentage of their cutting values must apparently be *greater* than a normal rate of interest. Thus, to demand only a normal rate of interest on the stands' cutting value, means letting the trees grow as long as the increment of the oldest ones does not correspond even to a normal rate of interest on the cutting value, and even less if the land capital, possibly calculated from another rotation period, is considered<sup>18</sup>.

Forester E. Andersson<sup>19</sup>, one of the most ardent Swedish supporters of the profitability requirement, assigns a normal rate of interest on the theoretical sales value, i.e. in my terminology: the total of the stands' cutting values, as a desirable and sufficient value for forestry. In doing so, he seems to overlook the fact, pointed out by himself, that the percentual increment of the younger stands exceeds the normal rate of interest. Thus, the average increment must be greater than the rate of interest considered normal, as long as no stands are allowed to increase in value less than

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<sup>18</sup> In this context, the cutting value of a stand is the value obtained when all felling and transport costs are subtracted from the value of the timber at the sales site. The sum of the stands' cutting value consequently is *not* the same as the amount possible to obtain at a *quick* sale of the whole forest, since in this case some extra losses are to be expected. This distinction is justified as a total sale is not being questioned because, here, the problems of a sustained-yield forestry are being discussed and compared between different rated values within the sustained-yield forestry.

<sup>19</sup> Ibid. p. 18 ff.

with a normal rate of interest<sup>20</sup>. It is true that “the only possible way the capital forestry constitutes can be made available is by decimating the forest by ruthlessly cutting the trees” and that one necessary condition “to make the capital invested in forestry fixed is for the forestry to yield an interest corresponding to the amount obtained if sold”. But this does not mean that the above condition, or a normal rate of interest on the theoretical sales value are sufficient. If the forest yields an interest of 5% on its sales value, which is actually higher than the real sales value, it is true that “it would be more profitable to keep the forest than to ruthlessly cut it”, but it would be even more profitable to cut the “over-aged” trees, i.e. the trees not yielding a normal rate of interest. In other words, *decreasing* forestry's fixed capital would be most profitable. Even if continuing as before would be better than cutting the whole forest and releasing the entire capital, the *best* could be to release *some* of the capital and thereby make the rest of it profitable.

It immediately appears from the above discussion that, firstly, the annual yield from forestry (all costs deducted<sup>21</sup>) should yield a somewhat higher than normal rate of interest on the total cutting value of the stands. Secondly, the rotation period yielding the largest profit *above and beyond this* (the highest land rent) is the best one. In this way the land value is the highest possible. Or, as was suggested above, taking the fixed capital expenses into consideration gives the highest land rent. Consequently, the following conclusion made by Forester Andersson is incorrect: “The surplus is available to pay interest on the sales and the land values of the forest. The interest on the sales value is set according to a fixed interest rate, the rest is land rent for the whole forest area.”<sup>22</sup> It is not the sales value of the stands, but their net present value in addition to the land value or the land capital that comprise the capital of the whole forest.

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<sup>20</sup> This can happen to younger stands even at a normal rotation period, if the latter increment more than compensates for the former loss.

<sup>21</sup> Estimated at the actual amounts of money paid, without a compound interest period, if the latter increment more than compensates for the former loss.

<sup>22</sup> Ibid. p. 22.

Although the above mentioned condition may not be of great importance in practice, it is not insignificant. Instead of e.g. calculating 5% of the stands' total cutting value, 5 ½ or 6% is more adequate, depending on its relationship to the stands' net present value and the size of the land capital during the best rotation period. However, the advantage of carrying out such a calculation seem somewhat dubious. If, for instance, it results in 4% instead of 5 ½%, then it can obviously be concluded that the rotation period is too long. However, such a result could equally easily be found through a study of only the increment of the last stand. This would in that case be considerably below 4% of the cutting value instead of being somewhat over 5% if land rent could be obtained. In any case, the real rotation period (i.e. the rotation period that yields the largest net profit or rather, the highest interest on the land capital) can not be calculated on the basis of the stands' total cutting value. If, in practice, a calculation based on the numerical series of the stumpage value at different ages would be difficult to obtain for the forestry as a whole, it is always possible to regard a stand as a unit and examine which rotation period would maximize its land capital. This occurs when the increment of the cutting value, at an extended rotation period, balances the loss arising from more infrequent fellings on the land<sup>23</sup>.

If particular precision is not considered necessary, the rotation period should be determined with respect to the age when the increment of a stand corresponds to the interest on its cutting value. Obviously, the land capital is not then taken into consideration, but this approximation is of minor importance since the land capital, as a rule, cannot be large for any rotation period. Computing the interest on the total cutting value of the stands, *also* means that the difference between this amount and the stands' net present value is disregarded.

At this point, I would like to mention Professor Jonson's comments on the above advocated way of regarding the question of capital invested in forestry. I will then say a

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<sup>23</sup> With a 65-year rotation period A SEK is obtained every 65th year, but with 70-year rotation period maybe not 1,3 A each 70th year. In that case, 65 years is preferable.



few words about Professor Jonson's own position. He writes: "Apparently, the value obtained when capitalizing the net income will not suffice, because the yield from forestry does not depend on what is being produced under the present circumstances but on the arbitrary extraction of values produced earlier".

This remark has a certain justification with regard to abnormally composed forests. Apparently, however, Professor Jonson overlooks the fact that a stand can be considered a separate unit and that its real cutting age can be calculated in the above mentioned way. Consequently, this enables the net present values of the immature stands to be calculated<sup>24</sup>. Thus, Professor Jonson's remark is not necessarily relevant when determining the rotation period.

An, on principle, different matter (though, unfortunately, seldom differentiated from the former) is the question of how to examine whether a forest is properly managed, with regard to thinning, draining etc. To further cite Professor Jonson: "Furthermore, such a valuation will lead to a cyclical process when establishing the profitability of forestry. Since the capital has been obtained by capitalizing the net according to a specific rate of interest, one will, in the calculation, always return to this self-chosen rate of interest when the net obtained is to be compared with the same capital. Both the expectation value of an entire forest and of the individual stands will, therefore, be inappropriate as a basis for valuing the forest capital".

Of course, many different additional calculations could help to provide a reliable idea about whether the forest cultivation is rational or irrational. However, I find it hard to believe that a calculation of interest based on one or two cutting values for the forest as a whole, as recommended by Jonson, can be the only correct approach. Does not bad management lead not only to a decreasing net value (the numerator) but also to a decreasing cutting value (the denominator)? And, in that case, in what way can this be expressed in a number which just states the relationship between the numerator and the denominator? Besides, such

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<sup>24</sup> In addition, there are always a few difficulties in connection with abnormally composed forests, and these can not be avoided in any way. Developing this would lead us to digress too far from our main point here.

a calculation can not say whether or not a bad result depends on an incorrect rotation period in relation to the actual growing conditions in the forest in question, or whether the growing conditions are poor as a result of incorrect silviculture (e.g. with regard to thinning).

I can not state a given opinion in this matter because I have no technical education, but it seems to me that it would be advantageous to find out whether the rotation period is right and the silviculture is good. This could be done using the above mentioned principles with regard to the stands' stumpage values at different ages in the forest studied. In addition, it could be investigated whether the stumpage values are too low because of inappropriate silviculture and if they could be increased. This question can be answered by a technical expert who can assess land quality, tree height etc.

If, in both respects, a numerical expression is desired for the silviculture, I argue that the only way to do this is to compare the net increments per unit area (after the rate of interest on the stands' net present values has been subtracted). In other words, the interest on the land capital per unit area in different forests should be compared. When comparing areas with identical conditions, the same result should be obtained, otherwise it can be assumed that one of the areas is better managed than the other.

#### PROFESSOR JONSON'S PRINCIPLE FOR THE GREATEST PROFIT-ABILITY

On several occasions Professor Jonson has spoken out against the land rent principle as a regulator of the forest economy and has tried to show its incorrectness. Some of his remarks have already been mentioned. The rest could suitably be dealt with in connection with a short description of Professor Jonson's own "principle for the best profitability". As far as possible I will use his own wording in order to avoid any misunderstanding.

The demand for remunerativeness within forestry is a suitable basis for assessing each principle of economics of forestry. The following quotation expresses Professor Jonson's opinion. "The proportion of capital maintained in timber in forestry must, at least, correspond to the yield

needed by the country and to guarantee continued forestry for all time. Thus, this minimum level of capital invested in forestry must be considered in the public consciousness to be of fixed kind. Consequently, a fixed rate of interest on the forest capital cannot be settled in advance"<sup>25</sup>. "Just as in all fields of the economy, forestry should be charged the prevalent interest rate for all depositions and working capital at its disposal"<sup>26</sup>. "We, the present generation, who have harvested the abundance of the virgin forests, will be held answerable to our descendants, if we do not reinvest a reasonable share of the profits to establish new forests. The 1903 Silvicultural Act laid down certain obligations to ensure the continued growth of the forest"<sup>27</sup>.

In Professor Jonson's opinion deforestation is wrong and perhaps, above all, morally indefensible. Clear-cutting of land, without ensuring continued growth, is not permitted in itself — and not simply because the national income should be decreased. Obviously, this would not happen if the unprofitable capital invested in forestry was placed in commerce and industry yielding normal capital interest. Indeed, just the opposite would occur — there would be an increase. Nevertheless, J. considers that we have a duty to "our descendants to reinvest a reasonable (?) share of the profits to establish new forests". This, I assume originates from his emotional thinking. Besides, J. seeks a purely economic argument for his refusal to accept the profitability requirement in its full extent. But, what does "the yield needed by the country" mean? Why should the yield be of such proportion that even land unable to support a profitable forestry should retain the capital invested in it? Is it not the opposite — the quantity of timber for which it is possible to find a profitable market, that the country needs?

Another illustrative example of J.'s attitude towards the requirement for profitability is the following extract from his criticism of the Swedish "theory of monetary interest".

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<sup>25</sup> Försök till grundlinjer för det svenska skogsbrukets ekonomi. (An attempt to lay down guidelines for Swedish forestry economics). Skogshögskolans festskrift, 1917, p. 341.

<sup>26</sup> Ibid. p. 342.

<sup>27</sup> Ibid. p. 343.

"This way of thinking emphasizes total clearance, as the primary method of treatment, while the regular forestry is only ascribed the right to exist on the condition that it is more profitable for the forest owner to run it than to abandon it"<sup>28</sup>. One major reason why I strongly dissociate myself from the basic view of the theory of monetary interest is its emphasis on private interest to the detriment of, or at least the disregard for, a considerable general interest"<sup>29</sup>.

The basic view of the land rent principle, as well as of the theory of monetary interest, is the requirement for profitability within *all* industries, including forestry. Consequently, this is what J. repudiates. However, he is not consistent. "Depositions and working capital" should yield interest. One may ask why the cutting value of a stand can not be considered to be a deposition, possibly with the small deduction allowed according to the legislation concerning regeneration.

J. makes further concessions to the requirement of profitability. The calculation concerning *new forest establishments* should indicate that the purchasing price of the land as well as the administration costs and the regeneration expenses are covered. Thus, the principle seems to be, on one hand, that there is no obligation to *increase* the forested area, but on the other hand, a *decrease* is not permitted<sup>30</sup>. J.'s opinion about the forests' sales value is also astonishing. A forest owner who could make, for example, 100,000 SEK from clear-cutting but who obtains only 3,000 SEK a year from running the forest, has to continue running it. His private interest is not allowed to be decisive. Moreover, if someone buys a forest "the interest paid should not be higher than what can be expected from persistent forestry". The purchase-price then becomes 60,000 SEK. Can it really be justified that only the initial forest owner, and not subsequent forest owners, is obliged to sustain losses?

The passages cited are sufficient to illustrate the basis of "the principle for the greatest profitability". I will summarize its implications by means of quotations, in so far as space permits.

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<sup>28</sup> Compare J.'s statement concerning the sales value of the forests.

<sup>29</sup> Ibid. p. 344.

<sup>30</sup> If a faulty calculation has brought about forestry on unprofitable land, ruthless cutting is, nevertheless, not permitted, according to J.

“The production principle recommended here ... *the principle for the greatest profitability* thus includes a demand for such an organization and management that the surplus, arising when wages and other running costs have been paid (interest on the working capital included), stands in the best possible ratio to the disposable forest capital. It could be equated with some already fixed real capital, generally of insignificant size, and consequently combined”<sup>31</sup>. J. divides the forest capital into land capital and timber capital. The former should be estimated according to “a simple formula or a scale automatically indicating a basic land value for calculations or accounts according to different site quality classes and market potentials... Apparently, good or bad management must not ... affect the land value, because it is just economic efficiency that is intended to be tested in the calculations”<sup>32</sup>. To estimate the timber capital “the best way will probably be to make an inventory of the supply of the usual assortment range within the forest or the stand. This range will then be given a *stumpage value* according to the current local prices for both timber and logging, preferably taken as an average of such a long succession of years that the periodical changes in business activity are eliminated... The younger and more delicate stands, without any set stumpage value, could best be valued using the price of larger useful wood as a guide, then graphic extrapolation could simply be arranged”<sup>33</sup>.

As we can see from the statement concerning the estimation of the land capital, J. wants to determine the economically correct rotation period not only by examining the greatest percentage of profitability, but also the capacity of the economy. As I have argued earlier, it seems preferable to keep these two questions apart. On one hand, an attempt should be made to determine the most appropriate rotation period, when this appears as a function of the stumpage value of the trees of different ages *in a specific forestry plan* and the level of the interest rate. On the other hand, it should be examined whether the stumpage values of the trees could be increased by means of a more suitable culti-

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<sup>31</sup> Ibid. p. 344.

<sup>32</sup> Ibid. p. 346 ff.

<sup>33</sup> Ibid. p. 348.

vation. I have also pointed out that a calculation of the percentages concerning the size of the annual yield in relation to the total cutting values of the stands would not give a reliable answer to the latter question, because poor management will reduce both the numerator and the denominator. The same applies if J.'s forest capital is used as a denominator, instead of the stands' cutting value, as the extent to which the value of the forest capital exceeds the former is an insignificant and subjectively estimated value based on the youngest stands and the land. Instead a comparison between the net profits<sup>34</sup> per area unit of different types of forestry, i.e. the level of land rent, seems to be adequate, together with an ocular inspection, to provide an assessment of the economic rationality.

In this paper, however, the primary discussion is the determination of the forests' rotation period. To what extent does J.'s profitability percentage constitute a decisive criterion?

It is clear, that the criticism of the calculation of the interest, on basis of the cutting values of the stands and the fixed rotation period, also applies to the calculation of profitability of J.'s forest capital. This is because there is an insignificant difference between the denominators<sup>35</sup>. In addition, it would presumably be very difficult to find a rational ground for graphic extrapolation when calculating the values of the youngest stands. Further, it is obviously faulty to give priority to setting the land value<sup>36</sup>, especially, as in J.'s statement, the possibility of the profitability demanded by the land rent principle is denied. This could only mean a negative interest on the land capital.

To make the principle of the greatest profitability clear, some of J.'s figures may be stated:

Rotation period (number of years)	40	50	60	70	80	90	100	110
Net yield per ha.	0	1,49	4,09	6,29	8,00	9,40	10,43	11,38
Forest capital per ha.	91	129	184	252	325	402	481	560
Current percentage of profitability	0	1,15	2,22	2,49	2,46	2,34	2,18	2,03

<sup>34</sup> After the deduction of the interest on the stands' net present values but not on the land capital.

<sup>35</sup> Compare with the previous page.

<sup>36</sup> As long as it is a question of fixing the rotation period.

J. writes the following about these figures: "On the contrary, it would not be correct to conclude that a maximum of about 2,5% (occurring at an interval of 70-80 years) would bring about a choice of exactly these rotation periods. If instead, for instance, a maximum of 10% had been obtained, a natural consequence would have been an extended rotation period, i.e. to a level above the maximum profitability where the normal rate of interest is obtained for the whole timber capital. This situation could be considered best or at least completely satisfactory, although the highest possible profitability will not be obtained. On the other hand, how far the rotation period of 47 years should be exceeded in a case similar to the one above (where the profitability in every aspect seems to be lower than the current rate of interest) must be considered to be a matter of dispute. This is because it depends, to a great extent, on the demand for particular assortments, the state of the owner's finances and the country's economy, the prospects for forestry, the existence of means to possibly improve its profitability and such biological factors as those affecting the sustainable production capacity of the land etc"<sup>37</sup>.

As far as I can see, it would have been more consequent to insist on choosing the rotation period that yields the best profit, i.e. 10%, if possible. However this may be, in this favourable case a decrease to an average of 5% would mean that the older stands grow less, e.g. 4%, since the younger stands are assumed to grow 10% or more. Even though clear-cutting need not be feared in such favourable circumstances, J. nevertheless recommends letting the trees live long after their increment has fallen below the profitability that, in his opinion, should be obtained in forestry.

Since I have no detailed information about the way in which the calculation has been made, I cannot say anything about the real meaning of the figures cited. It is interesting that J. does not even, in principle, assert the highest profitability (2,49%) to be correct, even if later more or less temporary conditions could involve a modification.

The above discussion, although strictly limited by the lack of space, is an attempt to show that the principle of the greatest profitability is not based on firm ground. Above

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<sup>37</sup> Ibid. p. 351.

all, the relationship between this principle and the profitability requirement is, in principle, precarious, which must be the decisive argument. Consequently, it is likely its use would lead to mistakes involving losses when determining the rotation period and perhaps also when estimating other matters concerning forest economics. I cannot possibly form an opinion about the importance of these drawbacks in practice, due to my lack of practical expert knowledge. However, under all circumstances, it is desirable that the administration's guiding principle (the basis for the determination of the forest economy and, especially, the rotation period) is based on fundamentally correct grounds, although it is often necessary and advisable to modify their practical consequences. But in that case, these modifications should be clearly decided and their direction and strength examined, which is possible only if a correct fundamental principle has been assumed. From this point of view, it seems to me that it is justified to discuss the basic principles for profitability in forestry, even if I am unable to make a positive contribution to the elaboration of practical and useful criteria for the rational administration of forestry.

### IS PROFITABILITY POSSIBLE TO OBTAIN WITHIN SWEDISH FORESTRY?

Perhaps a more fruitful formulation of this question is: why is so much actually paid for the forests that it is impossible to obtain profitability according to a normal rate of interest? How can a person's willingness to pay 1 million SEK for a forest yielding only 30,000 SEK a year be explained, when an investment elsewhere may yield 50,000 SEK?

It is probably true that this does not exclusively depend on ignorance, even if the difficulty in calculating the expected annual income allows free scope for optimism and pessimism. Consequently, it may be possible that overpayment occurs to a great extent.

On the whole, it might be assumed that "the overpayment" is only fictitious and explained by real reasons. One reason worth mentioning is the fact that a forest purchase forms an investment which combines a considerable degree of safety<sup>38</sup> with the quality of being relatively independent

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<sup>38</sup> In this regard, forest production is superior to e.g. industrial production.



of the fall in the value of money. In contrast to bonds and most capital investments, the nominal value of the forest will rise in proportion to the fall in the value of money. With regard to this, it may be said that savings invested in forests during the last few decades have given a far better guarantee against all kind of losses than most other investments. This being the case, the forestry's somewhat lower rate of interest, compared with the interest on bonds, seems to be justified.

Another essential factor was probably the rise in prices of timber before the world war. This might have been considerably higher, at least periodically, than the rise in the general price level (i.e. the fall in the value of money), especially for smaller quantities<sup>39</sup>. In this case, an increasing net income can be counted on, i.e. a continuous rise in the value of the forest. If the real rise in the prices of timber, expressed in a constant value of money, had been 1% a year, a net yield of 4% is satisfactory and 1% invested yearly is considered to increase the forest value.

However, the most important factor is the improvements in silviculture during the last few decades. This implies that the static condition, which is the basis of all the former discussions, is not fulfilled in reality. The forest cannot be regarded as a capital object with an unchanged composition and an average annual yield which remains about the same. By means of various more rational ways of cultivation, particularly better thinning, the yield value has gradually risen far above the level expected with the same rotation period some decades ago. Consequently, the forest is constantly increasing in value. Improvements in forestry technology have led to an increase in productivity, which can not be ignored when determining the rate of return. If productivity is able to rise by 1% per year with regard to the quality and quantity of timber, a yield of 4% of the cost price is satisfactory. If, in addition to this, there is a real rise in timber prices amounting to 1% yearly, one can probably be satisfied with a return of 3% during the first years, without sustaining any losses.

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<sup>39</sup> Many people considered that the rise in the prices of forests and forest products was a real rise in value. This misjudgement might have exerted an influence on the purchase price.

Surprisingly, Swedish literature has not paid much attention to the dynamic conditions of forestry. Nevertheless, a correct answer to the question about profitability is inconceivable as long as the discussion is restricted to static viewpoint. Perhaps it would be more advantageous if the advocates of the opposing opinions tried to reach a result in this question by disregarding other controversies. If it should really turn out to be possible to obtain profitability, it would appear that the practical significance of the differences based on principle would be considerably reduced. Nobody, or very few people are likely to suggest a return of 2-3%, if 4 or 5% can be obtained. Who knows, perhaps even the land should be prepared with the intention of reaching an agreement on the principles. From where does a view such as the one which is fundamental in "the principle for the greatest profitability" originate, if not from a supposed or a real impossibility to obtain normal profitability in forestry and, despite that, in a desire to justify the maintenance of forestry in roughly its present extent?

To here analyze the changes in the static principles, necessitated by the dynamic conditions, would take us too far from our main discussion. Besides, the author's considerable lack of expert knowledge might turn out to be completely disastrous when dealing with these questions. That is why I have to confine myself to expressing the hope that the question dealt with in this paper, will once again after having been dormant for a number of years, be the subject of discussion by the specialists, and that the dynamic problems will consequently be paid more attention than previously. In particular, more attention should be given to the difficult but extraordinarily interesting problem concerning the influence of the fixed costs as a consequence of e.g. the lack of flexibility and divisibility of the fixed capital in forestry, which implies different yield phenomena. It is hoped that this problem will attract the degree of interest which corresponds to the importance of the problem rather than the attention that has accrued to it from a mainly static point of view.