PROBLEMS AFFECTING THE USE OF FAUSTMANN'S FORMULA AS A VALUATION TOOL

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SYNOPSIS

To test its reliability as a valuation tool for forest land, the Faustmann formula is compared systematically with a more orthodox form of financial analysis which accounts for total forest income and expenditure. The criterion is the Maraetai land-use study which gave a land expectation value of $96 per acre for an interest rate of 4%. When Faustmann's formula is applied to the same range of basic data in accordance with traditional procedure, the indicated land expectation value is inflated to $180 per acre. The causes of the disparity are identified, and the action necessary to preserve accuracy is explained.

INTRODUCTION

(1) Faustmann's formula is now relatively old; when it made its debut more than a century ago the science of forestry was only in its infancy. Passage of time has not tarnished its reputation; foresters in general still regard it as one of the most useful and convenient economic tools, which it undoubtedly is. Basically, the Faustmann formula claims to express the unit economic value of land for forestry purposes, and also — by implication at least — to indicate the maximum economic price that can be paid for land for commercial forestry. It is in the exercise of this latter function that a problem is met; the formula has a pronounced tendency to exaggerate the value of land for forestry.

(2) Fortunately, in the vast majority of valuation exercises, Faustmann's formula is used to determine relative values in a comparative series rather than to assess absolute value in isolation; in that type of exercise there is no problem. It is comparatively rare for Faustmann to be invoked in an effort to establish a valid price or value in an absolute sense, yet occasionally it does happen. Then the objective may be to find the economic "price ceiling" before commencing negotiations to purchase; or the formula may be invoked as a valuation aid to assist in settling a claim for compensation; or to establish a forestry value for comparison with the quoted agricultural value for the same land (Ward, 1963). In such exercises as these, if the formula has an inherent tendency to exaggerate the land expectation value (LEV), obviously the implications are too serious to be ignored.

(3) It may be argued that the Faustmann formula is never used to establish a land value for purchase — that the purchase price of land is always decided on the basis of market value — *i.e.*, the price that a willing purchaser is prepared to pay for it. This, though probably true, is nevertheless not particularly relevant. No established market value for forest land exists in New Zealand

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as for agricultural land. One of the advantages hitherto claimed for the Faustmann formula is that it will show what a prospective grower can afford to pay for any given area of land; therefore, if Faustmann is used to assess the forestry potential of a sought-after area, there is a very real danger that the "willing purchaser" may be induced to offer more than the fair economic price.

(4) The purpose of this paper is to explore and identify those characteristics of the Faustmann formula which lead to persistent exaggeration of the LEV. Once this has been done, it may well be a matter for debate whether the formula itself is at fault or the person using it; is the formula open to criticism because it rests upon a series of over-simplified assumptions which rarely, if ever, accord with reality; or does the *modus operandi* tend to overlook some of the basic economic principles which govern the correct use of the formula?

Professor Petrini of Sweden (1951) has criticized the formula itself; he contends that its construction makes it incapable of yielding an accurate land value. He puts forward an amendment which, he claims, will achieve greater accuracy. However, the substance of his amendment is to reduce the annual cost of administration and general forest overhead as incorporated in the formula; this necessarily means that the indicated land expectation value will now be *even higher* than previously. Since there is conclusive evidence that the Faustmann formula already tends to give inflated land valuations, there is no point in discussing Professor Petrini's amendment any further.

THE PROBLEM

(5) The Faustmann formula assumes that a single representative acre of forest land can be effectively identified, and that all costs and revenues associated with the planting and management of this acre can be satisfactorily isolated. This approach involves one in difficulties as soon as the formula is applied to a forestry venture which is designed as a "going concern" with a continuous output of commercial wood. Virtually all the New Zealand exotic forests conform (either actually or potentially) to the concept of a commercial going concern, and they rarely if ever develop along completely symmetrical lines during the formative years. But the most asymmetrical forest programme presents no real problems to an investment analysis technique because this latter method looks at the whole forest and treats it as a single comprehensive productive unit. When intelligently set out as a fully detailed model, this method virtually presents a "bird's-eye view" of the entire financial and economic structure. In this respect Faustmann is unrealistic because he pretends to see the whole forest revealed (or concealed) within a solitary acre. The investment analysis technique now invoked as a criterion is essentially a detailed financial projection whereby everything required to develop the forest up to the stage of a stable going concern (normality) is costed into the exercise both quantitatively and chronologically. Because every item of expenditure and revenue is visibly accounted for in this way, this technique provides a satisfactory criterion against which to examine Faustmann's formula.

(6) A suitable economic model is available from the Maraetai study published by Lincoln College (Ward *et al.*, 1966). The forestry sections of this composite study followed an analytical procedure developed within the N.Z. Forest Service a few years earlier to interpret the economics of forestry investments more realistically than seemed possible by the traditional Faustmann formula. The approach is essentially that of the economic accountant who regards the forestry enterprise as analogous to the planning and development of a large industrial plant. The productive forest is in effect treated as a commercial wood-producing plant. In this context, all essential labour, services, buildings, vehicles, supplies and equipment are costed seriatim into the capital structure as and when the expenditure is incurred. Contrary to what happens when Faustmann's formula is used, this technique embraces the entire forest structure and it accounts for the totality of expenditure.

(7) Accountants recognize that it is virtually impossible to obtain an accurate picture of the economic worth of any industrial undertaking unless the project is scrutinized in its entirety as a commercial going concern. No investigating accountant would attempt to assess the economics of a pulp and paper plant by isolating a typical area of 100 sq. ft of floor space, complete with an average installed machine capacity, plus an average estimated capital expenditure and annual operating cost per 100 sq. ft; indeed, any such approach would be regarded in accounting circles as highly suspect. If, therefore, this approach is unsatisfactory for evaluating the processing phase of forest products, it is very questionable whether in principle the method can be any more satisfactory for the growing phase. However, it must be conceded that Faustmann's approach has the advantage of simplicity and convenience; this practical advantage is probably worth preserving, even though the formula, however it be adjusted, is likely to remain inferior to the more detailed financial analysis.

(8) The economic model used for the Maraetai study is given in condensed form on pages 124–5 of Ward *et al.* It illustrates a complete forestry project, progressively developed to the stage where it functions as an economic going concern. Every item of expenditure and revenue for the 25,000-acre forest is recorded chronologically in an investment account in accordance with sound accounting principles, and everything is capitalized up to the year when the forest becomes normal. At that stage the capital investment is closed off in orthodox accounting fashion, and the entire enterprise is transferred to an annual profit and loss basis. The relevant rate of interest is calculated on the grower's investment (represented by this capital account), and this is deducted from the annual net profit; the balance is the annual earning capacity of the land and therefore represents interest on the compounded land value. This annual income accruing to the land is capitalized at the agreed rate of interest to give the compounded land value at normality, which happens to be year 41; it is then discounted at the same rate to give the LEV in year 1 and at that point is translated into an average value per gross forest acre. The methodology itself is virtually foolproof. As long as the basic data are realistic, this technique will accurately interpret

the business economics of a commercial forestry investment for any block of land large enough to support such a forest as a going concern. The Maraetai exercise provides a reliable yardstick whereby to assess the accuracy of Faustmann's formula. In that study three alternative rates of interest were employed, but for simplicity and convenience 4% will be used in this present exercise. (That 4% is quite unrealistic as an industrial yield is irrelevant.) On this basis the Maraetai study gave a LEV of $96 per acre for the 25,000-acre block as it stood before land-clearing activities commenced. This is the "target" for the Faustmann formula.

APPLICATION OF FAUSTMANN FORMULA

(9) Perusal of the Maraetai study shows that selection of data for feeding into the Faustmann formula is not at all easy. The forest model is not constructed initially as a normal forest with equal annual plantings over the length of the agreed cycle; there is a heavy concentration of development and construction expenditure during the early years; the establishment phase for a 36-year cycle is completed within 18 years; there is a small pulpwood working circle and a much larger sawlog working circle; the initial crop is all planted but in subsequent crops only 10% has to be planted; part of the forest consists of a shelterwood series; the overall conversion to normality requires that half the first rotation in the sawlog working circle be harvested as an untended pulpwood crop at age 20; and, finally, the annual cost of administration is by no means constant from year 1 onwards. All who are familiar with Faustmann's formula will concede that it is not tailored to fit the Maraetai forest model as herein described.

(10) Had an independent investigator approached the original Maraetai valuation exercise with the intention of using Fuastmann's formula, it may be assumed that he would first have assembled a series of representative costs and revenues on the basis of an average productive acre. Assuming that he had access to the full range of cost and income data as given in the Maraetai study, one concludes that his list of basic data would have been as follows:

	$ Per Productive Acre
Establishment:	
Machine planting	10
Hand planting	20
Re-establishment	6.50
Blanking	4
Releasing	6
Tending:	
Prune to 8 ft	16
Prune to 8–14 ft	18
Prune to 14–20 ft	18
Prune to 20–28 ft	18
Prune to 28–36 ft	18
Thin to waste	26
Annual administration cost	4.70
Land clearing and roading (discounted)	8 per gross acre

	$
Revenue:	
Pulpwood circle—	
Clearfellings	318 per acre
Sawlog circle—	
Lower logs	1,360 per acre
Upper logs	102 per acre
Thinnings	86 per acre
Land Area:	
Gross area overall	25,000 acres
Net area—	
Pulpwood	2,200 acres
Sawlogs	18,600 acres
Planting:	
Pulpwood circle—Hand planting	100%
Sawlog circle—	
Machine planting	60%
Hand planting	40%

The revenue quoted in respect of sawlogs is the value on forest road as given in the Maraetai study, but reduced by the cost of logging and the interest on logging capital. Clearfelling of tended sawlog stands commences in year 38.

(11) This information is now used to demonstrate how such a per-acre forest budget would probably be used with the Faustmann formula. It is evident that there are two diverse management regimes, so the area devoted to each must be evaluated independently. Because the cost of the initial tree crop exceeds the long-term replacement cost, the excess is treated as a once-for-all capital outlay in year 1; this sum is then treated as a capital deduction similar to the capitalized annual administration charge. At that point the two sets of results are combined, thereby obtaining a weighted average value, inclusive of all land improvements, for the total productive forest area. The average cost inclusive of non-productive land is wanted, so the result is adjusted to suit, and finally the costs of land clearing and the main access roads are deducted so as to show the unit expectation value of the Maraetai Block in its original unimproved state. Apart from any incidental changes in the actual mode of presentation, Appendix 1 represents the traditional application of Faustmann's formula to the information listed.

(12) This methodology gives an indicated LEV of $180 per acre for the Maraetai Block under the prescribed management plan. This is close to twice the unit value of $96 shown by the original study based on precise accounting techniques — a degree of divergence which, to say the least, is alarming. Close examination shows that there is more than one economic factor responsible, but the major cause is the spread of the planting phase over a period of 18 years. In the Faustmann approach, which concerns itself with a solitary forest acre, the assumption is that planting is done in year 1. In actual fact, the final acre of land lies idle for another 17 years but nevertheless carries the cost of interest for the whole period. This has a very marked effect on the discount period, a fact which is automatically taken care of in the parent

Maraetai model where the entire chronology of the investment is correctly recorded.

(13) As pointed out earlier, the Faustmann formula assumes that a single representative acre can be identified; therefore unless this "average acre" which is fully representative of the entire forestry project can be located, not only physically but also chronologically, the basic prerequisite for a satisfactory Faustmann valuation will be lacking. As Joubert (1966) says:

> In a case where it is impossible to afforest the entire land area in the first year after purchase, the rate of afforestation will affect the purchase price because a portion of the land will be unproductive. A calculation of an hypothetical case revealed that if a plantation of, say, 3,600 acres were to be afforested within the first year of purchase, a price of £28 per acre could be paid. However, if the rate of afforestation is only 400 acres per annum, the purchase price of the land should not exceed £22.5 per acre. Although this factor will not carry much weight when bargaining for a lower land value, the timber grower, or prospective timber grower, cannot afford to ignore its importance.

In this particular example, the necessity to spread the planting programme over a period of only 9 years has the effect of reducing the economic value of the land by 20%. It therefore follows that the reduction will be much greater where, as in the Maraetai example, afforestation is spread over 18 years.

CAUSES OF EXAGGERATED VALUATIONS

(14) General observations over a number of years on the use of Faustmann's formula suggest that this need to operate in terms of an average forest acre has not been recognized as a fundamental prerequisite where a reliable estimate of LEV is desired. The formula gives the unit value of the area which is planted in year 1, but this $180 cannot be applied to the remainder of the block. It is not always easy to determine the average year in a geometric series; in the present case, Appendix 2 shows how the value of the average acre can be found when only the value of land planted in year 1 is known. With the average acre, chronologically speaking, now known, the initial LEV of $180 is reduced to only $128 per acre. But this figure is still one-third higher than it should be.

(15) Reverting to the Faustmann formula, this cardinal principle can be noted: although the formula sketches the economic profile for a solitary forest rotation, the underlying assumption is that the cycle of events and related expenditure will be repeated in perpetuity. The formula moreover implies that forest expenditure is spread uniformly over every productive acre and also that indirect expenditure is spread uniformly in time — an idealistic situation which can rarely, if indeed ever, be achieved in practice. Examination of the Maraetai model shows that a marked concentration of expenditure for land clearing and for the provision of capital services such as roading, fencing, and water supply occurs during the early years of the forest. Similar remarks apply to H.Q. buildings, forest accommodation, equipment of various kinds, and vehicles. In each case expenditure is incurred well in advance of much of the related afforestation programme —

e.g., an office and store are erected almost at the beginning of planting and therefore initially each planted acre will carry a much higher proportion of this cost than Faustmann's formula would recognize. The only capital expenditure of this nature which has been taken into account so far is the cost of land clearing and roading; nothing has been done about the cost of such capital items as buildings, vehicles, and mechanical equipment because the structure of the N.Z. Forest Service accounting system indicates that these items are very likely to be omitted when Faustmann's formula is applied.

(16) Much depends on just how Faustmann's formula is interpreted, that is to say, what is read into it. The early background of the formula is somewhat obscure, and it seems impossible at this late date to be at all sure just how Faustmann viewed the many items which make up the cost of a commercial forest. One thing is fairly certain — Faustmann did not see his formula against a background of large-scale afforestation activity in which new forests, complete with their own housing schemes, are created from large tracts of undeveloped land. It is more likely that he saw his formula against a setting of relatively small areas of forest land forming part of, or extensions to, continental estate forests already well established and complete with a comparatively stable administrative overhead and well ordered management routine. Against such a background Faustmann's expression for the annual cost of forest administration (e/O.Op) may have been completely free of all ambiguity. It seems clear from the comments of writers such as Hiley (1954, 1956) and others, who have likewise tended to write more from a background of estate forestry than from one resembling the contemporary New Zealand scene, that they also regarded Faustmann's formula as quite satisfactory for its purpose and free from any ambiguity. The capitalization of the annual cost of administration was quite evidently intended to include, *inter alia*, full recognition of all costs pertaining to any capital assets not specifically catered for elsewhere by the formula.

(17) Changes since Faustmann's day have obviously had a bearing on any looseness of interpretation that has crept into use of his formula. When Faustmann developed his formula, the tractor, motor vehicle, and power saw simply did not exist; there was no complex system of machine accounting — indeed the entire scope of financial transactions was very much narrower, and the system of forest records was essentially far more simple than is found today. But as the modern forestry scene has become progressively more complex, so does it appear that Faustmann's formula has become less appropriate for the valuation of forest land. This modern development of a complex financial background where few can "see the wood because of the trees" is probably the main reason for a degree of misunderstanding as to precisely what Faustmann's e/O.Op was intended to signify. It is now clear that many have failed to read into this expression all that Faustmann evidently intended. Indeed, it might be fair comment to suggest that the very abbreviated nature of Faustmann's formula leaves rather too much to the imagination of those who must use it within the context of practical, every-day forestry rather than from the detached academic viewpoint.

(18) For contemporary New Zealand forestry, it seems to have been well understood that the expression e/O.Op was designed to cover all administrative expenditure and general forest overhead costs. But the comprehensive nature of the cost items now covered by this single insignificant expression gives rise to a serious weakness. It is all too easy for an important cost to be overlooked. This is particularly true in the case of N.Z.F.S. forest accounting. As far as depreciable assets of an administrative nature are concerned, the indirect costs include both the annual charge for depreciation and also any expenditure on repairs and maintenance. For non-depreciable assets such as roads, the full annual maintenance cost alone is included in the N.Z.F.S. concept of indirect costs or forest overhead. The design of the Public Accounts system does not demand anything more than this. As a result, it seems to have been taken for granted that no more was required by Faustmann's formula than to spread the cost of capital assets over the tree crop through the annual charge for depreciation.

(19) Thus is found what might logically have been expected where an over-simplified, century-old valuation formula is used in conjunction with the modern complex forest accounting system of a large department of state: a lack of precision in accommodating the one to the requirements of the other.

Before any depreciation can be costed against the growing crop, the initial cost of the asset itself must be paid in full and therefore must be incorporated within the forest investment from the very outset (as indeed it is in the parent Maraetai study). Thereafter, the annual depreciation charge serves to maintain effectively the value of the initial investment. Faustmann's formula is not at all informative on this point, but the annual "e" clearly must include an implied charge for interest on the aggregate capital value of buildings, services and general works. Earlier in this analysis, the discounted cost of land clearing and roading (because these seem to have been generally recognized as deductible improvements) were deducted but these capital costs could just as easily have been left in the forest investment and instead the interest thereon added into the annual "e".

(20) Similarly, it is equally logical to impute to Faustmann's "e" the appropriate amount of interest to cover the capital investment in vehicles and mechanical plant up to (but not including) the logging phase. Alternatively, this interest charge can be incorporated within the standard hire rates relevant to each item; indeed, some cost accountants would prefer this latter system, but it is scarcely appropriate for State forests. The essential point is that here is the key to most of the remaining disparity between the two land expectation values. As each asset is paid for, the cost becomes part of the forest investment; therefore, economic interest begins to operate immediately. But although Faustmann's formula is to be interpreted as incorporating an annual charge for interest on such capital expenditure, it is really more convenient to prepare and deduct a single summary of all relevant expenditure duly discounted to the appropriate base year.

(21) Appendix 3 illustrates this procedure for the Maraetai model. In this example the expenditures are all discounted initially to year 1; then the unit cost per acre is adjusted to year 10, the

base year. It may be more convenient to take the discounting process direct to the base year, when, of course, all expenditure occurring prior to the base year must be compounded. Appendix 3 shows that the value of all capital expenditure discounted to the base year amounts to $36 per acre when computed on the gross land area of 25,000 acres. It so happens that in the present model land clearing and main access roads have already been allowed for to the extent of $10 per acre in Appendix 2. Normally, a single all-inclusive schedule would be prepared for capital items, but now it is merely the difference of $26 that is deducted from the $128 per acre derived in Appendix 2. At this point the LEV has been reduced to $102 per acre — leaving only a small disparity of $6 still to be accounted for.

FURTHER DIFFERENCES EXAMINED

(22) Left now are only two items of cost which were included in the original Maraetai study but which have not yet been formally introduced into this comparison: these are an allowance of $2,000 p.a. to cover contingencies over the first 40 years, and the provision of an additional $100,000 at the end of year 40 by way of working capital. The former was intended to cover any deficiencies in the basic costing; the latter is recognized as a necessity in any business undertaking where expenses in producing the market product must be met by anything up to three months or more before cash from the sale thereof is actually received. The two sums, duly discounted to year 1, amount in total to $60,000 or $2.40 per acre, which in turn equates to $3.60 (or, say, $4 in round figures) for the average acre which is located chronologically at year 10. With this further capital sum deducted from the indicated LEV of $102 an amended figure of $98 per acre is obtained for the entire Maraetai Block as valued by Faustmann's formula. It appears that all of the significant factors which operated to inflate the initial assessment of land value by the Faustmann formula have now been located and identified.

(23) Although the equivalent of an accountant's reconciliation statement has been produced, it must be conceded that there is probably an element of chance in the very close agreement of the two results. The traditional Faustmann formula assumes a fairly stereotyped pattern of forest operations, and, to accommodate the Maraetai model to the exacting requirements of the formula, the model has been reduced to a much more simple structure than that shown in the Lincoln study. Selected from the original model were those characteristics representative of the long-term operation of the forest as a commercial going concern, with stability of input and output. Only a very limited attempt was made to deal with the complex pattern which permeates the first 40 years of the project. This over-simplified approach postulates a pulpwood working circle on a 22-year cycle and a net yield of 8,500 cu. ft per acre. In fact, however, the rotation varies from 18 to 23 years during the first four years of clearfelling, and the yield from as low as 6,500 cu. ft during the same period. Pulpwood also comes in large quantities from both the shelterwood series and the untended first half of the sawlog working circle; in these the yield varies from 5,000 to 7,500 cu. ft per acre. Evalu-

ation of the effects of these substantial variations on the Faustmann results has not been attempted, but it is known that the effect would be to reduce the indicated LEV still further, other things being equal.

(24) However, other things are not equal. During the first 40 years there is a wide variation in the unit rate of indirect expenditure, and for the early years of the establishment phase the cost per acre actually exceeds the long-term cost of $4.70 used in the Faustmann evaluation. But over the entire 40 years the average cost per acre per annum is considerably less than the stabilized long-term cost adopted. Expressed as a capital sum discounted to year 1, this difference in cost has the effect of adding about $10 per acre to the Faustmann LEV. Because in paragraph 22 it was possible to finally reconcile the Faustmann approach with the original model almost $ for $, it is concluded that these other departures from the simplified pattern are virtually self-compensating in their effect on the economics of the project and therefore can be ignored as far as this comparative study is concerned. To keep the study as simple as possible, the formal comparison of the two techniques has been terminated at this point but rather rough calculations suggest that, if the effect of these factors were to be assessed in detail, there would be no significant change in the amended land value of $98 per acre.

SUMMARY OF FINDINGS

(25) A simple recapitulation will help to put the situation in clearer perspective:

(a) In any large-scale forestry project, the spread of establishment operations over a period of years will inevitably reduce the economic value of the land because of the consequent lengthening of the non-productive period. The Faustmann formula contains no built-in compensation for this factor.

(b) To provide a realistic land valuation, the Faustmann formula necessarily depends on the effective isolation of an "average forest acre" that fairly represents the economics of the project as a whole. This seems to have been largely overlooked hitherto.

(c) Because the N.Z. Forest Service costing system ignores interest on any expenditure incurred to provide capital assets, both fixed and mobile, the annual cost of indirect expenditure as extracted from Departmental records will be too low to satisfy Faustmann's e/O.Op. It is likely that the same comment would also apply to some of the private forestry costing systems.

(d) Unless the user of Faustmann's formula modifies his technique so as to recognize effectively the significance of these factors, his indicated LEV is likely to be anything up to 100% higher than the true economic value of the area as a whole. How far the formula itself contributes to this is probably a matter of opinion.

(26) In retrospect, it seems fair to conclude that Faustmann's formula has possibly been used rather too casually at times when

accurate valuations have been required — but this is not surprising. The formula is ill-suited to a modern system of forest finance and fails to give a realistic valuation because it leaves too much to the discretion of the forester who invokes it. It is almost impossible to be sure that all essential costs have been included unless the user has a very good knowledge of the relevant accounting system. Probably one of forestry's most pressing needs is for a better liaison between the forester and the financial accountant. Between these two there is a kind of no-man's land which tends to accentuate any weakness inherent in the structure of the formula itself. The most effective way to bridge this gap is by introducing the management accountant to forestry; his specialist skills are those of the business economist, and his principal task would be to transform the financial accounting system into a viable economic tool.

PROCEDURE TO ENSURE ACCURACY

(27) No problem arises when Faustmann's formula is used to compare the economics of two or more alternative policies, regimes, or management systems; if there is any distortion of land values, all are likely to be uniformly affected. But occasionally in the future, as in the past, a simple and convenient method will be wanted at times for estimating a realistic value for a given area of land.

In the interests of simplicity, clarity, and emphasis, the essential rules are "spelt out" in appropriate detail; if they are followed with care, there is every reason to expect that the resultant LEV by Faustmann's formula will not differ unduly from that which would be given by a detailed investment analysis. The latter method is not as simple and convenient to use as Faustmann — but it is inherently more reliable.

(28) When a *bona fide* economic value is required for any given area of land, this procedure should be used:

(a) Select representative data for every significant item of expenditure and revenue on a net per-acre basis, and then apply these data to the Faustmann formula in accordance with traditional usage.

(b) If more than one species and/or rotation is involved, separate LEVs must be established for each. At this stage *no* deduction should be made for the cost of any capital improvements such as clearing, roading, fencing.

(c) If there is a significant difference between the cost of establishing the initial crop and the estimated long-term cost of replacement crops, this difference should be accounted for (as a plus or minus) as indicated in Appendix 1.

(d) The indicated LEV derived from this conventional application of Faustmann's formula must then be discounted by a factor which represents the difference between year 1 and the average year for the entire planting period.

(e) Where complementary expectation values have been established, it is logical at this stage to calculate a weighted average

expectation value per net productive acre. This value must then be equated to a gross overall unit value which includes all non-productive land.

(f) The final adjustment is to arrange *all* capital expenditure in chronological sequence and then to discount this series to the base year. The discounted total is then divided by the gross land area, and the resultant per-acre cost is deducted from the end-result of (e) above.

Two further matters should be mentioned in passing. First, in private forestry the user of Faustmann's formula should be quite clear in his own mind whether his choice of interest rate is before or after allowing for the incidence of taxation. Secondly, there is the treatment of depreciation; compound interest must not be charged on depreciation allowances; instead, the depreciation charge must be converted into its equivalent as a discounted annuity.

CONCLUSION

(29) The need for extreme care in the use of Faustmann's formula, if a reliable land value is required, is obvious. The formula is not as accurate as a detailed investment analysis, but, provided the precautions outlined herein are observed, it would seem to produce valuations which are not significantly astray. The danger scarcely arises when Faustmann is used to compare the economics of alternative management policies, though even here the accuracy of the comparison could be upset if significant changes in expenditure on buildings, communications, and equipment are not correctly taken into account. Perhaps the greatest single need in public forestry today is the modern science of management accounting with its emphasis on analysis, interpretation, and business economics.

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APPENDIX 1

THE LAND EXPECTATION VALUE OF THE MARAETAI BLOCK ACCORDING TO FAUSTMANN'S FORMULA[1]
(Interest @ 4%)

	Per Production Acre $	$
(a) *Pulpwood Working Circle*:		
(1) Revenue:		
Clearfelling at age 22		318
(2) Expenditure:		
Planting ($6.50 × 2.37)	15.40	
Blanking ($4.00 × 2.28)	9.20	
1st Release ($6.00 × 2.28)	13.60	
2nd Release ($6.00 × 2.19)	13.20	52
		$266
(3) Divided by $(1.0p^n - 1)$: $266/1.37:	194	
(4) Less planting differential ($20–6.50):	14	180
(5) Less annual indirect costs $4.70/0.04:		118
Value cleared and roaded		$62
(b) *Sawlog Working Circle*:		
(1) Revenue:		
Sawlogs at age 37[2]	1,360	
Pulpwood at age 37	102	
Pulpwood at age 20 ($86 × 1.95)	168	1,630
(2) Expenditure:		
Planting ($6.50 × 4.27)	27.80	
Blanking ($4 × 3.95)	15.80	
Releasing ($6 × 3.95)	23.80	
Pruning 1 ($16 × 3.51)	56.20	
2 ($18 × 3.37)	60.60	
3 ($18 × 3.12)	56.20	
4 ($18 × 2.88)	51.80	
5 ($18 × 2.66)	47.80	
Thin to waste ($26 × 2.88)	74.80	414
		$1,216
(3) Divided by $(1.0p^n - 1)$: $1,216/3.27:	$372	
(4) Less planting differential ($14–6.50):	8	$364
		118
(5) Less annual indirect costs $4.70/0.04:		
Value cleared and roaded		$246
(c) *Average Land Value (Productive Land)*:		
Pulpwood circle ($62 × 2,200/20,800)		$6
Sawlog circle ($246 × 18,600/20,800)		$220
Average value per acre (improved):		$226

(d) *Average Land Value Overall*: Up to this stage, all unit values are expressed in terms of the net productive forest area. The non-productive areas are now introduced so as to obtain an average per-acre value for the entire Maraetai Block (improved basis).

$226 × 20,800/25,000 = $188 per acre

(e) *Value on an Unimproved Basis*: Land clearing and road construction extend over a number of years, but the total cost discounted to year 1 is $180,000 or $8 per gross forest acre, in round figures. Therefore the indicated LEV is:

Average improved value	$188 per acre
Less cost of improvements	$8 per acre
Value before clearing:	$180 per acre

[1] Originally this analysis was carried out in £.s.d. and values were rounded to the nearest £. Conversion of all data direct to dollars now means that minor discrepancies creep in occasionally as a result of this rounding.

[2] The compounding period has been shown as 37 years because clearfelling the sawlog working circle commences in year 38. Actually sawlog areas are managed on a cycle of 36 years. This would increase the indicated land value somewhat.

APPENDIX 2

MODIFICATION OF THE FAUSTMANN FORMULA TECHNIQUE SO AS TO COMPENSATE FOR THE SPREAD OF THE AFFORESTATION PROGRAMME OVER 18 YEARS

(see also footnotes to Appendix 1)

(a) Formula. The formula for averaging a geometric series such as a given number of acres of forest land which are planted in succession over a period of years at compound interest is*:

$$X = \frac{Y}{N}\left\{\frac{1-\frac{1}{1+p}^{N}}{1-\frac{1}{1+p}}\right\}$$

Where Y = highest land value of the series of forest acres
N = number of years over which planting is spread
p = the rate of interest
X = the value of the average acre.

(b) Because two distinct planting series are involved, it is necessary to work out both working circles separately before integrating them. Using unit values derived in Appendix 1 (a) and (b), the calculations are:

Pulpwood circle: $62/5 × 0.178/0.0385 = $58
Sawlog circle: $246/18 × 0.507/0.0385 = $180

Weighted Average

Pulpwood $58 × 2,200/20,800:	$6
Sawlogs $180 × 18,600/20,800:	$160
Value per acre (after improvement):	$166

* This formula was supplied by the F.R.I. Biometrics Section.

(c) *Average Land Value Overall*

Equating the above unit improved value of $166 to an average value inclusive of all non-productive land gives:

$166 × 20,800/25,000 = $138/acre

(a) *Cost of Land Improvement*

Discounted to year 1, the cost of land preparation and roading is $180,000 which over the entire forest area of 25,000 acres amounts to $7.20 per acre.

The whole of this cost related to year 1, whereas the concern now is with the "average acre" which is located at year 10. So the cost of land improvement is increased from $7.20 acre to $10.80 for the average acre. Therefore the value of the gross land area is:

	$
Average improved value	138 per acre
Less improvements	10 per acre
Unimproved value	128 per acre

APPENDIX 3

CAPITAL EXPENDITURE ON THE MARAETAI BLOCK FOR LAND IMPROVEMENT, ROADING, BUILDINGS, PLANT, VEHICLES AND OTHER EQUIPMENT (EXCLUSIVE OF LOGGING VEHICLES AND PLANT)

Year	*Land Clearing* $	*Roads Buildings Services* $	*Plant Vehicles Equipment* $	*Total Expenditure* $	*Expenditure Discounted to Year 1 at 4%* $
1	66,000	25,600	12,800	104,400	104,400
2	—	25,600	—	25,600	24,600
3	—	25,600	4,000	29,600	27,400
4	10,000	25,600	—	35,600	31,600
5	—	25,600	—	25,600	21,800
6	—	21,200	27,400	48,600	40,000
7	400	21,200	—	21,600	17,200
8	600	21,200	8,000	29,800	22,600
9	400	21,000	—	21,400	15,600
10	600	21,000	—	21,600	15,200
11	400	19,200	5,200	24,800	17,000
12	16,600	19,000	—	35,600	23,200
13	400	19,000	6,000	25,400	15,800
14	—	19,000	—	19,000	11,400
15	600	19,000	—	19,600	11,400
16	4,000	14,200	—	18,200	10,200
17	4,000	14,200	—	18,200	9,800
18	—	14,000	2,000	16,000	8,200
19	—	14,000	4,000	18,000	8,800
20	—	14,000	4,000	18,000	8,600
21	—	70,800	12,000	82,800	37,800
22	—	70,800	—	70,800	31,000
23	—	70,800	—	70,800	29,800
24	—	70,600	—	70,600	28,600
25	—	70,600	—	70,600	27,400
26	—	1,600	—	1,600	600
27	—	1,400	—	1,400	600
28	—	1,400	—	1,400	400
29	—	1,400	—	1,400	400
30	—	1,400	—	1,400	400
			Total:	$ 949,400	601,800

(1) *Unit Cost*: Based on a gross land area of 25,000 acres, the discounted cost in year 1 is $24 per acre. This in turn equates to $36/acre for the average acre which has been identified with planting in year 10.

(2) Whereas in the present model the "average acre" can be readily identified with a specific year's planting, it may be easier to centre the entire calculation directly on the average year instead of discounting first to year 1.

(3) The distribution of expenditure emphasizes the burden of capital expenditure during the early years of any large-scale forestry enterprice: *e.g.*, years 1 to 5, $60/acre; years 14 to 18, $6/acre.