ECONOMIC PRINCIPLES OF LAND USE: A COMPARISON OF AGRICULTURE AND FORESTRY

J. T. WARD

SYNOPSIS

Proposals for further large-scale land development in New Zealand for agriculture and forestry have focused attention upon competing demands for land and other scarce resources. The present paper outlines the basic economic principles of land use and suggests techniques, based on the concept of "land expectation values" for use in empirical studies. A case study of an area on the Canterbury Plains illustrates the application of these principles to specific problems.

INTRODUCTION

The realization that forestry could play an increasingly important role in the New Zealand economy leads naturally to a discussion of some of the economic considerations involved. The N.Z. Forest Service has suggested that this country will need a further million acres under trees by the end of the century. This proposal focuses attention upon the relationship between forestry and agriculture, as it may be assumed that much of the land suitable for planting is in agricultural use at the present time, or is potentially capable of such use. The relationship is not necessarily a competitive one, however; it may in fact be complementary. The integration of these two vital enterprises is an important feature of rural policy in several European countries, foremost amongst them Sweden, and growing attention is being paid to it in several other parts of the world (Inst. of Agrarian Affairs, 1955). It is therefore encouraging to read that the Forest Service envisages that half of their proposed expansion programme should come from a farm-forestry effort (Entrican, 1960). Nevertheless, any further expansion of forestry will mean some competition with agriculture (and with other uses) for some land and for some labour and capital as well. Although such competition cannot be resolved solely on economic grounds, since social factors can never be left out of account, a review of the economic considerations involved will help to provide an objective basis for taking policy decisions. This short paper will therefore concentrate entirely on the economic aspects of competition between agriculture and forestry.

Basic Economic Principles of Land Use

The economic principles which may be applied to securing the best use of land are no different from those employed in determining the optimum allocation of all resources. In allocating land amongst competing uses it is essential to realize that land cannot...
be considered in isolation, because it cannot be used in isolation. This is evident from the very phrase, land use, which implies the application of labour and capital to land. Both labour and capital are scarce resources whose use has to be economized, and in New Zealand, in comparison with many other countries, they are relatively more scarce than land. Their use in any industry entails a reduction in some other form of production. This loss of output in other industries is the real cost to the nation of using resources to produce butterfat or timber. It may be noted that during a period of unemployment some supplies of labour and capital have no alternative use and hence no real cost. This was the case during the depression of the inter-war years when large areas of exotic forest were established in New Zealand at little real cost to the nation.

The fact that co-operating factors of labour and capital have to be withheld from other employment means that the criterion of land use cannot be the total value of output (gross output) achieved from a given land area. The type and amount of other resources required must also be taken into account. By deducting the costs of these other resources from the value of gross output it is possible to calculate the productive value (net value) of the land itself, i.e.,

\[
\text{Net output of land} = \text{Gross output of land} - \text{Non-land costs}. 
\]

The concept of net output provides the economic criterion needed for land use decisions. The optimum use of land is secured when it is allocated amongst competing uses in such a way that the sum of its net outputs is maximized. This will be achieved when the value of its (marginal) net output is the same in all uses.

In order to simplify the argument I have ignored the possibility that the imputed residual value of land may not be equal to its true marginal productivity.

Application of These Principles to Competition between Agriculture and Forestry

This reasoning may be applied to competition for land between agriculture and forestry. Since both require capital and labour as well as land, the choice between them must be based not upon gross output per acre (of, say, timber or butterfat), but upon their comparative net outputs when the costs of other resources have been deducted.

In agriculture, gross output consists of the value of sales (fat lambs, butterfat, wool, etc.) off the property, plus any change in stocks. The costs to be deducted comprise expenditure on materials, such as seeds, fertilizers, fuel and oil, and on services, such as regular labour, transport and contract work. They must also include an allowance for the wages of management of the farmer, and interest on all capital invested on the property except that corresponding to the unimproved value of the land itself. The latter is then isolated as a residual to give the net output of the land in agricultural use.

In forestry, gross output consists of the sale value of trees (for timber, pulp, etc.), while costs are usually recorded in terms of operations (planting and tending) rather than materials or services.
This is, of course, merely a matter of convenience in accounting. Forestry operations could readily be broken down into costs of materials and labour and management services.

**The Treatment of Time in Land Use Analysis**

The calculation of the net output of land already in agricultural use is little affected by the element of time because, owing to the relatively short period of production of most farm enterprises, many of the inputs and outputs relate to the same year. The major exceptions are inputs of long-term capital (in the form of land improvements and buildings) and medium-term capital (machinery), which yield a flow of services over a period of many years. Although capital investment in these items takes place at the beginning of the period, the costs involved may conveniently be expressed in terms of annual charges for interest and depreciation. In this form they can be included in the calculation of the net output of land on an annual basis. This procedure has a sound practical as well as a theoretical justification since many farmers borrow on long term to provide major improvements to their properties and repay the loan by annual payments of interest and capital.

The position is more complex, however, in the case of forestry, which is outstanding in its long period of production. Most of the costs of production are incurred at the beginning (planting), or in the early years (pruning), but the major yield (wood) is secured only at the end of the rotation. The long period of waiting involved complicates the calculation of net output because it is not possible to make a direct comparison of costs incurred in one year with returns forty or fifty years later. This is a fundamental problem of analysing the economics of forests managed on a rotation basis, and is relevant to any discussion, such as the present, of establishing new forests. It does not arise in the case of existing forests managed on a sustained yield basis, which requires a different form of analysis. It is a matter of common observation that a return of £100 in fifty years' time is not worth £100 here and now. The present is preferred to the future. It is the incidence of time preference which deter many individuals from engaging in forestry, even when the financial returns from it can be shown to be as high as, or higher than, those from other forms of investment. This is one of the primary reasons why the State, with a longer viewpoint than the individual, must concern itself with forestry.

In order to bridge the time gap between costs and returns, it is necessary either to discount the future returns, or to compound the present costs, at the prevailing rate of interest. These processes are widely used in forestry economics, particularly in the form of the Faustmann formula (Hiley, 1956). This may be presented in several ways; the one selected here, as most appropriate in the present context, is in terms of the land expectation value. This may be regarded as the capital sum that could be paid now for land to be planted to forestry, if all other inputs were to be rewarded at the prevailing market rates and their costs compounded over the period of the rotation. The equation then takes the following form:

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\[ L_f = \frac{Y_n + \sum T_a(1+r)^{n-a} - \sum P_b(1+r)^{n-b} - C(1+r)^n}{(1+r)^n - 1} \]

- \( L_f \) — land expectation value in forestry
- \( Y_n \) — standing value of timber in year \( n \)
- \( n \) — length of rotation
- \( \Sigma T_a \) — sum of value of thinnings during rotation
- \( \Sigma P_b \) — sum of costs of pruning during rotation
- \( C \) — cost of establishment
- \( e \) — annual costs of management
- \( r \) — rate of interest

**Comparison of Land Expectation Values**

The land expectation value, calculated in this way, may be regarded as the capitalized net output of land under forestry. As a capital value it cannot be compared directly with the annual net output of land in agriculture. In order to compare like with like the latter must also be capitalized. This can be done by means of a capitalization formula widely used in farm appraisal. To suit the present context the usual formula has been modified to express it in terms of a land expectation value in agriculture, namely:

\[ L_a = \frac{(i-c)}{r} \]

where,

- \( L_a \) — land expectation value in agriculture
- \( i \) — annual gross output
- \( c \) — annual costs
- \( r \) — rate of interest

It is now possible to make a direct comparison of the capital value of land in the two competing uses. In terms of the land expectation values it may be said that, where

- \( L_f > L_a \) — the land should be used in forestry;
- \( L_f < L_a \) — the land should be used in agriculture;
- \( L_f = L_a \) — the land use is a matter of economic indifference.

**The Application of the Basic Formulae**

The application of these general economic principles, and of the basic formulae, to specific land use cases involving forestry and agriculture requires extensive and carefully compiled information on financial costs and returns. A limited amount of the type of agricultural information required is available for certain farming areas in New Zealand, and surveys and compilation now being undertaken by the Forest Service will provide comprehensive data for forestry. When these are available it should be possible to conduct more, and more thorough, case studies of the type given below.

**CASE STUDY: LISMORE SOILS — BURNHAM/AYLESBURY AREA**

The case study presented here should be regarded essentially as an exercise showing how the principles developed in this paper
may be applied, rather than a study designed to compare the productivity of agriculture and forestry in a particular area. The Burnham/Aylesbury area on the Canterbury Plains is by no means well suited to timber production, owing to relatively unfavourable climatic conditions and light, shallow soils. Indeed, the primary purpose of plantations there has been to serve as windbreaks, rather than for the production of timber. Nor is the area very productive in pastoral use. The choice of this area was fortuitous in that it was the only one for which the necessary input/output data for both agriculture and forestry could be obtained.

1. The Land Expectation Value under Forestry

In calculating the land expectation value under forestry in this area, use has been made of data provided by the courtesy of E. A. Cooney and A. W. Grayburn of the Selwyn Plantation Board. The costs given below are based on accounts kept for one of the Board's plantations of 1,000 acres, which was established in the late 1930s; they have been re-valued at present-day prices to put them on a comparable basis. The returns are based on a similar, though older plantation in the same area.

Assuming a 40-year rotation of radiata pine, the following costs and returns were used:

<table>
<thead>
<tr>
<th>Return or Cost (per acre)</th>
<th>£400</th>
<th>£16</th>
<th>£40</th>
<th>£11</th>
<th>£5</th>
<th>£12.1</th>
<th>£1.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final yield</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First thinning, at 15 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second thinning, at 30 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First pruning, at 15 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High pruning, at 20 years</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of establishment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual cost of maintenance</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

The rate of interest was taken at 5%.

Substituting these values in the Faustmann formula gives $L_f$ equal to

$$L_f = \frac{\£400 + 16(1.05)^{15} + 40(1.05)^{10} - 11(1.05)^{15} - 5(1.05)^{10} - 12.1(1.05)^{15}}{(1.05)^{10} - 1}$$

$$= \frac{\£400 + 54 + 65 - 37 - 13 - 85}{0.05} - 30$$

$$= \£(384/6.05) - 30$$

$$= \£63.4 - 30$$

$$= \£33.4$$

In general terms, the land expectation value under forestry is approximately £33 per acre. In this example this must be taken as a maximum value because it was not found possible to allow for risks in forestry (fire, windthrow, insect attack, etc.).

2. The Land Expectation Value under Agriculture

Data relating to the gross output and costs of production on forty farms in the Burnham/Aylesbury area were obtained from an economic survey carried out by the Department of Farm Management at Lincoln College. The purpose of the survey was to

* Thanks are due to J. W. B. Guise and G. Mason for the provision of this unpublished information.
establish efficiency standards and statistical measures of inter­relationships between farm inputs and outputs. For the present paper, data for the year 1957/8 and 1958/9 were analysed to show the value of gross output, the costs (other than land costs) of production, and the residual value, which was attributed to the unimproved value of land itself. These values, expressed in terms of £'s per 100 acres, are shown below in the form of a farm budget.

### Output (per annum)

<table>
<thead>
<tr>
<th>Item</th>
<th>£'s per 100 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep sales</td>
<td>611</td>
</tr>
<tr>
<td>Wool and skins</td>
<td>330</td>
</tr>
<tr>
<td>Grain and seeds</td>
<td>141</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>42</td>
</tr>
<tr>
<td>Change in stock and crops</td>
<td>27</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,151</strong></td>
</tr>
</tbody>
</table>

### Inputs (per annum)

<table>
<thead>
<tr>
<th>Item</th>
<th>£'s per 100 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock purchases</td>
<td>230</td>
</tr>
<tr>
<td>Wages and contract</td>
<td>106</td>
</tr>
<tr>
<td>Seeds and manure</td>
<td>94</td>
</tr>
<tr>
<td>Motor expenses and cartage</td>
<td>77</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>52</td>
</tr>
<tr>
<td>Repairs and maintenance</td>
<td>63</td>
</tr>
<tr>
<td>Rates and insurance</td>
<td>21</td>
</tr>
<tr>
<td>Depreciation</td>
<td>70</td>
</tr>
<tr>
<td>Interest on capital (excluding land)</td>
<td>146</td>
</tr>
<tr>
<td>Wages of management</td>
<td>109</td>
</tr>
<tr>
<td><strong>Total costs</strong></td>
<td><strong>968</strong></td>
</tr>
</tbody>
</table>

### Net output

<table>
<thead>
<tr>
<th>Item</th>
<th>£'s per 100 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net output</strong></td>
<td><strong>183</strong></td>
</tr>
</tbody>
</table>

The budget shows that the average gross output from agriculture in this area amounted to £11.5 per acre. When allowance was made for non-land costs of £9.7 per acre the net output of land itself was found to be £1.8 per acre. These are annual values; in order to compare them with the land expectation value in forestry they must be capitalized. Substituting these values in the formula given above and assuming a rate of interest of 5%, gives:

\[
L_0 = \frac{£(11.5 - 9.7)}{0.05} = \frac{£1.8}{0.05} = £36
\]

The land expectation value in agriculture is £36 per acre.

On the basis of these calculations, the land expectation value is slightly lower in forestry than in agriculture. No account has been taken, moreover, of the greater risk in forestry. This could possibly be allowed for by using an adjusted estimate of final yield, or by using a higher rate of interest for forestry than for agriculture. If the rate of interest in the forestry calculations were increased to 5½%, the land expectation value in that use would fall to £22 an acre.
CONCLUSION

In conclusion, the following general comments may be made.

It is suggested that the simple model presented in this paper could be used for comparing the claims of forestry to relatively small areas of land, which are already developed and in agricultural use. Where the problem is one of opening up large new areas of land, the costs of development (provision of roads and other services, housing, land clearance, etc.), and the question of access to markets must also be taken into account. They could be analysed on the same basis by introducing additional variables into the basic formulae, or, where necessary, modifying the formulae.

The use of the Faustmann formula and the farm appraisal equation requires estimates of future levels of product prices, costs and interest rates. In the case study, present values have simply been projected into the future. It is clearly highly unlikely that this will be so. If the changes that take place affect all costs and product prices in both industries to the same extent (as, broadly speaking, happens when such changes are the result of changes in the value of money), the comparison will not be invalidated. This would not be the case, however, if there were changes in the relative prices and production costs of forestry and agriculture. This problem might be tackled by either of two methods, or preferably a combination of the two.

(1) The values used in the formulae can be based on forecasts of future prices and costs instead of current values. The forecasting of future economic conditions is now receiving more attention in this country (Philpott, 1957), but much basic work has still to be undertaken.

(2) Instead of calculating land expectation values in agriculture and forestry upon one set of assumptions, a series of assumptions could be made for different

(a) product prices,
(b) costs,
(c) rates of interest.

Comparisons of agriculture and forestry could then be made on the basis of these different assumptions (Walker, 1960). In some cases the calculations might show a clear-cut advantage to one of these uses under any likely assumptions; in others, decisions would have to be based on the relative probability of the assumptions made.

REFERENCES


