The use of computer models for forestry investment and policy appraisal

Adrian Whiteman[1]

Introduction

With the development of modern microcomputers it has become much easier to perform economic appraisals of forest management and policy decisions. The use of computer models is now common in many developed countries and a number of computer programs are commercially available. These range from relatively simple programs that help the user to construct cash-flows and calculate Net Present Value (NPV) and Internal Rate of Return (IRR), to more complex packages that incorporate forest compartment databases, mapping functions and budgeting software. In addition, with an understanding of economics and some competence in programs such as spreadsheets, the forester can now perform relatively simple analyses very quickly (see, for example, Lorrain-Smith (1993) for further guidance).

One role of the Food and Agriculture Organisation of the United Nations (FAO) is to assist countries with the development and sharing of information, so that they can improve forest management and policies. The development and dissemination of tools and models forms part of this effort. FAO has collected a number of computer models for forest investment and policy appraisal and has made these freely available as part of this effort. This paper describes some of the models that are currently available.

Forest Plantation Profitability Model

Model description

This model was developed in 1999 for an FAO Technical Assistance Project in Lithuania. It is based on the Forest Investment Appraisal Package (FIAP) used by the UK Forestry Commission (Forestry Commission, 1997). The model is contained in one Excel Workbook (size: 1,380 KB), comprising five separate spreadsheets.

The planting models spreadsheet contains all of the plantation establishment and management cost data. This information can be entered as totals, or broken down into labour, materials and vehicle, machinery and equipment (VME) costs. Overheads are input as a percentage increase in costs, which can be input separately for each operation here or as a common variable (on the results spreadsheet). The year in which each operation takes place must also be entered here (or the first and last years in the case of repeated operations). The letters "T" and "F" can be used to signify the years of first thinning and felling respectively.

The yield models follow a standard format that most foresters will recognise, showing the volume and size (dbh) of thinnings and main crop at each of a number of crop ages. The convention in Lithuania is to refer to each yield model by top height at a specified age (e.g. pine-100-15 = pine that is 15 metres high at 100 years), but the model also calculates mean annual increment (MAI).

The price-size curves spreadsheet contains the price data used in the model. For each species, this is expressed as a series of stumpage prices for each dbh (see: Sinclair and Whiteman (1992) and Whiteman *et al* (1991), for a further description of price-size curves).

The lookup tables spreadsheet takes the titles given to each model and uses these to construct the drop-down menus on the results spreadsheet. It also contains a few other cells that assist with the calculations. There is no need for the user to refer to this spreadsheet.

The results spreadsheet is the interface for the model (Figure 1). General parameters, such as: the stocking rate; rotation age; and discount rate, are input into the boxes on the left-hand side. Planting models, yield models and price-size curves are selected using the drop-down menus on the right-hand side. Results are shown underneath these and include measures such as: total discounted revenue and expenditure; NPV; annualised expenditure, revenue and NPV; and the land expectation value. All of these results are presented as amounts per hectare for a single combination of costs, yield and prices. The IRR can be calculated using the solver function in the spreadsheet, by setting the target cell (NPV in cell I24) to zero and telling it to vary the discount rate (in cell E20). Similarly, the economically optimal rotation age can be found by telling the solver to maximise NPV by varying the rotation age (in cell I16).

Application

The model was used to examine the profitability of forest plantation investments in the public and private sector in Lithuania. It was also used to calculate the economically optimal rotation ages for different crops (Figure 2). The analysis showed that the stumpage prices set by the government were relatively low, resulting in a low rate of return. It also showed that the rotation ages they were using were longer than the rotation ages that would maximise NPV and IRR.

Although the model was only used for these relatively simple applications, it could also be used to appraise silvicultural investments, market development activities and to calculate forest plantation valuations (see, for example, Insley *et al* (1987) for examples). The model contains information collected in Lithuania (Mizaras, 1999), but it would be easy to replace this data with information from another country. Of all of the models presented here, this one is probably the most relevant for New Zealand.

Harvesting Cost Model

Model description

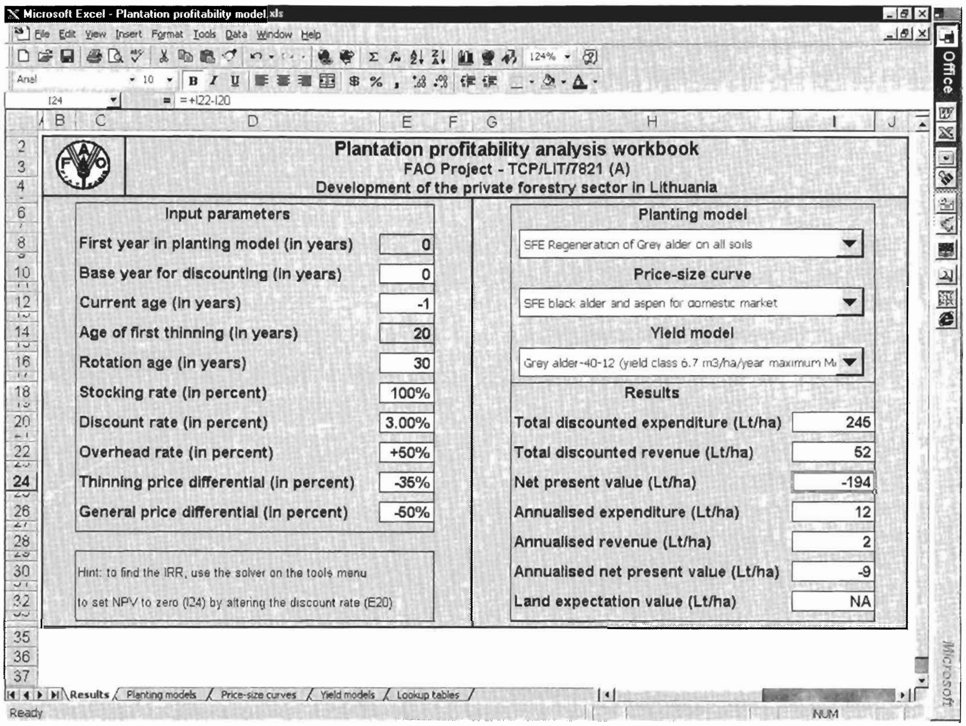
The harvesting cost model was developed in 1998 for an FAO Project in Suriname. The model calculates the delivered roundwood production cost for harvesting in the natural forest, using standard cost formulae (see:

[1] Food and Agriculture Organisation, Viale delle Terme di Caracalla, 00100 Rome, ITALY. E-mail: adrian.whiteman@fao.org. The views expressed here are those of the author and do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations.

Caterpillar (1996) and FAO (1977), for further details). The model is contained in one Excel Workbook (size: 100 KB), comprising six separate spreadsheets.

The capital spreadsheet contains the following information: the price of machinery; the average current age and expected life of machinery; repair and insurance costs; and the proportion of capital expenditure financed by loans. The consumables spreadsheet contains information about the cost of fuel and lubricants and their consumption, plus information about the cost of filters, tracks, tyres, minor spare parts and other consumables. The labour spreadsheet contains information about the number of operators required for each machine and their cost. The cost information input into these spreadsheets is used to calculate the total per-cubic-metre cost of capital, consumables and labour for each machine.

Figure 1: An example of the results spreadsheet in the plantation profitability model.



The miscellaneous data and productivity spreadsheets contain all of the other information required to convert the raw cost data into per-cubic-metre costs. The productivity spreadsheet calculates the available and effective working hours per year for each machine, based on parameters specified by the user. The output rate for each machine is used to calculate the annual production per machine and, from this, the number of machines that will be required. The miscellaneous data spreadsheet contains information about total forest production, haulage distance, haulage speeds, forest road and skid trail density and the speed of skidding and road construction. It also contains general parameters that are used in the calculations, such as the exchange rate, required level of profit and interest rate.

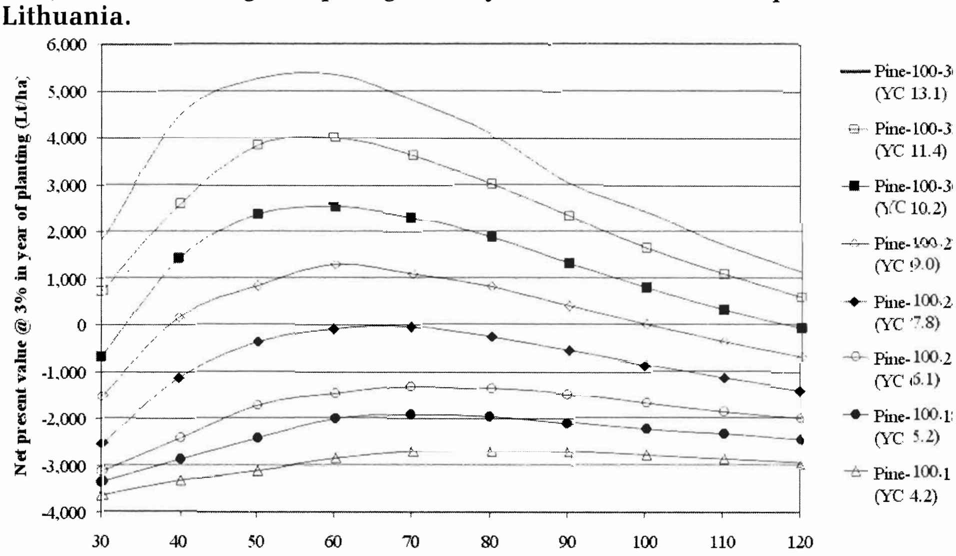
The total delivered roundwood production cost is displayed in the summary spreadsheet in Suriname Guilders (Sf) and US$ per cubic metre (Figure 3). This spreadsheet also shows the breakdown of costs by operation and by type of expenditure. The conventional way of incorporating profit into such calculations is to include an amount for "return on capital" but current practice in Suriname is to add a "mark-up" onto current expenditure instead, so the total cost (including an allowance for profit) is shown using both of these methodologies.

The workbook can be protected, so that the user can only enter data into the appropriate cells. It also contains notes and comments attached to many of the cells to assist the user. Full documentation for the model is presented in Whiteman (1999a).

Application

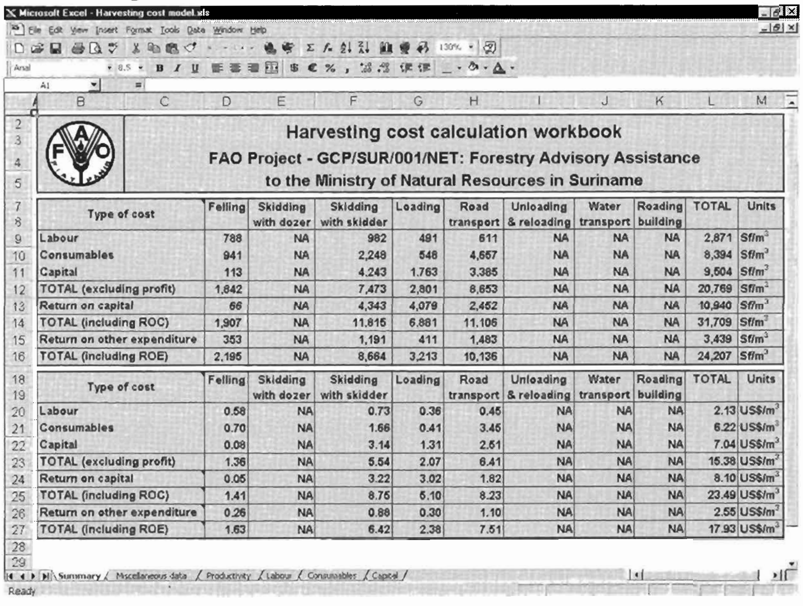
The model was designed to calculate the delivered roundwood production cost in Suriname to help the government to determine the appropriate level of forest charges (stumpage charges). In addition, it was also used

Figure 2: The relationship between net present value (with a 3% discount rate) and rotation age for pine grown by the State Forest Enterprise in Lithuania.



Note: 1,000 Litas (Lt) = US$250.00

Figure 3: An example of the summary spreadsheet in the harvesting cost model.



Harvesting cost calculation workbook
FAO Project - GCP/SUR/001/NET: Forestry Advisory Assistance to the Ministry of Natural Resources in Suriname

Type of cost	Felling	Skidding with dozer	Skidding with skidder	Loading	Road transport	Unloading & reloading	Water transport	Roading building	TOTAL	Units
Labour	788	NA	982	491	611	NA	NA	NA	2,871	Sf/m³
Consumables	941	NA	2,248	548	4,657	NA	NA	NA	8,394	Sf/m³
Capital	113	NA	4.243	1.763	3.385	NA	NA	NA	9,504	Sf/m³
TOTAL (excluding profit)	1,842	NA	7,473	2,801	8,653	NA	NA	NA	20,769	Sf/m³
Return on capital	66	NA	4,343	4,079	2,452	NA	NA	NA	10,940	Sf/m³
TOTAL (including ROC)	1,907	NA	11.815	6.881	11.106	NA	NA	NA	31,709	Sf/m³
Return on other expenditure	353	NA	1,191	411	1,483	NA	NA	NA	3,439	Sf/m³
TOTAL (including ROE)	2,195	NA	8,664	3,213	10,136	NA	NA	NA	24,207	Sf/m³

Type of cost	Felling	Skidding with dozer	Skidding with skidder	Loading	Road transport	Unloading & reloading	Water transport	Roading building	TOTAL	Units
Labour	0.58	NA	0.73	0.36	0.45	NA	NA	NA	2.13	US$/m³
Consumables	0.70	NA	1.66	0.41	3.45	NA	NA	NA	6.22	US$/m³
Capital	0.08	NA	3.14	1.31	2.51	NA	NA	NA	7.04	US$/m³
TOTAL (excluding profit)	1.36	NA	5.54	2.07	6.41	NA	NA	NA	15.38	US$/m³
Return on capital	0.05	NA	3.22	3.02	1.82	NA	NA	NA	8.10	US$/m³
TOTAL (including ROC)	1.41	NA	8.76	5.10	8.23	NA	NA	NA	23.49	US$/m³
Return on other expenditure	0.26	NA	0.88	0.30	1.10	NA	NA	NA	2.55	US$/m³
TOTAL (including ROE)	1.63	NA	6.42	2.38	7.51	NA	NA	NA	17.93	US$/m³

to examine some options to improve profitability in the forestry sector (Whiteman, 1999b).

The analysis of production costs showed how costs varied by scale of operations, harvesting intensity and haulage distance (Figure 4). Recommended stumpage prices were calculated by subtracting these costs from roundwood prices, giving values of between Sf 5,000/m³ and Sf 16,000/m³, with an average of around Sf 11,000/m³ (US$ 8.15/m³). The analysis also showed how profitability (and, hence, stumpage prices) could be improved by increasing the scale of operations, improvements in harvesting efficiency and work planning, investment in new technology and development of the processing industry and export markets.

The model contains information collected in Suriname (Whiteman, 1999c) but this could easily be replaced with information from another country. Although not particularly relevant to New Zealand, the model calculates production costs using standard formulae that could be applied to harvesting operations anywhere.

ITFMP Forest Concession & Forest Industry Models

Model description

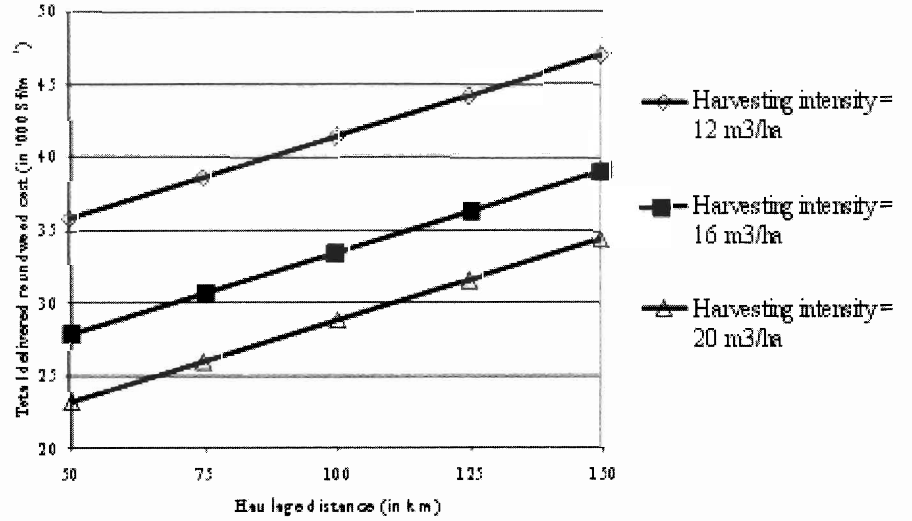
During the 1990's, the Indonesia-UK Tropical Forest Management Programme (ITFMP) developed a number of models for the Indonesian Ministry of Forestry, with support from the UK Department for International Development. The final versions of the forest concession and forest industry models run in Lotus-123 Version 3.1, but will also run in Excel. In both of these models, the data and calculations are contained in one spreadsheet. These spreadsheets can be protected and contain some checks to assist the user with data entry.

The forest concession model (size: 520 KB) is similar to the harvesting cost model described above, but was designed to analyse the large-scale forest concessions that are typically found in Indonesia. Thus, in addition to harvesting costs, the model also includes information about forest inventory and management costs and investment in facilities such as logging camps. The model also includes revenue from forest operations (i.e. income from sales). In several places (e.g. felling, production and haulage costs and forest management costs) the user can either enter costs directly (i.e. as amounts per cubic metre or per hectare) or enter raw cost data and let the model calculate the unit costs.

The model constructs cash flows for income and expenditure over an investment period of up to 20 years. It also constructs schedules for road construction, forest management activities and the purchase of machinery. The model calculates NPV and IRR for the whole forest concession (and NPV per cubic metre), taking into account depreciation, tax and financing.

The forest industry model (size: 270 KB) is similar in appearance to the forest concession model, but contains information about the income and expenditure associated with running a processing facility (e.g. sawmill or plymill). The model contains information about roundwood costs, fixed and variable manufacturing costs, product sales, capital costs and the production start-up schedule (in the case of new mills). The forest concession model was constructed after this model, so a detailed specification of roundwood costs in the forest industry model is no longer required. Instead, both of

Figure 4: The relationship between total delivered roundwood cost, harvesting intensity and haulage distance for production from the natural forest in Surinane in 1999.



Note: The exchange rate for the Suriname Guilder (Sf) is very variable; at the time of this analysis the market exchange rate was approximately Sf 10,000 - US$7.50.

the models can be used together by using the same roundwood prices in each of them.

This model also constructs cash flows for income and expenditure over an investment period of up to 20 years. It calculates NPV and IRR for the processing facility, taking into account depreciation, tax and financing. Full documentation for both of these models can be found in Scotland and Whiteman (1997a and 1997b).

Application

These models were designed to help the Ministry of Forestry to determine forest charges. The forest industry model was used to calculate the amount that the processing industry could pay for roundwood, taking into account processing costs and the required return on capital. This was calculated using prevailing product prices and cost data collected from a number of mills operating in different parts of Indonesia. These roundwood prices were then used in the forest concession model to determine the level of stumpage charges that forest concession holders could afford to pay. The cost information used in these calculations was also collected from a survey of forest concessionaires in each of the main regions of Indonesia.

These models were used on several occasions to calculate stumpage charges and staff of the Indonesian Ministry of Forestry were trained in how to use the models. For example, in 1996, the analysis showed that forest charges could be increased by US$ 10 to US$ 40 per cubic metre (depending on location), given the sawnwood and plywood prices prevailing at the time (Whiteman, 1996).

Further Developments

The models presented here can be downloaded for free from the FAO website (under Forest Finance Resources: Tools and Models at: http://www.fao.org/forestry/planning), along with several of the references given here. They come without any warranty or technical backup, but anyone with some knowledge of forest economics and spreadsheets should be able to use them or develop them further. FAO invites others to submit similar tools and models to help with this effort, which will hopefully lead to improved forest management and policies around the world.

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