network of Forest Service regional offices, rural Forest Service headquarters and numerous extension officers moving freely in the community. Our advisory services are now attenuated, and confined within a strait-jacket of 'user pays'.

A large group of highly-trained forestry company staff are presumably influenced by the problem of commercial sensitivity, and consultants probably do not venture out unless remuneration is guaranteed beforehand. The Ministry of Forestry is limited to a few key centres and appears to be severely constrained by shrinking budgets and continuing staff cuts. One can only guess at the frustration experienced by experienced staff unable to meet the needs of the private forestry community.

Organisations such as the NZ Farm Forestry Association continue to play a role, but their membership still stands at only around 5000. By comparison, the magazine 'Growing Today' reaches a public of 25,000, many of them deeply conscious of land-use issues.

As forestry moves towards a dominant position as our largest export earner, it must carry public opinion along with it by developing a constant dialogue, particularly with regard to environmental issues, or risk alienation.

The present discussions surrounding planning consents for new industries, such as those proposed by Rayonier and Wenita, highlight this need.

I believe the Institute is capable of responding from within its membership to questions arising across a wide range of matters relating to land use, industrial development and the social issues resulting from the emergence of substantial new industry. In fact, the questions are quite predictable and we should be providing the answers in anticipation.

Where is the next generation of Chavasses and Purey-Custs?

Bill Gimblett

A mathematical complexity

Sir,

The May 1995 issue of the Journal published an article by Dr Hugh Bigsby called "Accounting for Plantations – National Accounts and Forestry". Three formulae appear in the article of which the first and third appear to need correction or at least clarification.

Dr Bigsby introduces his first formula by stating (p. 17) "… a more appropriate way to value forests would be through the calculation of NPVs for each of the regions, species, and silvicultural treatments. The value of the forest estate would then be the sum of these NPVs,

$$\text{Value of the Forest Estate (VFE)} = \sum_{g=1}^{m}\sum_{h=1}^{n}\sum_{i=1}^{o}\sum_{j=1}^{p} NPV_{ghij} \tag{B1}$$

where g is the region, h is the species, i is the silvicultural treatment, and j is the age class."

Dr Bigsby's definition of NPV_{ghij} needs at least two clarifications. Firstly, his definition is incomplete because it does not refer to j. Secondly, his definition assumes there is a one-to-one correspondence between forests and the set of ordered 4-tuples (ghij). In general, there may be more than one forest with the same (ghij) combination, so his definition should have read:

$$NPV_{ghij}= \sum_{f \in S(ghij)} NPV(f) \tag{H1}$$

where $NPV(f)$ is the NPV of the forest f and the set $S(ghij)$ is the set of all forests in the population which have the combination (ghij). The term "forest" includes parts of forests.

Dr Bigsby introduces his third formula by stating (p. 17): "The components of the present value of a forest stand can be separated as prices (P), volume per area (V) and area (A). A change in the net present value could arise from a change to any one or all of these factors.

$$\Delta NPV =\sum_{i=1}^{n} \frac{\Delta P_n \times \Delta V_n \times \Delta A_n}{(1 + r)^n} \tag{B3}$$

"The price, P, is actually a composite price which is a weighted average of the expected products."

I assume that the "n" in the summand is a misprint for "i". Dr Bigsby does not make the status of this formula clear. If it is a definition of ΔNPV then the question of validity does not arise. However, it seems unlikely to be a definition because this would involve an unconventional use of Δ. It seems more likely it is meant to be a derivation from the formula

$$NPV=\sum_{i=1}^{n} \frac{P_i\times V_i\times A_i}{(1+r)^i} \tag{H2}$$

on the assumption that the change in NPV arises from changes in P_i, V_i, A_i or r. If this is so, then his formula is incorrect. Using the commutivity of Δ and $\sum$ for finite sums and the product and quotient rules for finite differences the correct formula can be derived as

$$\Delta NPV=\sum_{i=1}^{n} \frac{(1+r)^i((\Delta P_i\times V_i\times A_i)+(P_i\times\Delta V_i\times A_i)+(P_i\times V_i\times\Delta A_i)+(\Delta P_i\times\Delta V_i\times A_i)+(\Delta P_i\times V_i\times\Delta A_i)+(P_i\times\Delta V_i\times\Delta A_i)+(\Delta P_i\times\Delta V_i\times\Delta A_i)-P_i\times V_i\times A_i\times((1+\frac{\Delta r}{(1+r)})^i-1)))}{(1+r)^{2i}(1+\frac{\Delta r}{(1+r)})^i} \tag{H3}$$

Dr Bigsby has implicitly assumed r to be fixed, in which case this formula reduces to

$$\Delta NPV=\sum_{i=1}^{n} \frac{(\Delta P_i\times V_i\times A_i)+(P_i\times\Delta V_i\times A_i)+(P_i\times V_i\times\Delta A_i)+(\Delta P_i\times\Delta V_i\times A_i)+(\Delta P_i\times V_i\times\Delta A_i)+(P_i\times\Delta V_i\times\Delta A_i)+(\Delta P_i\times\Delta V_i\times\Delta A_i)}{(1+r)^i} \tag{H4}$$

but this is still not the same as his formula. To obtain Dr Bigsby's formula it would be necessary to impose a condition

$$\sum_{i=1}^{n} \frac{(\Delta P_i\times V_i\times A_i)+(P_i\times\Delta V_i\times A_i)+(P_i\times V_i\times\Delta A_i)+(\Delta P_i\times\Delta V_i\times A_i)+(\Delta P_i\times V_i\times\Delta A_i)+(P_i\times\Delta V_i\times\Delta A_i)}{(1+r)^i} =0 \tag{H5}$$

but such a condition would not be satisfied for arbitrary changes and arbitrary values of the variables.

It seems Dr Bigsby has made the error of assuming the change in a product is the product of the changes in its factors. As a piece of historical trivia, I note that according to Professor Bell ("Men of Mathematics", chapter 7), Gottfried Liebniz (1646-1716), the discoverer with Isaac Newton (1642-1727) of the Calculus, at first made the same mistake when trying to find the product rule for derivatives.

Garry Herrington

Dr Bigsby responds

The formula is a definition of NPV and is meant only to illustrate the point that changes to NPV will arise from changes to any or all of prices, volumes per area and area over time. My apologies if I have misled anyone as to how the changes would actually have to be calculated. With any luck, Liebniz will read this as well and not feel compelled to have to return and pull me up for it also.

Hugh Bigsby

ARTICLES

RegRAM-I – A flexible, forest harvest scheduling and industrial processing, global optimisation model

Brian McGuigan[1] and John Scott[2]

ABSTRACT

*This paper describes a Regional Resource Allocation Model, known as **RegRAM-I**, that has been used by Tasman Forestry Ltd, since 1991 as the company's major resources planning tool. RegRAM-I allows the user to interactively describe the objects to be modelled, (forests, processes, external suppliers, markets), transport costs between various locations, and how time is to be treated, on separate independent spreadsheets. The system uses both optimisation and simulation techniques, and can generate: individual stand models, single time period resource allocation models, single forest 'on-truck' models, multiple forest 'delivered to mill gate' models, multi-location integrated forestry and processing models – all without the need for separate mathematical formulations.*

COMPANY BACKGROUND

Tasman Forestry Limited is the forest growing and harvesting subsidiary of New Zealand's largest company, Fletcher Challenge Ltd, and is the sole log supplier to the wood processing companies in the Group:

- Tasman Pulp and Paper Ltd,
- Tasman Lumber Ltd,
- and Fletcher Wood Panels.

    In New Zealand the Group's current annual production is:
- 342,000 tonnes of newsprint,
- 153,000 tonnes of kraft pulp,
- 190 million board ft of sawn timber,
- 402 million sq ft of wood panels,
- 800,000 m³ of log exports.

The company has two major areas of operation in New Zealand: the Central North Island where it owns 165,000 ha of forest, and Nelson/Marlborough, where it jointly owns 60,000 ha of forest.

The Central North Island is by far the most complex region, with all the Group's processing plants situated there, including: newsprint and kraft pulp mills at Kawerau, sawmills at Kawerau, Putaruru, Rainbow Mountain and Taupo, and particle board and medium density fibre board plants at Taupo.

The company also supplies logs to other companies and small sawmills throughout the region, as well as substantial volumes of log exports via Mt Maunganui.

The company logs its own forests, state-owned forests, and minor woodlots, throughout the region. Wood residues such as sawmill chip, for its pulp and paper and wood panels' plants, come from both its own and external processing plants.

THE PROBLEM TO BE SOLVED

The pattern of log allocation between the forests and processing plants in a region varies over time, because the availability of logs from each forest varies. Since cartage costs can be a significant part of the delivered value, it is impossible to decide the best time to harvest a crop without knowing where the logs will be sold. However, where logs will be sold depends upon the log availability from all other forests. Thus even for a pure forest owner, harvesting decisions need to be made in conjunction with log allocation decisions.

For an integrated forest owning and processing group, the situation is even more complex. For example, the more wood residues that are produced, the fewer pulp logs that will be required by the pulp plants. Thus the volume of logs to be delivered to the pulp mills cannot be determined until you know the volume of sawlogs going to the sawmills and how much chip will be produced as a result.

Since a substantial proportion of the costs at existing processing plants can be regarded as fixed, the marginal value of logs to existing processing plants can be very high. Marginal values will also vary from one grade of log to another. Moreover, the differing log grades can incur different processing costs, and consume different amounts of plant capacity.

These considerations were persuasive enough to suggest that the work done on an earlier single-period resource allocation model, LOGRAM (McGuigan 1984), should be carried forward into a new multi-period version RegRAM-I, that would include harvest scheduling as well as resource allocation. This paper describes the new model and some of our experiences to date.

DESIGN OBJECTIVES

Fletcher Challenge is an exceedingly dynamic company. The only thing that is permanent is change. Thus any system developed had to be highly flexible. There was no point in developing a system

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