

CHAPTER 7 DISCUSSION

7.1 INTRODUCTION

Research on the economics of uneven-aged forestry was needed because there is increasing interest in this type of management, particularly in sensitive areas, such as recreation and amenity forests, and no research has previously been carried out in Britain. However, research on the economics of uneven-aged forestry is hampered by the almost complete lack of data on costs and returns from such forests. This lack of data from uneven-aged forests was the main factor leading to the adoption of a modelling approach to the problem, and the building of a model of operations in uneven-aged forests using fragments of data mostly obtained from studies of even-aged forests.

The resulting model does have limitations (mostly imposed by the type and quality of data available). The model itself appears to produce sensible results and is in a form which can be easily adapted and expanded as the appropriate, detailed data become available. It seems clear that, with the increased interest generated in uneven-aged forestry over the past five years, the relevant data will eventually be collected.

7.2 THE MODEL

The model uses a series of square two-dimensional arrays to represent a block of forest, which means that the groups are set out in a regular grid pattern. The justification for choosing a regular shape for the group (in terms of efficiency of operations) was discussed in Chapter 2. However, adapting the model to investigate the efficiency of rectangular groups, for example, would be a useful refinement. Rectangular groups, with a long axis placed perpendicular to the extraction rack, would require fewer forwarder visits, for example, because each temporary extraction rack would contain more volume than the corresponding extraction rack for a square group of the same area.

Similarly, whilst the simple square arrangement of groups with a central road was adequate for investigation of the objectives of the research, the model could be developed further and the group arrangement made more flexible in order to explore means of reducing costs for a particular group size. An example of this would be the comparison of different road layouts and extraction networks for a particular group size.

in each felling period, groups which are to be harvested are selected randomly, with the constraint that adjacent groups are not harvested in consecutive felling periods. This approach was chosen in order to maximize the irregular appearance of the forest. A further step in the experimentation process would be to investigate different systematic harvesting patterns, as a means of reducing costs. However, it is unlikely that substantial cost savings could be made in this way, because the variability in operational times associated with the distribution of final fellings is low. If final fellings and thinnings were not carried out at the same time, the distribution of groups would be a more important factor, but when the two operations are combined, most of the groups in the block must be visited during each felling period.

Most other refinements to the model require data which were not available during the development of the model. For example, although the model offers a choice of three forwarders and three skidders, it does not include the machine which is most appropriate for small, private forests, i.e. the modified farm tractor. Detailed data were not available for this machine, but incorporating it into the model, as data become available, would be a high priority in any further development of the model.

Another important point with regard to extraction machines was the choice of a single value for each machine for the machine cost per Standard Minute. The use of a single value may mask some cost differences between the two silvicultural systems and the different group sizes, because machine depreciation varies, depending on the conditions the machine is operating under. Maximum depreciation rates for skidders are associated with the in-forest movement phase, whilst depreciation rates for the terminal and road movement phases are much lower (Price, 1986). The in-forest movement phase is the one which is lengthened in an uneven-aged system, which means that machine costs should be higher for the uneven-aged system to take account of this. However, the percentage of the maximum depreciation rate associated with each phase of the skidding operation were estimates and only given for skidders.

The main potential for future application of the model is in comparisons of the economics of other silvicultural systems. In its present form it is not suitable for direct application to specific forests by forest managers, because the road layout and extraction rack network are inflexible and these factors are significant determinants of operating costs.

73 RESULTS FROM THE MODEL

The time taken to carry out an operation is influenced both by the absolute size of the group within the forest block and by the number of groups of that size within the forest block. This fragmentation effect is illustrated in the results (see forwarding, skidding, felling/thinning and replanting results) for the 16 ha. and 10 ha. blocks. The operational times for the 0.0625 ha. group in the 16 ha. block, when compared to those for the 0.0694 ha. group in the 10 ha. block, are always significantly higher. Therefore, it is not possible to determine the absolute costs of working with a specific group size. It is not group size alone which determines costs, but the combination of group size, number of groups and forest block size.

7.3.1 FORWARDERS

Forwarders are heavily penalized when working in very small groups, particularly when the groups are *so* small that they do not contain a single full load of sawlogs or pulpwood. Results obtained from running the model indicate that a group size of **0.0625** hectares incurs significantly higher forwarding costs, but that forwarding times for the whole range of larger group sizes (0.11 ha. to 1.00 ha.) are similar. Therefore, the group size may be relatively small without any significant increase in forwarding time. However, any increases in forwarding time are important because forwarding costs (£/hour) are very high (particularly for the 10-tonne forwarders) due to the high capital cost of the machines.

The spacing of forwarder racks, as determined by the group size (and shape) has a significant effect on forwarding time. Forwarding time is lower if rack spacing is close to the optimum for the type of crane fitted to the forwarder. However, choosing a group size based on the capacities of a specific forwarder is probably a futile exercise

because technology changes so rapidly and the life of a forwarder is no more than five to ten years. The issues of technological change and machine life also raise the question of whether it is appropriate to only consider a single machine type (or even a single harvesting system) for the whole of the transformation period. During a 60- or 80-year transformation period the range of tree sizes, from the start of the transformation to the transformed forest, is enormous. Shortwood forwarding in the early stages of the transformation followed by pole-length skidding for the remainder is a possible strategy which merits further investigation.

7.3.2 SKIDDERS

The pattern for skidder extraction is quite different to that for forwarder extraction. There is not a clear trend towards higher extraction times as the group size decreases. This occurs because skidders do not have the manoeuvrability of forwarders and, therefore, a part-load must be extracted if a full load cannot be made up when extracting timber from a group. Consequently, skidding times are most heavily influenced by how close a group is to containing one or more full skidder loads. This feature of the skidding operation dominates all the model results for skidding and no clear patterns emerge with respect to Yield Class, absolute group/blocksize and length of transformation period. On the other hand, the skidding time (for the skidders included in the model) for any scale of group management is significantly higher than that for clearfelling the forest block. This is where consideration of small-scale skidders and modified farm tractors becomes important. This type of machine would not be so heavily penalized when working in a group system because the low load capacities mean that these machines would not be working significantly below maximum efficiency when extracting timber from small groups. Using one of the available small-scale skidders would also help ameliorate the disadvantages of skidder extraction early in the transformation, because the skidders included in the model are very inefficient in extracting very small-sized timber. The future development of machines specifically designed for working in small, scattered groups is also a possibility if there is sufficient demand,

7.3.3 POLE-LENGTH AND SHORTWOOD FELLING

Average felling times, during the transformation from an even-aged to uneven-aged structure, are significantly higher than the average felling times associated with even-aged management. Part of this increase is due to increases in movement times as workers move between groups. Another portion of the increased time is attributable to the extra snedding and brashing time needed for the coarsely branched trees on the edge of a group and extra time needed for directional felling or more care during felling. However, a significant proportion of the increased costs is attributable to the harvesting of immature trees because, like skidding times, felling times increase dramatically as mean tree volume decreases. The differential in felling time between the even-aged and uneven-aged system decreases once the uneven-aged forest is in its transformed state, because the premature harvest operations are no longer necessary.

7.3.4 REPLANTING

The only variables considered which affect replanting time are block size/group size (because movement time between planting sites is altered) and the length of the transformation period (because the total number of sites to be planted during any one felling period is altered). The increases in replanting time as group size decreases and the number of groups increases, is attributable to increased movement time as workers move between planting sites, the setting up of more plant dumps and the possible extra use of sighting sticks. The fragmentation effect in using group management is particularly well illustrated in the replanting operation because some of these factors, such as the setting up of plant dumps and the use of sighting sticks, are more dependent on the number of groups being planted rather than the absolute size of the groups.

Although the model contains a replanting option only, natural regeneration may play an important part in an uneven-aged system. A natural regeneration option was not included in the model for two reasons. First, the quantity and distribution of natural regeneration and the resulting species mix are unpredictable. Although this would be influenced by the age and species of trees in the surrounding groups, it would also depend on other factors such as soil type, vegetation cover and weather conditions. Second, the results from a respacing experiment, carried out at Glentress in 1987,

showed that using natural regeneration was not significantly less expensive than replanting. Also, the costs of managing natural regeneration would be influenced in a similar way to replanting by the size of group and the number of groups in the forest block, because time is needed to visit each group several times to carry out respacing operations.

The inclusion of a site preparation subroutine, or modification of the replanting subroutine to include site preparation, is another high priority in any future development of the model. The volume of logging slash remaining in small groups after the harvesting operation may make replanting during the year of felling impossible without any slash treatment. At Glentress, in group sizes greater than approximately 0.1 ha. the brash has been piled and burned, or pushed to the edge of the group, in order to facilitate planting. However, the cost of this operation is approximately €1 per cubic metre (Blyth and Malcolm, 1988) and the effect on the soil is questionable. The slash treatment operation, in a confined space, is fairly unique to the group management system and could, therefore, only be modelled using data from work study experiments on the operation. Such experiments have not yet been carried out.

7.3.5 BRASHING AND PRUNING

Extra time is needed for brashing and pruning operations in the uneven-aged forest due to the coarse branching of trees on the edges of groups. Coarse branching would be expected in trees adjoining extraction racks or adjacent to groups of an age class (or species) where light is penetrating the stand.

Brashing times are heavily influenced by group size, because smaller groups have a larger proportion of edge trees, but generalizations about the relationship between group size and brashing time are difficult because it varies enormously with the factors mentioned above and with the tree species.

Pruning is not, in general, carried out frequently in British forestry, but occurs regularly in a large proportion of the uneven-aged forests in England. The problem in the uneven-aged forest is, again, the development of coarse branches on edge trees, as described above. The cost of this operation is also very specific to the tree species,

Yield Class, intensity of the pruning, group size and layout of the forest (i.e. the arrangement, width, and number of extraction racks).

7.3.6 WEEDING

Weeding operations are not included in the model due to insufficient data, although this was one of the original objectives. One would expect to see a relationship between group size and weed growth, but this relationship would also be dependent on many other factors, such as the age and species of the surrounding trees, the site type and the method of harvesting. Therefore, average values obtained from even-aged forests were used in the financial calculations and the issue of weed growth was discussed in the chapter dealing with non-quantified values.

7.4 FINANCIAL ANALYSES

When the small increases in operational times which occur as group size decreases are combined with the reduced volumes obtained from a group management system (due to the fact that as group size decreases, extraction racks take up a greater proportion of the area) the effect on the financial analysis is significant. In Chapter 5, the differences between clearfelling and group management on a fairly large scale (1.00 ha. groups) were shown to range from -£22 to £10,000. However, converting these values to percentage decreases or increases is not very enlightening. The £10,000 referred to above represents a decrease in Net Present Value of approximately 9.5% for the Yield Class **20** site whereas the corresponding decrease of **£4070** for the Yield Class **8** site represents a **23%** reduction in Net Present Value. These values were obtained using a discount rate of **3%**. As the discount rate increases, the difference in Net Present Value between the two management systems gradually decrease until, at discount rates of **7%** or more, they are virtually indistinguishable.

Although the use of discounting was necessary for comparison of even-aged and uneven-aged management, because the timing of the cash flows is so different, consideration of the net cash flows, after transformation, is as important for the forest manager as Net Present Values.

The results in Chapter 5 showed that the net cash flows, after transformation, are significantly higher for an 80-year transformation period compared to a 40-year transformation period. This can be explained by the higher proportion of large, valuable trees with the longer transformation period. The discussion of the non-financial factors also concluded that longer transformation periods should be preferred, because they are associated with greater benefits in terms of scenic beauty values, recreation potential, wildlife habitat diversity and conservation. The main factor which would restrict the length of the transformation period is the possibility that trees from the original crop might not survive until the end of the transformation, if the transformation period was too long.

The net cash flows for each felling period, after transformation, for the range of group sizes (1.000 ha. to 0.0625 ha.) are also interesting. They range (for the Yield Class 12, Sitka spruce baseline example used throughout) from €1521 for the 1.000 ha. group to £10444 for the 0.0625 ha. group, which is a decrease of approximately 9%. This is similar to the percentage decrease in Net Present Value across the range of group sizes (at 3% discount rate) shown in Chapter 5. It is also worth noting that the decrease in net cash flows between the 1.00 ha. group and the 0.25 ha. group is only approximately 2%, indicating that it is possible to adopt a fairly small group size with a minimal financial penalty.

Unfortunately, the rate of planting grant is not determined by the size of each individual area planted in a forest, but by the total area planted in any one year. However, if the total planting area in any one felling period is sufficiently small, the forest may qualify for one of the higher rates of planting grant.

The Forestry Commission planting grants are presently banded (based on the total area planted) in recognition of the fact that small areas incur proportionately higher costs than large areas. It seems feasible to propose that the grant scheme be modified to introduce another series of bands (based on group size and number of groups) in recognition of the fact that the costs of using small groups is higher (-10% - 25%), if the Forestry Commission is serious about creating forests which "make a positive contribution to the landscape and which [are] designed to create a diversity of wildlife habitats".

7.5 RECOMMENDATIONS FOR FURTHER RESEARCH

Priority in further research should be given to the development of growth models for uneven-aged forests. Treating uneven-aged stands as an aggregation of even-aged groups is a crude approximation to reality and the lack of such growth models hampers further research in other areas of uneven-aged management. Helliwell (1990) in an unpublished report on research in uneven-aged silviculture, suggests that growth models could be based on a "combination of experience in other countries, basic physiological knowledge and measurement of small uneven-aged stands or individual trees". The problems of projecting from physiological models to stand management appear formidable and the experience in other countries, in terms of development of growth models for uneven-aged forests, appears to be fairly limited. The most useful information would, from the above list of possible sources, come from measuring small group of trees. The two main factors which influence the growth of trees in groups is the improved microclimate within the group which may help in the early development of the trees, and the reduced growth of the edge trees in the group caused by shading of trees in the edge of the group by trees in the surrounding groups. The effects of shading on the growth of trees in small groups could be investigated by measuring the trees at the interface of two even-aged stands. Quantifying an "edge effect", in terms of the decrease in tree growth and the proportion of the group affected, and applying adjustments to the even-aged growth models would be a relatively straightforward and productive line of research.

Most of the subjects covered in the chapter on the assessment of the non-financial factors associated with the uneven-aged forest were placed in that chapter because little quantified information was available. For example, most of the literature on the relative merits of different silvicultural systems, in terms of scenic beauty, is based on conjecture. However, since the development of the Scenic Beauty Estimation Method (Daniel and Boster, 1979) this is a subject which could readily be investigated. As far as I know, this method of evaluating scenic beauty, which is widely applied and accepted as sound in the United States, has not been applied to questions of forest management and public preferences in Britain. If a strong preference for an uneven-aged type of management was established, this could be used to justify more research into other aspects of uneven-aged management.

Although it appears, from Peterken's guidelines for nature conservation, that uneven-aged forests fulfil more of the important principles for nature conservation **than** even-aged forests, this needs to be validated. It is often asserted that uneven-aged forests are "better for wildlife", but for which species? and how much better? **As** with the question of the scenic beauty values associated with different forest management strategies, if uneven-aged forests could be shown to support a greater diversity of wildlife species, for example, this would help increase the interest in uneven-aged forestry and perhaps encourage more use of such systems.

Finally, the question of the quality of timber obtained from uneven-aged forests needs further research. The management objective at Tavistock is the production of high-quality stress-graded timber with **4-6** growth rings per inch. However, in order to achieve this objective the trees are intensively pruned to **24** feet, in three separate operations. The early groups at Glentress are not suitable for investigation of wood quality, because they are very small, closely planted, and unthinned. But, the larger, more widely planted groups are now reaching the age where they will provide useful information.