CHAPTER 6: ASSESSMENT OF NON-FINANCIAL FACTORS ASSOCIATED WITH UNEVEN-AGED SYSTEMS

6.1 INTRODUCTION

The previous chapters have considered the financial penalties involved in changing from an even-aged system to an uneven-aged system, the relative cost increases or decreases associated with various scales of working in the uneven-aged forest, and the influence of other variables such as the length of the transformation period, age at which transformation begins, and type of harvest system. Apart from these quantified differences between the two systems there are a whole host of costs and benefits which have not been included in the simulation model, either because detailed data are not available or because certain benefits have not been quantified. However, with the information available it is possible to make some generalizations and to consider the effect of some of the variables mentioned above (i.e. group size, transformation period, age at which transformation begins and type of harvest system) on these costs and benefits. The aim of this chapter is to provide an assessment of non-financial factors, in addition to the financial costs, to help in decision-makingThe conclusions from this chapter are summarised in Figure 6.5 (page 161).

6.2 SCENIC BEAUTY

6.2.1 "THE VIEW FROM THE ROAD"

People tend to be resistant to sudden changes in the landscape. In sensitive landscape areas it may therefore be necessary to maintain the appearance of continuous tree cover. The areas where this is likely to be important are wooded hillsides close to towns and villages, and forests surrounding scenic viewpoints, visitor centres, car parks, and scenic drives.

The aesthetic qualities of the forest and the impact of forest operations can be considered in terms of observer's view of the forest. Thus, a landscape may be divided into three zones: Background (~5.0+miles), Middieground (–0.5-5.0 miles), and Foreground (–0.0-0.5 miles) (USDA,1973), depending on the amount of detail that can be resolved by the observer.

1)BACKGROUND ZONE: At this distance the viewer sees little detail and objects are seen as patterns of light and dark (USDA,1973). In this zone, the scale of operations can be quite large because individual impacts are least apparent. It would be appropriate to use a clearfelling system in this situation, with the size of the felling area being dependent on factors such as the scale of the landscape and the amount of aerial perspective involved.

2)MIDDLEGROUND ZONE: At this distance some detail can be discerned and vegetation textures (e.g. conifers and broadleaves) become apparent. In this zone, individual felling areas can be distinguished and therefore must be kept small to maintain the appearance of continuous cover. Again, it is difficult to recommend size limits but in two forests in Britain where this is the primary management objective (see Powderham Estate and Abberley Hall in Appendix 1), felling areas range from single tree size up to one hectare.

3)FOREGROUND ZONE: At this distance the viewer can distinguish between individual plants and species (USDA,1973), and in this zone single tree removal would be most appropriate. However, in the case of forests adjoining scenic drives, where the trees are generally only viewed by motorists, there is a danger that the forest will appear as a monotonous "green-sided corridor" (McDonald and Burton Litton,1987). In this case the excessive heterogeneity has a negative impact (Shafer,1967; Hodgson and Thayer,1980; USDA,1980) and breaking up this expanse using small groups is preferable.

The length of the transformation period would have little effect on the scenic beauty values of forests viewed from a distance, because the observer sees little detail and is not able to distinguish easily between age classes. However, there may be value in a longer transformation period in the foreground zone, because this will lead to a forest with a greater range of age classes and hence a richer texture. Visibility of forest operations is sometimes cited as having a negative impact on scenic beauty and thus starting transformation when the stand of trees are of a size when they provide a screening effect may be beneficial in the foresground and middleground zones. Finally, it would be preferable to avoid pole-length extraction in the foreground zone because pole-length extraction by skidders has a higher incidence of damage to residual trees compared to shortwood extraction (Aho et al, 1983; Heij and Leek, 1981).

6.2.2 INSIDE THE FOREST

Ulrich (1986) found that aesthetic preferences tended to be significantly higher for managed forest stands than for non-managed stands. Therefore, doing nothing and letting nature take her course are not appropriate responses when aesthetics are a management objective. Several researchers (Arthur,1977; Brush,1979; Brown and Daniel,1986; Ulrich,1986) have established that tree size is one of the most important factors (along with the amount of dead timber on the ground) influencing scenic beauty evaluations. High values of scenic beauty are usually associated with the presence of large trees. In an uneven-aged system the full array of tree sizes is always present and it is quite feasible to retain trees beyond the usual felling age. John McHardy at Longleat (see Appendix A) leaves small groups of trees and individual trees to become forest giants and at Glentress, groups of old Douglas fir, near picnic sites and forest walks, will be retained. In an even-aged system the forest manager does not have the flexibility of being able to retain small groups of trees beyond maturity and the financial penalties of holding the whole stand, even a short period beyond the optimum rotation age, are high.

A second important consideration is the concept of space and enclosure. Brush (1976) states:

> "Harvesting groups of trees can bring about stimulating and strongly contrasting spatial effects. Openings create well-defined edges, open to the sky and flooded by direct sunlight. In gently rolling terrain, clearings on wooded sideslopes often provide the only opportunity for viewing the surrounding countryside."

Kaplan (1985) carried out a scenic beauty evaluation of several landscape scenes using a preference rating approach, and found that forests which are more open received higher ratings than closed ones. She concluded that this was either because open forests permit greater visual access or because the smoother ground textures of openings suggest to people that walking through the forest will be easy.This finding is supported by several other landscape architects and is summarised by Simonds (1961) in his statement that "man enjoys moving to and through a space" and "also enjoys moving from one space to another.".

Enclosure is a concept taken from architecture and it is roughly estimated as the ratio of wall height to the distance from the wall (Brush,1976). The sense of enclosure (a positive feeling) is strong when the ratio is 1:1 or greater, and a ratio of 1:3 sets the lower limit for a well-defined enclosure. Therefore, depending on the height of the surrounding trees, a group size of 0.01 hectares (10-metre trees) up to 0.09 hectares (30-metre trees) would give a strong sense of enclosure, but group sizes greater than 0.09 hectares (10-metre trees) to 0.81 hectares (30-metre trees) would lose the sense of enclosure.

Longer transformation periods could be very important in increasing scenic beauty values within the forest because the presence of large trees is the factor which has the greatest effect on scenic beauty values. And because longer transformation periods do not have significantly higher operating costs than short transformation periods, they should certainly be encouraged. Shortwood harvest systems are again preferred because damage to residual trees is reduced, but it is difficult to predict how the age at which transformation begins will affect within-forest scenic beauty values.

6.3 RECREATION

Grayson, Sidaway, and Thompson (1973) observe that "very little objective evidence is available on the effect that manipulation of the tree stands has on visit rates.". However, they do acknowledge it is probable that the attractiveness of a forest for recreation may be enhanced **by** the management methods used.

Recreation activities can be divided into specialized types and informal types. Specialized recreation includes activities such as archery, skiing, and golf and is generally more dependent on terrain, slope, and presence of permanent structures rather than the silvicultural system (Goodall and Whittow, 1975). Informal recreation (e.g. walking and picnicking), on the other hand, is mostly influenced by the general attractiveness of the forest. Although Hamill (1971) recommends that recreation and scenic beauty are evaluated separately, it is difficult to differentiate between the two, and factors which encourage informal recreation also lead to high scenic beauty evaluations.

Goodall and Whittow (1975) identified six forest characteristics they considered significant for recreational activities:

• Forest layout
• Age/Height of trees
*Penetrability or spacing of trees
*Tree species variety
*Screening factors
*Existence of forest route networks

An uneven-aged system fulfils more recreation requirements (in terms of the six characteristics stated above) than a clearfelling system in several ways. Most importantly, the presence of a range of age classes on a small area means that the negative impacts of the thicket and seedling stages are minimized. Most types of recreation are totally excluded from the thicket stage and are severely limited in the seedling stage (Goodall and Whittow, 1975), so in a clearfell situation recreation would be curtailed during some 15 to 20 years of a rotation. Second, the presence of open spaces interspersed with groups of trees increases the range of recreational activities which can be accommodated in the forest. Third, the network of extraction racks, which **are** a feature of an uneven-aged system, provide easy access to the forest.

The discussion on scenic beauty pointed out that an uneven-aged system allows flexibility in retention of some older trees and introduction of a variety of tree species. **As** large/old trees are highly valued for recreation, longer transfomation periods are preferable. In the case of recreation values, a shortwood harvesting system is better in terms of lower levels of residual tree damage, but forwarders, being heavier, are more likely to cause ground rutting which in *turn* may affect recreational access. **Again,** it is difficult to predict how the age of the crop at the start of the transformation will influence recreation values.

6.4 WILDLIFE **HABITATS AND CONSERVATION**

Very little research has been carried out in Britain to quantify individual species habitat requirements and therefore only general principles can be considered. In his guidelines for nature conservation in British woodlands, Peterken (1977) includes three principles (number 6, number 7, and number 9) related to the silvicultura1 system.

PRINCIPLE ***6:*** Minimize rates of change within woods.

This involves maintaining a wide range of age classes, arranged so that different habitats are constantly available and colonization from one habitat to another is facilitated. This is particularly important for species whose colonizing abilities are low and are unable to move large distances when the stand is harvested, for example. In the Bradford Plan system (See Appendix 1), Harris (1986) found that plants with dispersal limits of a few tens of metres (especially shade flora), could be found at any time during the 54-year rotation period, in some part of the forest. Apart from conservation of species richness amongst the ground flora, Harris (1986) also discovered that species richness in the seedbank was conserved. However, some species would not thrive in this complex small-scale interweaving of habitats because they might require large areas of, say, mature trees.

PRINCIPLE **7:** Encourage maturity by maintaining long rotations

Again, uneven-aged systems have the flexibility which allows retention of groups of trees beyond what is considered an economic rotation. Currie and Bamford (1982) found that both breeding bird density and diversity in small overmature conifer stands was about double that of pole-stage or mature stands. Also, Helliwell (1982) points out that it is relatively easy to maintain a continuity of dead trees, for cavity nesting species, in an uneven-aged forest. Single-tree selection, however, may not fulfil this principle because groups of trees can provide a certain amount of mature woodland conditions whereas single older trees cannot (Forestry Commission, 1985).

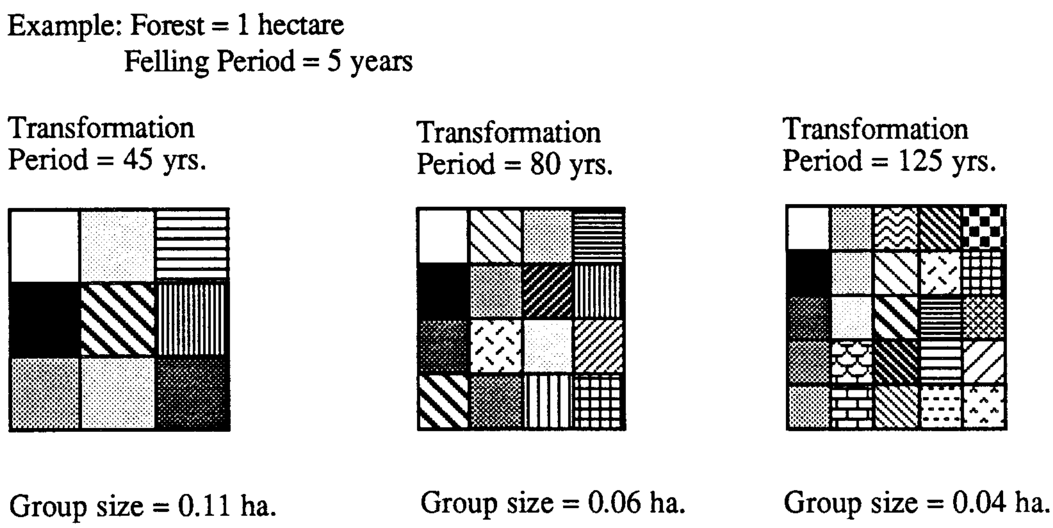
PRINCIPLE 9: Encourage diversity of:

i)Structure
ii)Tree and shrub species
iii)Habitat

This principle is echoed by Opdam and Schotman (1986) who suggest that to enhance breeding bird richness management should aim at increasing the tree diameter and increasing the heterogeneity of the canopy and shrub layers. In the same way that it is possible to retain groups of trees beyond maturity, tree species variety can more easily be accommodated in an uneven-aged system. In general, the theory of Island Biogeography (MacArthur and Wilson, 1967) predicts that increased habitat diversity enables more species to exist in a given area, and allows more species to colonize the given area.

A long transformation period would create a wider age class range and, therefore, an increased number of habitats. Also, the proportion of mature or over-mature trees present during transformation would be higher than with a short transformation period. However, in small isolated woodlands, a long transformation period may lead to groups which are not large enough to provide mature woodland conditions (See figure 6.1). It should be noted at this point that this situation could be prevented by altering the length of the felling period: a longer felling period would decrease the number of felling groups and therefore increase the individual group size. This is another indication of the flexibility of an uneven-aged management system.

Figure 6.1: Relationship Between Forest Size, Transformation Period And Group Size



In this example, the 0.04 hectare group will only hold approximately two mature oak trees (Matthews, **1986),** and thus is too small to provide mature woodland conditions. Starting transformation as early as possible is preferable because the creation of habitat diversity is so important. However, choice of harvest system would not appear to affect wildlife habitats in any obvious way.

6.5 PESTS, DISEASES, AND BIOTIC DAMAGE

6.5.1 INSECTS AND PATHOGENS

The question of the relative disease resistance and health of irregular forests, compared to even-aged forests, is by no means resolved. For a long time, the theory of "complexity equals stability" was enshrined in the ecology literature (Elton, 1958). The implication was that diverse ecosystems contained a range of enemies of a specific pest, and they would act as a series of checks and buffers against large increases in the pest numbers. However, May (1976), using randomly constructed model food webs, found that these food webs were less likely to be stable the more species they contained. One explanation of these contradictory views is the definition of the terms 'complexity' and 'stability'. Complexity can be measured in terms of Species Richness, Connectance (the number of actual interspecific interactions divided by the number of possible interspecific interactions), and Interaction Strength (the mean magnitude of interspecific interaction). Similarly, stablity can be measured in terms of Resilience (the time it takes the variables to return to equilibrium following a perturbation), Persistence (the time a variable lasts before it is changed to a new value), and Resistance (the degree to which a variable is changed following a perturbation) (Pimm, 1984). Using these more precise definitions, the opposing viewpoints can both be supported. For example, Pimm and Lawton (1977) showed that with more trophic levels (i.e. increased complexity) there is less resilience, but Pimm (1979) also showed that with more connectance (also increased complexity) there is greater resilience. In terms of uneven-aged forests versus even-aged forests May (1976) acknowledged that man-made monocultures are <u>more</u> vulnerable, not because of their simplicity, but because they have a lack of "any significant history of coevolution with pests and pathogens".The impacts of man on these simple systems are many and varied and simplification may not be the only, or even the main cause of instability (Pimm, 1984). Johnston (1978) concluded that catastrophic pest outbreaks were governed more by factors such as climate and species mix, rather than the management system ***per* se.**

In experiments with mixed stands of agricultural crops it has been found, generally, that they suffer less disease than pure stands of the same overall density (Leonard, 1969; Berger, 1973). Mixed stands, in this case, could be mixtures of species or mixtures of individuals of the same species having different susceptibilities to a specific pathogen. For interspecific mixtures and multi-age mixtures, disease reductions may result from subtle changes in the microclimate caused by morphological differences between individual plants (Burdon, 1978). But this would not explain disease reductions in intraspecific mixtures, for which several hypotheses have been proposed. The hypothesis that resistant plants may interfere with the passage of inoculum between susceptible plants is the one which is widely assumed to be largely responsible (Burdon, 1978).

Waggoner (1962) showed that the probability of an epidemic is reduced if fields are small and scattered, and this was supported by the work of Zadoks and Kampmeijer (1977) who demonstrated that, in the case of focal epidemics, small fields become infected later and develop less disease than large fields. By analogy, therefore, small group sizes and scattered groups would reduce the probability of an epidemic in an irregular forest. However, this must be tempered by the fact that the number of extraction racks needed increases as group size decreases and thus there is an increased risk of damage to trees alongside the extraction racks.

In one other situation it is conceivable that there would be benefits from an irregular structure: For example, Waring and Schlesinger (1985) note that plant tissue is generally only marginally nutritious to most insects and pathogens, and that biochemical changes, often caused by stress, can make the plant tissue more nutritious. Therefore, in the case where an irregular system is used to exploit small-scale site variations one would expect trees to suffer less stress, and hence be more disease resistant, because the tree species would be chosen to suit the site.

6.5.2 VERTEBRATE PESTS

Concentrating good wildlife habitat in a small area, as happens in an uneven-aged system, also concentrates the numbers of some vertebrate pests. Eiberle and Wenger (1983) found larger numbers of roe deer in a selection forest, compared to an even-aged forest, and they concluded that it was because of the complex interweaving of cover and browse areas. Fencing groups of seedlings is generally prohibitively expensive, although this is the solution adopted in some of the irregular forests of Bavaria. In Britain, a combination of population control and avoidance of preferred tree species appears to be effective, but browsing damage may be one of the biggest problems associated with uneven-aged forestry.

Longer transformation periods may help alleviate the problem of deer browsing because this will reduce the proportion of the forest in the vulnerable seedling stage. And a shortwood harvest system is again preferable because this will reduce the **risk** of infection and attack by insects of residual trees damaged during harvesting operations. The effect of the age of the crop at the start of the transformation period on susceptibility to damage by pests is not known.

6.6 WIND **STABILITY**

Increased wind stability is a benefit traditionally associated with uneven-aged forests. **As** far back as 1928 Troup stated that an uneven-aged structure minimized wind damage to the stand due to the "larger trees protecting the smaller ones and by the good development of crowns and root systems". However, experience in Britain and the United States contradicts this as it has been found that cutting holes in a regular structure increases windthrow amongst the perimeter trees surrounding the opening (Hungerford, 1980; Neustein, 1964). At least two factors are involved here. Firstly, cutting holes in the stand increases turbulence as the aerodynamic smoothness of the stand is interrupted (Newton, 1985), and secondly, wind momentum cannot be absorbed by **crown** to crown contact as occurs in a regular stand (Malcolm and Taylor, 1979). Neustein (1964) found that the windrun within a group was related to the size of the group, but despite lower wind speeds in smaller groups, the number of windthrown trees per hectare was higher because the greater length of perimeter per hectare felled has more effect than the lower wind speeds. Newton (1985) found that trees grown under the uneven-aged system at Cawdor (See Appendix A) suffered from the effects of exposure at the time of first thinning. Johnston, Grayson, and Bradley (1967) concluded that the relationship between wind stability and silvicultural system is mostly dependent on the soil type, and this is supported by evidence from the Edinburgh University Experimental area at Glentress (See Appendix A). The experimental area is located on generally well-drained soils (Blyth and Malcolm, 1988) and windthrow has not generally been a problem so far, even though the area lies within a relatively high wind hazhard class.(2-4)

The preceding discussion applies to endemic windthrow rather than catastrophic windthrow. In a catastrophic windthrow situation the degree of stand damage is influenced by wind speed, wind direction, and topographic features rather than silvicultural practices (Miller, 1985). In this case also, an uneven-aged forest may be an insurance policy against loss of the entire stand, because some of the younger age classes are more likely to survive. Also, in an even-aged system, retaining groups of surviving trees is generally infeasible because it makes later operations, such as extraction of fellings, more difficult and costly wheras the system of permanent;$. extraction racks in the uneven-aged forest facilitates saving such trees.

The length of the transformation period would have some effect on wind stability because longer transformation periods lead to a forest with a larger proportion of older/taller trees which would be more susceptible to windthrow. Similarly, it would be preferable to begin the transformation at an early age because a young crop should be more able to survive having holes cut into it.

6.7 TIMBER QUALITY

Production of high quality timber is often cited as a benefit of uneven-aged forestry. However, if this theory is investigated, it transpires that the high quality timber is a function of the more intensive working rather than a change in growth habits of trees in uneven-aged forests (Newton, 1985; Matthews, 1986). In fact, there is evidence that, if left to their own devices, the trees from an uneven-aged system will be of poorer quality than those from an even-aged system. Troup (1928) commented that "timber produced by the selection system is inferior in quality to that produced by more even-aged systems.".

Observations at Glentress show that the size and number of branches on the outside edge of the groups is higher than those within the group, and the proportion of live branches is also higher (See Appendix B). This occurs as the outer trees are exposed to increased light when the surrounding trees are removed to produce a new group, and in groups planted within a matrix of light-branched species such as larch. It should be noted that this problem is exacerbated at Glentress because the groups were planted at close spacings (0.9 metres) so the inner trees are self-pruned. One would also expect to see similar asymmetric branching along the edges of permanent extraction racks.

Branch knots cause localized, often severe, grain distomon, which can effect structural performance (Brazier, 1986). Even if the wood is destined for the pulpmill, chemical pulping yields are also influenced by the size and number of knots, which are particularly difficult to digest (Faulkner, 1969), and the presence of knots makes debarking more costly. The development of lopsided branching leads to the development of an asymmetric crown (with associated increase in reaction wood) and Isomaki (1986) found that trees on the edges of extraction routes had developed slightly elliptical stems at breast height. In more general terms, heavy branching leads to increased risk of snow and ice damage, and attacks by fungi and insects (Ehrenberg, 1969).

Harrison (1986) found that the outer trees in some of the groups at Glentress were more strongly tapered than those on the inside. Although trees with a large stem taper have a higher assortment of larger log sizes, they may be less valuable as a whole because they are more costly to debark and saw, and the strength of the sawn material is affected by the presence of inclined grain (Ehrenberg, 1969).

Finally, as group size decreases and the number of extraction racks increases, the risks of damage to standing trees during extraction also increases. Invasion of these wounds by fungi and insects may lead to degrade of the timber in affected trees.For the same reasons, a shortwood harvesting system is preferable.

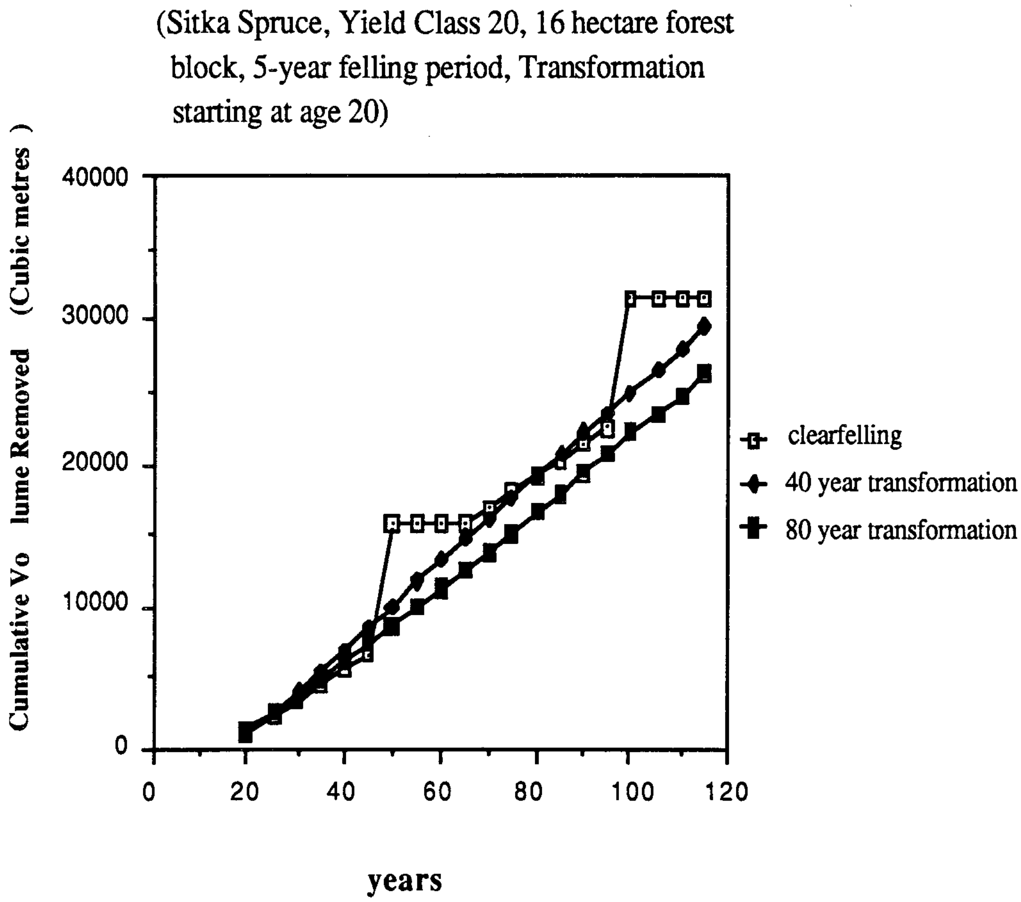
6.8 MARKETING

The two marketing problems traditionally associated with uneven-aged forestry are the low volumes of timber produced in each period, and the size-class diversity of the products (e.g. Alexander, 1977).

6.8.1 VOLUME OF TIMBER OFFERED FOR SALE

The volume of timber removed from an uneven-aged forest during any felling period is actually quite similar to that obtained by managing the same area under a clearfelling regime, providing the even-aged management includes thinnings. Figure 6.2 shows the volumes removed under each system for a 16 hectare block over a 100 year time frame (20x5 yr. felling periods), based on Sitka spruce Yield Class 20 and starting with a crop aged 20. The values have been calculated using the Forestry Commission Yield Tables for Sitka spruce at 2.0 metre spacing (Forestry Commission, 1981).

Figure 6.2: Cumulative Volume Removed From An Even-Aged System Compared With Two Uneven-aged Regimes



Although the final felling volume from the clearfelling system is large this is offset by the three periods when no volume is removed before the age of first thinning. The final volumes in each uneven-aged system are repeated in perpetuity. The volume removed over a whole rotation in the clearfelling example (15744 cubic metres) is not so different to the volume obtained over the same period from the transformed uneven-aged forest (14760 cubic metres for the 40-year transformation period). A feeling which is common amongst managers of uneven-aged forests is that they are in a position to exploit the markets, rather than be penalized by them. They feel they have the flexibility to wait for the right market and then fell, instead of felling and then trying to find the right market (McHardy, 1986) and that there is always a good market for the quality of timber they are producing (Williams, 1986).

6.8.2 SIZE CLASS DIVERSITY OF PRODUCTS

Size class diversity of products is usually considered to be a problem because thinnings are being removed at the same time as final fellings (USDA, 1980). Figure 6.3 shows the number of 8-metre sawlogs in each volume class (0-0.1,0.1-0.2 etc.), again using Sitka spruce yield class 20, with a 40-year transformation period, starting the transformation at age 20. Values have been generated partly from the model, and partly from Forestry Commission yield tables (Forestry Commission, 1981) and volume assortment tables (Forestry Commission, 1985a).

At the beginning of the transformation period the uneven-aged system has approximately the same range of sizes as the clearfelling system, because the thinnings and final fellings in the uneven-aged system are of the same age. As the transformation proceeds the range of sizes increases and in the final year of the transformation (period 8) a wide range of sizes are removed. But, at no stage is the distribution wider than that of the final felling in the clearfelling system, and in fact once transformation is complete the system always produces a narrower range of sizes than the final fellings in clearfelling. The distribution becomes less smooth from period **6** onwards, because the groups which were felled and regenerated in the first fellling period have now reached the age of first thinning.

In the case of shorter sawlogs (See Figure **6.4)**the uneven-aged system performs even more favourably. However, it must be noted that I have not considered possible extra stem taper in unpruned edge trees, which would effect the volume assortments. Also, the range of sizes would increase as the length of the transformation period increased because cutting would take place from a wider range of age classes.

With a mixture of species, in addition to an uneven-aged structure, the diversity of products would be much higher. The age of the crop when transformation begins has an important effect in terms of marketing: If transformation begins too early, finding markets for the small timber, which is expensive to fell and extract, may be impossible.

Figure 6.3: Comparison of Sawlog Volume Distribution for an Uneven-Aged System (40-year Transformation Period) and a Clearfelling System (8-Metre Logs)

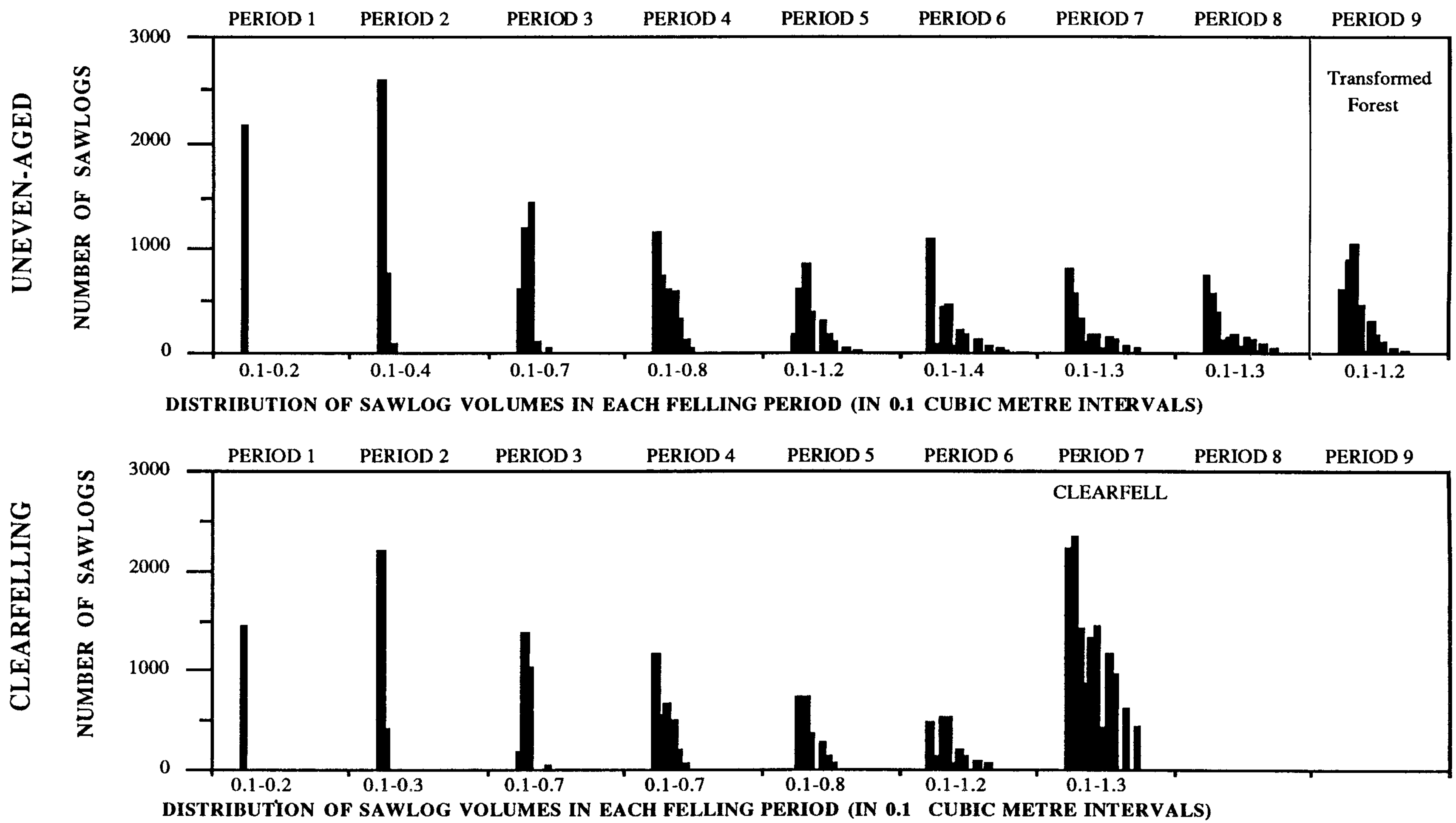
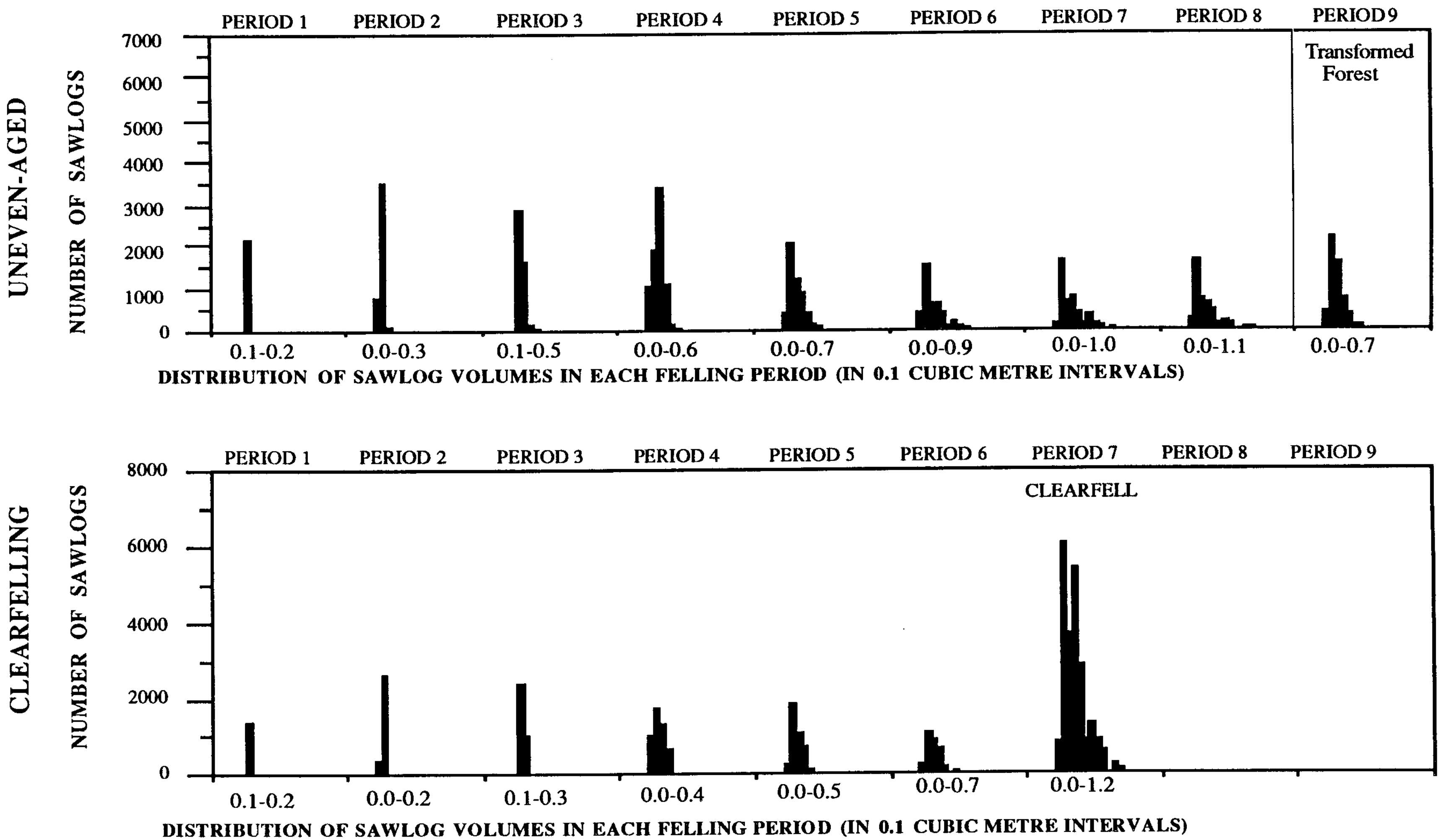


Figure 6.4: Comparison of Sawlog Volume Distribution for an Uneven-Aged System (40-year Transformation) and a Clearfelling System (4.5-Metre Logs)



6.9 WEED GROWTH

The relationship between group size and volume of weed growth (and hence increases or decreases in weeding time) has not been included in the model. At the moment, opinions on the relative problems of weed growth under uneven-aged versus even-aged regimes are varied. Singh, Sharma and Gupta (1983) found that density and growth of weeds was least in a selection forest and highest under clearfellings, an observation supported by Hutt (1974) from his experiences at Tavistock.

Weeds are defined as competing vegetation which impairs the growth of a tree (Wittering, 1974) and the problem being highlighted above is the distinction between weed growth and the growth of the ground flora or understorey vegetation. When the tree crowns close in an even-aged forest the understorey vegetation is often drastically reduced or even eliminated for the remainder of the rotation, whereas the regular felling of small openings in an uneven-aged forest allows maintenance of this understorey vegetation. But it is the growth of vegetation on the harvested area for the first five years or so after harvest which determines the amount of weeding needed to release the young seedlings from competition. In general, the greater the amount of overstorey removal, the more vigorous the growth of the understorey on that patch (Schmidt, 1979) and, therefore, larger felling areas would be expected to have higher weeding costs.

An added complication is the degree of site disturbance which occurs during harvesting, site preparation, and replanting. Small groups may be subjected to more concentrated activity, leading to increased damage to any shrubs and herbs which are already present, and lengthening their post-harvest recovery time. Therefore, pole-length extraction by skidders is likely to increase weed recovery time because dragging poles across the felling area will damage any vegetation present.Also, this ground disturbance may help provide a good seedbed for natural regeneration.

It seems unlikely that the length of the transformation period or the age at which transformation begins would have much influence on weeding costs because neither of these variables directly affect the size of the felling area which is the main factor governing weed growth.

6.10 MANAGEMENT COSTS

Included in management costs are the costs of operations and activities such as inventory, selection of felling areas and supervision of other operations. Management costs will vary depending on whether the uneven-aged forest is going to be regulated by area or by volume. The simulation model is based on management by area which is a relatively simple way to maintain an irregular structure, but no attempt is made to obtain an even flow of volume from the forest. In most of the cases where an uneven-aged system is appropriate, as discussed in Chapter 1, management by area is acceptable because most of the benefits associated with the uneven-aged system (e.g. æsthetics, wildlife habitats and recreation) will still be obtained.

The management costs associated with regulation by area should not be much higher than those associated with a clearfelling system. Any additional costs are likely to be incurred at the beginning of the transformation period. Choosing and marking the initial groups is time consuming and costs increase as group size decreases. Supervision costs during the early stages are also likely to be high because workers will not be familiar with system, but these costs should decrease rapidly as workers become practiced. Supervision costs will also increase as group size decreases because more time will be spent moving between and searching for groups. Block-of-the-year working will keep management costs down, because if thinning operations are combined with regeneration fellings, management time is used more efficiently.

Increased management costs associated with uneven-aged forestry are primarily those involved in implementation of the Check Method or *'méthode du contrôle'* (Biolley, 1920; Knuchel, 1953). This method, with its repeated 100% enumerations is time consuming (Malcolm, 1971) and, therefore, expensive. At Glentress forest (See Appendix **A)** the 100% enumerations have been discontinued and a 10% sample has been introduced (Blyth and Malcolm, 1988). If this proves successful, the increased management costs associated with periodic enumeration will be reduced.

Figure 6.5: Summary of Discussion on Costs and Benefits not Included in the Model

	Group Size	Length of Transformation	Age at Start of Transformation	Harvest System Shortwood/Pole length
Scenic Beauty	>0.03 ha. avoids monotony <0.80 ha. maintains sense of enclosure	Long: More large/old trees, More variety, More contrast	Begin when trees are large enough to give a screening effect	Shortwood: Less tree damage
Recreation	Unknown	Long: More large/old trees	Effect difficult to predict	Shortwood: Less tree damage but more ground rutting
Wildlife Habitat and Conservation	>0.03 ha. need groups of trees rather than single trees	Long: Increase variety of habitats	Begin early: diversify habitats	Little effect
Pests, Diseases and Biotic Damage	Small scattered groups: Possibly less risk of disease epidemics	Long (roe deer): reduce proportion of seedlings	Little effect	Shortwood: less tree damage
Wind Stability	Unknown	Short: less old/tall trees	Begin early: young trees less susceptible to wind damage	Little Effect
Timber Quality	Large: less edges and fewer permanent extraction racks	Little Effect	Little Effect	Shortwood: less tree damage
Marketing	Little effect: if trees are pruned	Short: minimize size range of products	Begin later: when first harvests are marketable	Shortwood:less diverse products Pole length:increased demand for large volume trees in longer lengths
Weed Growth	<0.03 ha. reduced weed growth...otherwise effect unknown	Little Effect	Little Effect	Pole length: may increase weed recovery time
Management Costs	Small groups higher costs, but minimized if thinning and regeneration felling combined	Little Effect	Little Effect	Little Effect