Robinwood

The Robinwood Altman report:

Cost Benefit Analysis of Continuous Cover Forestry

Introduction: setting the context of the component

There has been much unnecessary confusion in the UK over what continuous cover forestry entails – as there has been elsewhere.

"Continuous cover forestry" is not synonymous with low impact silvicultural systems or with near-to-nature forestry – it can involve frequent and moderately heavy silvicultural intervention. It does not imply the use of mixtures, nor of native species only, nor exclusive dependence on natural regeneration, though all or any of those may be embodied in a particular application of continuous cover forestry. Continuous cover forestry implies, or ought to imply, continuity of forest cover: no less and no more.

Even continuity of cover does not seem to have been considered a strict requirement. In what follows, three broad versions of continuous cover forestry, as it has been discussed in the UK, will be distinguished, for the important reason that each has its own collection of costs and benefits, which may differ strongly between versions. A schematic presentation of each is given, as a backdrop to the ensuing discussion. There is difference of view about the precise specification of each version, but debate about nomenclature is not a principal purpose here. See Mason et al. (1999) for another account.

- Shelterwood systems involve establishment of a replacement crop, often but not necessarily by natural regeneration, before removal of a light canopy of the previous crop. A normal precursor is crown thinning to favour the trees expected to function as the shelter and the seed source for regeneration.

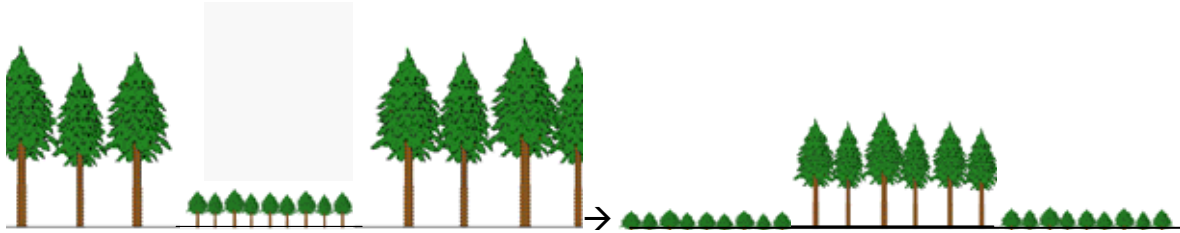**Figure 1: Shelterwood as continuous cover**

- Group felling entails cutting of small groups – variously sized between 0.1 and 0.25 ha in the normal UK interpretation, and possibly containing a few retained trees. The group is either extended successively, or further groups are formed until all the original crop has been removed. There has been some controversy about the size at which a group becomes "a small clear felling", and even about whether group cutting can be strictly termed continuous cover forestry at all.

Figure 2: Group felling as continuous cover

- Single tree selection entails removal of individual trees, classically of various sizes, on an on-going basis, so that there is no particular "regeneration phase". The full range of age classes is maintained in the stand all the time.

Figure 3: Single tree selection as continuous cover

Within the version of continuous cover forestry depicted here there are also wide variations, from strictly controlled and implemented regimes, to opportunistic opening up of the canopy, when regeneration seems to be present and worth encouraging.

Cost–benefit analysis, understood broadly, is an economic appraisal of all the costs and all the benefits, whether marketed or not, to whomsoever accruing, both present and future, under a range of plausible scenarios, in so far as possible in a common unit of account, of alternative courses of action or allocations of resources.

There is again, it might be said, variety of interpretation between commentators, but the above definition contains all the main elements that might be present, and some would say that should be present,

There are also three modes of cost–benefit analysis. Financial cost–benefit analysis considers benefit as revenue, and cost as expenditure, for the agency responsible for a project or programme, and possibly also for other economic agents involved in its implementation. Economic cost–benefit analysis considers in addition benefits and costs which lie outside the market and accrue to all stakeholders, usually through the medium of **willingness** to pay. It also accepts that market prices are not necessarily an accurate reflection of opportunity costs of resources, and that environmental and social costs outside the market are appropriately measured as **willingness to accept compensation** for bearing them. Social cost–benefit analysis is a term much misunderstood at present. In its classical form, evolved in the 1960s and 1970s, its focus was not on products and resources, but on gains and losses to stakeholders. It was more often practised in the conditions of developing countries than in the UK. Those unfamiliar with the evolution of cost–benefit analysis often assume that social cost–benefit analysis means "cost–benefit analysis applied to social projects", but the distinctiveness lies in the approach, not the subject to which it is applied. The terms "environmental" and "extended" cost–benefit analysis are both redundant: cost–benefit analysis's scope in principle includes all costs and benefits anyway.

Within a classical decision-making structure –

1. setting objectives
2. defining alternatives
3. enumeration
4. valuation
5. synthesis

6.   decision-taking
7.   monitoring/**ex post** evaluation

   – cost–benefit analysis concerns itself most with the stages of valuation and synthesis. Over the past few decades numerous techniques for evaluating non-market benefits and costs have formed the focus for efforts in developing cost–benefit analysis. There remains much disagreement on the relative merits and even validity of different techniques.

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Table 1: Methods of valuing non-market costs and benefits

1   Marketable benefits are created or lost elsewhere in the economy as a result of externalities.
2   Financial costs are saved, imposed, or voluntarily undertaken elsewhere in the economy.
3   Comparable products are marketed elsewhere in the economy.
4   Voluntary subscriptions are made to related causes or campaigns.
5   Consumers/clients are asked what they would be willing to pay for a product, or what compensation they would accept for suffering a "bad" (this is the popular contingent valuation method).
6   Decision makers or experts ask themselves the same questions as in 5 above, or get a "feel" for acceptable answers.
7   The costs (including opportunity costs) of past decisions made to favour non-market benefits, or abate non-market costs, are taken as a measure of presumed benefit, or cost.
8   Willingness to pay for market goods which give access to non-market goods is measured.

Synthesis involves aggregating on the four dimensions implied in the definition: benefits and costs from different goods or for different resources, to different stakeholders, over different time periods, and across different scenarios. Great and ongoing debate attends each dimension of aggregation.

The following account is not about cost–benefit analysis of forestry, but about the difference between different types of forestry: the three versions of continuous cover forestry described, with clear felling or rotational forestry as the baseline, or "do-nothing", or "business-as-usual" alternative, against which the versions of continuous cover forestry are compared.

There is no attempt to present a particular and detailed cost–benefit analysis of an individual forest as it might be managed for either continuous cover forestry or for rotational forestry: such a study if properly conducted would be very time-consuming. Instead, relevant factors are raised and indicative figures are given for the kind of differences that might be found, with illustrations where appropriate from individual cases.

Financial aspects

There is little empirical work which quantifies as much as the financial outlays and rewards that accrue to practising – even less to transforming to – continuous cover forestry in the UK. Sporadic forays into the field from continental Europe and North America have sometimes conflated the effects of continuous cover forestry with those of shortening rotations (Knoke and Plusczyk, 2001) or reducing the number of age classes (Kant, 1999).

By contrast, there are accounts suggesting that continuous cover forestry is a much more costly form of silviculture (Mäntyranta, 2007) which may in some circumstances be justified by environmental advantages, but should not be claimed as financially

advantageous. This is certainly the perception of many private foresters (see the contribution of CONFOR to this programme).

Experimental work at Trallwm Forest in Mid-Wales has investigated in detail the harvesting costs that may be involved in transformation (Price, M., 2007). Three conventional harvesting treatments were included: continued low thinning directed towards a later clear felling; group felling, in which low thinning was practised in the matrix outside the groups and a few large trees were retained within the groups; a "frame tree" treatment which used crown thinning to favour large wind-firm trees that would form the basis of a shelterwood. A fourth thinning treatment was designed from an economic perspective, with the following desiderata in mind.

- Early revenue is better than delayed revenue.
- Big trees make more money per cubic metre than medium-sized trees.
- Very fast-grown trees yield poor quality timber.
- Taking small trees in thinnings increases investment.
- Felling before or after optimal rotation incurs a cost.
- Trees may not survive past a critical height.
- Large canopy gaps encourage regeneration.
- The more trees are planted, the more it costs.
- Prolongation of transformation is a bad thing, if the target system offers higher profit.

Fuller discussion is given in Price and Price (2006). These considerations lead to a thinning regime which, from about halfway through the rotation, takes the largest diameter trees remaining in the crop, leaving increment to be put onto remaining, smaller trees. A similar regime has been advocated from the point of view of silviculture and utilisation of timber, though with a somewhat different rationale (Sterba and Zingg, 2001).

Plate I: Harvester operator's view of economic thinning [photograph: Martin Price]

In addition, a "premature clear fell" treatment was used, as an alternative to continuous cover forestry in order to raise early revenue – an advantage sometimes claimed for continuous cover forestry. In the event the site was of such high productivity that the stand was already close to its optimal rotation. This treatment thus afforded results relevant to timely clear felling at the end of an economic rotation.

Some costings, still being refined, from this work suggest the following, against a base-line of clear felling costs. It must be borne in mind that up to 50% of volume with rotational

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forestry might be removed by low thinnings. But the same would be true for much of the rotation for group and shelterwood treatments, but less so for the economic thinning treatment.

Table 2: Cost of harvesting per m³ for the experimental treatments

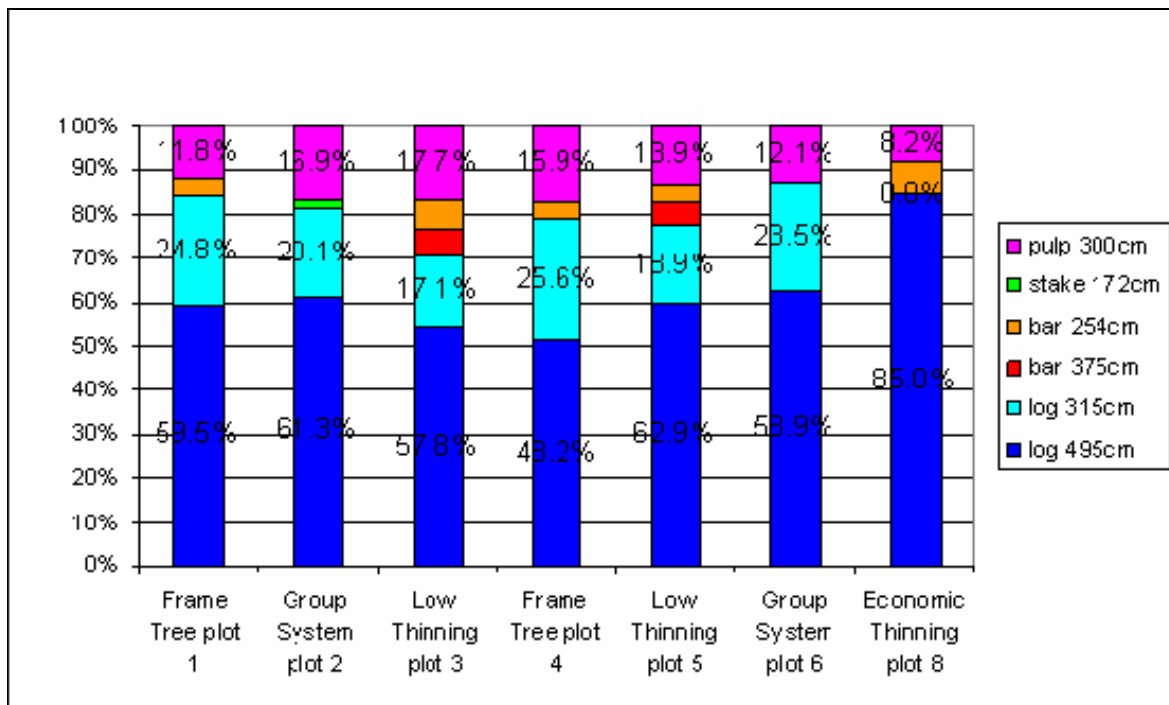| Treatment	Clear cutting	Low thinning	Group felling	Shelterwood	Creaming
Cost/m³	£9.14	£13.00	£12.40 (£11.80)	£11.13	£9.82
Difference from clear cutting	–	£3.86	£3.26 (£2.66)	£1.99	£0.68

Figures in parentheses are estimates. The original group felling cost included the (high) cost for low thinning the area surrounding the groups. Separate figures for groups and surrounds have not yet been calculated.

Bearing in mind that the chief financial advantage of shelterwood and group treatments is hoped-for avoidance of regeneration costs (saving of less than £1000 per hectare), and with clear felling volumes of around 400 m³ per hectare on this site, the harvesting penalties are quite likely to exceed savings.

Moreover, deviation from optimal rotation (small trees being felled before optimal rotation, or large trees being felled after optimal rotation, or both) by definition reduces profitability.

The economic thinning treatment, by contrast, might not incur any net harvesting penalty, once up-and-running, because it is always large trees that are harvested. Even in the short term it has a much smaller penalty than any other treatment, except perhaps premature clear felling. Moreover, the product assortment, even during transformation, appears to be highly advantageous, greater proportions of volume being produced in the highest value product categories than by any other treatment, including clear felling. This condition is likely to be perpetuated once a single tree selection system is up and running, provided that it is managed with the object of concentrating increment onto final crop trees.

Figure 4: Comparison of assortments by percentage of volume produced

Felling times may well be at about the optimal rotation for individual trees, even during the transformation period, as the trees felled are the ones furthest advanced towards the ideal product assortment, and achieving the lowest indicating percent (value of increment divided by sale value of tree).

Early indications are that regeneration is, at the least, not worse under the economic thinning than under other treatments. However, natural regeneration of Sitka spruce in Wales is notoriously unpredictable: one cannot assume that this result, if maintained, will be reproduced on other sites.

The main concern is with potential dysgenic effects of early removal of the largest tree sizes. At feasible levels, these are sufficient to outweigh the cost and price advantages of economic thinning as a mode of transformation to continuous cover forestry. The concern arises during the transformation period. Beyond that, the large trees removed are large because they are the **oldest**, not the **most vigorous** of the crop. There would be a case for attempting artificial regeneration experimentally, to get through this phase.

Questions were raised by the Brandenburg partners about implications of economic thinning for biofuel production, as a shift takes place towards larger product assortments. Brash baling (see Stewart's component of the Robinwood Programme) as a source of biofuel cannot be undertaken without due regard to possible nutrient and hydrological effects (Anon., 2007). Consideration of carbon emissions does not necessarily favour small dimension biofuel material over large dimension structural material. Barrow et al. (1986) demonstrate that the greater saving in fossil fuel per unit forest production may in fact be achieved by substituting renewable structural materials for non-renewable ones

The economic models developed in conjunction with the Trallwm project are capable of including an increased value for small dimensions in the assortments shown in figure 4: sensitivity analysis can be conducted readily.

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Hydrological effects

In the wet northern and western parts of the UK where commercial conifer forests are concentrated, experimental results have indicated a significant net loss of water run-off following conifer afforestation (Calder and Newson, 1979), though the strength of the effect is not agreed even among hydrologists. Commercial afforestation has also been considered responsible for increased sediment loads and acidity of water supplied (Edwards et al., 1990). On the positive side, forest rooting systems encourage rapid infiltration of intense rainfall, and hence may mitigate flooding. In recent times in the UK, catastrophic flooding has become frequent, with a perceived increase in frequency of extreme climatic events. Costs attributed to individual flood events may run into thousands of millions of pounds. This is not to say, however, that forests, even on entire catchments, would have avoided such costs. Calder (2007) suggests that alleviation of flooding by forests will not avoid the most extreme events.

However, Robinson (1998) has speculated that the impacts of continuous cover forestry might be rather different, in particular in less concentrated ground disturbance, leading to more diffuse physical and chemical effects on watercourses.

The expectation would be of little differential effect on water infiltration and hence on flooding and low flows, between continuous cover forestry and rotational forestry.

There might be more reason to suppose that there would be differential effects on sediment loads, owing to the more dispersed nature of harvesting under continuous cover forestry. This would apply to small headwater catchments (on the scale of individual forest sub-compartments). However, for forest scale catchments, the profile of harvesting activity through time would be similar under either regime, whether as diffuse activity through the entire area, or intensive clear felling of a small proportion of area, and diffuse thinning activity in much of the rest. If, as some claim, continuous cover forestry produces a greater total yield than rotational forestry, that would be cause to expect greater site disturbance, but this claim is not generally agreed. It has been argued that continuous cover forestry produces insufficiency of brash to allow an adequate protective mat for the soil surface. However, Price, M. (2007) shows that in all the transformation treatments studied, there was a similar and adequate mat. No research was encountered to substantiate or refute the view that sites left open by clear felling are vulnerable to additional disturbance by direct impact of rainfall. Indeed, the dripping of amalgamated water drops from a tree canopy may have a more erosive power than the fall of a finer rain, and hence lead to greater sediment loss. Only a multi-storeyed canopy suffices to mitigate such an effect, and it is not offered throughout a growth cycle by any of the continuous cover forestry forms discussed above.

Plate II: Ground disturbance happens under continuous cover forestry too

Pricing of any differential effect can be addressed by considering the cost of the downstream consequences of sediment loads, as on fisheries, requirements for dredging, and in particular on drinking water supply. In one celebrated extreme rainfall event, an area of recent afforestation led to costs amounting to £4000 per hectare afforested (Stretton, 1984). This catastrophe was not repeated everywhere: it has become notorious precisely because of its unusual severity. It would be a gross error to take this cost as a base-line, against which the benefits of any modified form of management should be compared. The area involved represented only 0.1% of the area afforested in Wales in the twentieth century, and foresters are quick to point out that the policy for water is more aware of and sensitive to potential problems these days (Forestry Commission, 2003). Moreover, as discussed above, the differentials between continuous cover forestry and rotational forestry are likely to be small for forest-scale catchments.

Evaporative loss from the canopy would be expected to differ between types of cover. As Robinson (1998) observes, in rotational forestry the canopy does not close until several years into a rotation, and in the phase where the ground is relatively bare of both trees and grass or shrubby vegetation, evaporative loss may be less than for a grassland or forest cover. By contrast, continuous cover forestry has no phase when there is no tree cover, so might be expected to cause continuous evaporative loss, compared with a grassland baseline. Moreover, the roughness of a multi-storeyed canopy increases the evaporative potential related to turbulent air-flow over the canopy, and potentially its greater canopy volume could intercept more rainfall to be the subject of evaporative loss. No experiments on the hydrological effect of continuous cover forestry in the UK seem to have been initiated, but indications of additional loss might be derived, speculatively, from the observed increase of evaporative loss per unit area in small woodlands (Roberts and Rosier, 2006); from hedgerows (Herbst et al., 2006); and from line-thinned forests (Calder, 1990), all of which

present more aerodynamic roughness and greater edge-to-area ratio. Approaches to pricing this loss are discussed below.

Plate III: Evaporative loss from continuous cover forest, Glen Tress

Pricing water loss from forests as lost benefits

There are two problems with costing the impact by this route.
- Domestic water supply is at present mostly not delivered at a price per 1000 litres, from which lost benefits could be evaluated. (Industrial use *is* priced, however, or the impact of reduced supply on industrial output could be calculated.)
- Except in very dry years the loss may be of no significance, because existing capacity more-than-suffices for needs.

Hence an appropriate approach might be to consider how the greater speculated losses of water, as a result of continuous cover forestry, might be calculated through the costs of maintaining a reliable supply in the face of water losses.

Pricing water loss from forests as the cost of advancing investment

This technique is due to Collet (1970). A more recent application appears in a study of costs and benefits of forestry in England's South-West Region (Land Use Consultants, 2002). The first variant looks at an annual cost of maintaining the additional capacity required as a result of additional evaporative losses. The second is based, like the Collet approach, on the cost of bringing forward new investment. From either perspective, the cost to water resource agencies of afforestation is substantial, comparable, say, with the financial cost of establishing a hectare of conifer forest.

Table 3: Costing water losses through forestry – South-West Region

Extra reduction in rainfall run-off when canopy closed	15%
% of rotation during which loss occurs	$\times$ 50%
Mean annual rainfall (mm)	$\times$ 1400
Thousand litres/ha/mm rainfall	$\times$ 10
Cost of new capacity / 1000 litres / year	$\times$ £3
	= £3150
Annual cost equivalent of this	
Interest rate	$\times$ 6%
Cost per ha **per year**	= £189
OR	
If time lapse until new capacity is required is 25 years, discounting @ 6%	£3150 ÷ 1.06^{25}
Cost per ha **in perpetuity**	= £734

Note that this cost assumes that rotational forestry involves full canopy closure only 50% of the time. For genuine continuous canopy, the losses might be doubled. Hence the figures quoted above would *also* be the cost of water loss through continuous cover forestry. This does not allow for any additional evaporation due to turbulence or edge effects.
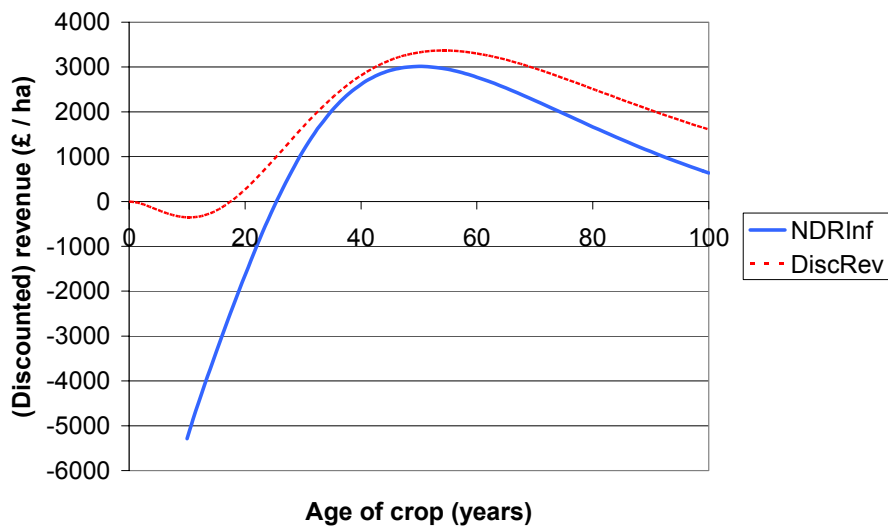
Of course, this is not a pervasive cost against forests. Conventional reservoir catchments occupy only 1% of England and Wales's land surface, though a much higher proportion lies upstream of water intakes. There are clear implications for land use policy concerning the mutual location of continuous cover forests and utilised water catchments.

Further illustrative costings of potential water losses could be derived from Barrow et al. (1986), who investigated the effect of forestry on hydroelectricity generation, but assuming that only the first 12 years of a 50 year rotation would be subject to extra evaporative losses. Again, differential losses from continuous cover forestry could be of the order of hundreds of pounds per hectare, depending sensitively on local meteorological factors and particularly on the joint operating head of all hydroelectric power schemes being fed from a point on a catchment.

Carbon storage and climate change

Claims have been made that rotational forestry has no advantage in relation to carbon fixing, because all carbon fixed is released to the atmosphere at the end of the rotation period. By contrast, it is said that continuous cover forestry maintains carbon stocks indefinitely. This view represents a misunderstanding of rotational forestry, in which all stages of a rotation are likely to be present, in roughly equal proportions, at anything above the scale of the individual tree stand. The relevant scale in relation to global climate change is global, and clear felling occurring anywhere on the Earth's surface should be compensated by growth of rotational forests occurring elsewhere. Broadly speaking, there is no differential benefit between rotational forests and continuous cover forestry of the group felling type. Shelterwood continuous cover might store more carbon on average owing to the retention of the overstorey beyond a normal economic optimal rotation. But a similar increase could be obtained by prolonging slightly the rotation of rotational forestry, which has little effect on profitability, as shown below. A lesser financial sacrifice is required by such brief prolongation for the whole final crop, than for a proportionately longer prolongation for part of the crop.
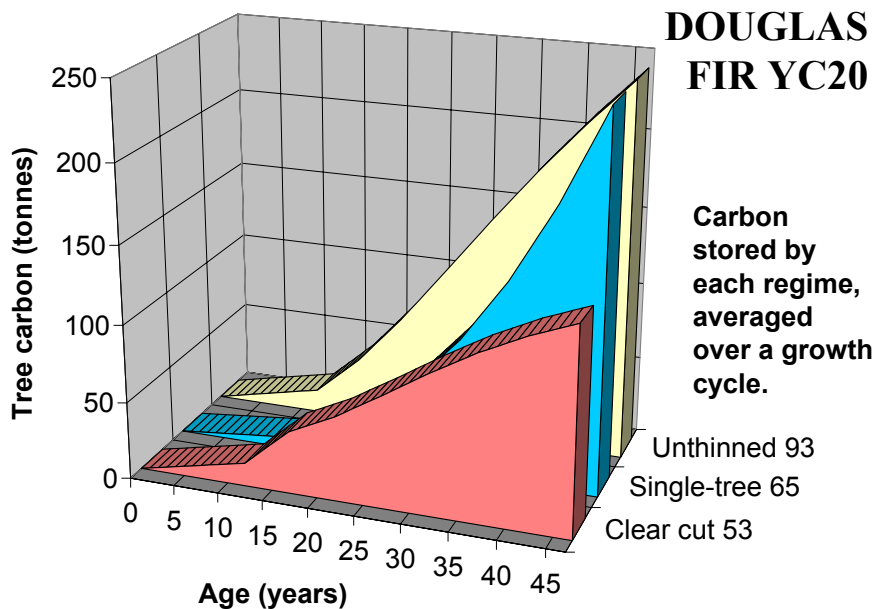
Figure 5: The minimal effect of slight prolongation of rotation with rotational forestry

Other strategies than changing to a continuous cover forestry regime are more effective to increase forestry's carbon storage benefits: for example, not thinning, or fertilising low-productivity crops (Hoen and Solberg, 1994).

By contrast, single-tree selection in which thinning is done *only* by means of removing full-sized trees does offer some benefits compared with a conventional thin-and-clear-fell rotation. The figure below shows an example of the profile, and average, of carbon storage for a single tree selection regime managed to give constant diameter increment of trees through their lives.

Figure 6: Carbon storage under various regimes

There may be further advantages from soil carbon storage, but no information, even speculative, was found on this effect.

A wide range of figures for the price of a tonne of carbon in the form of carbon dioxide may be found in the literature, from £0 to £240 in a survey by Price and Willis (1993). Newell and Pizer (2001) more recently quoted figures in the range £5–10 only. The Department of

Trade and Industry however suggest £70 per tonne. This is a value for a flux of carbon, rather than for a state of storage, an important distinction because the relationship between such concepts depends on discount rate. The £70 figure could be applied to the result of switching state from rotational forestry to continuous cover, say over 20 years. The consequent value would be less than £1000 per hectare, and rather speculative in any event.

Recreation

Three effects of continuous cover forestry are relevant to recreation.
1.　　The effect on visual experience of recreationists. This is treated under the landscape heading.
2.　　Accessibility into the stands.
3.　　Screening the presence of other recreationists, and hence reduction of the sense of crowding.

Many evaluations of forest recreation using the travel cost method (Clawson, 1959) have been made over the years (e.g. Christensen et al., 1985; Benson and Willis, 1992). None gives any insight into the value of converting to continuous cover forestry.
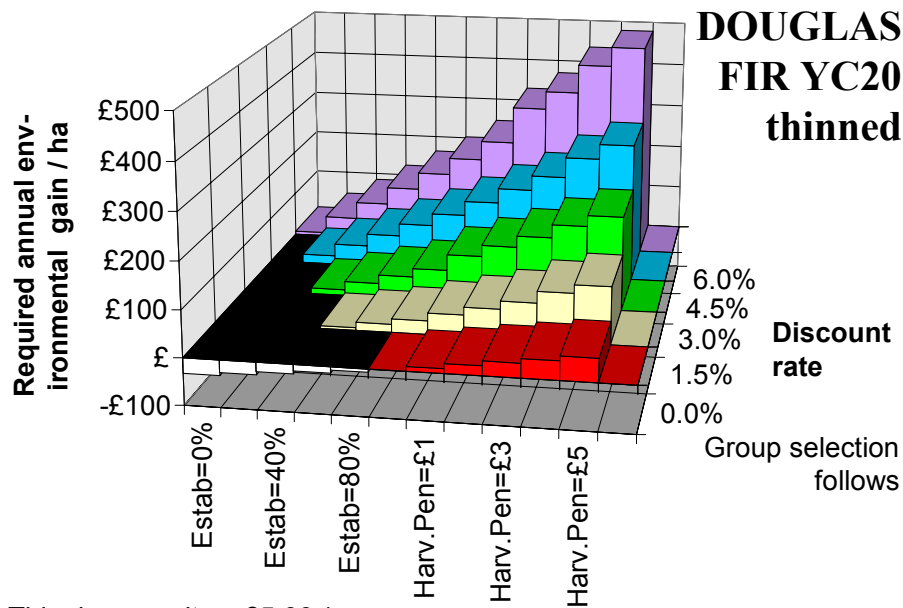
Chambers and Price (1986) found that the influence of forest type on understorey vegetation had a strong effect on the density of *visible* visitors, and suggested that this might be one reason why perception of and dissatisfaction with crowding have not been found strongly related to actual numbers of visitors on site. The monetised value of freedom from crowding has only been quantified speculatively (Price, 1979). It depends sensitively on the type of environment and the crowd-aversion of the visitor.

Only single tree selection would definitively give more effective and pervasive screening than rotational forestry, which itself provides – and has been claimed by foresters to provide – effective screening. This would be a relevant consideration when it is deemed desirable to screen particular facilities which may compromise the sense of naturalness, such as mountain biking trails.

Accessibility constrictions may counter-balance the screening benefits of single-tree selection: some respondents to the questionnaire of the Robinwood landscape component explicitly mentioned possible difficulties of access into the denser continuous cover forestry stands. Accessibility under continuous cover forestry may be further compromised by the greater proportion of time when harvesting work is being undertaken in a particular small area. The percentage of time actually active is unlikely to be great, but more frequent disturbance of trails may bring greater re-routing and reinstatement costs. I know of no costing of such effects.

It can be said that the less economically attractive forms of transformation to continuous cover forestry require a surprisingly high level of compensating environmental benefit, up to hundreds of pounds per year with unfavourable assumptions, as shown in figure 7. Such levels of benefit may readily be forthcoming in the environs of popular tourist accesses, but are unlikely to be achieved in the majority of commercial forest areas, which remain little visited by recreationists.

Figure 7: Illustrative environmental gain required to offset cost of transformation to continuous cover forestry

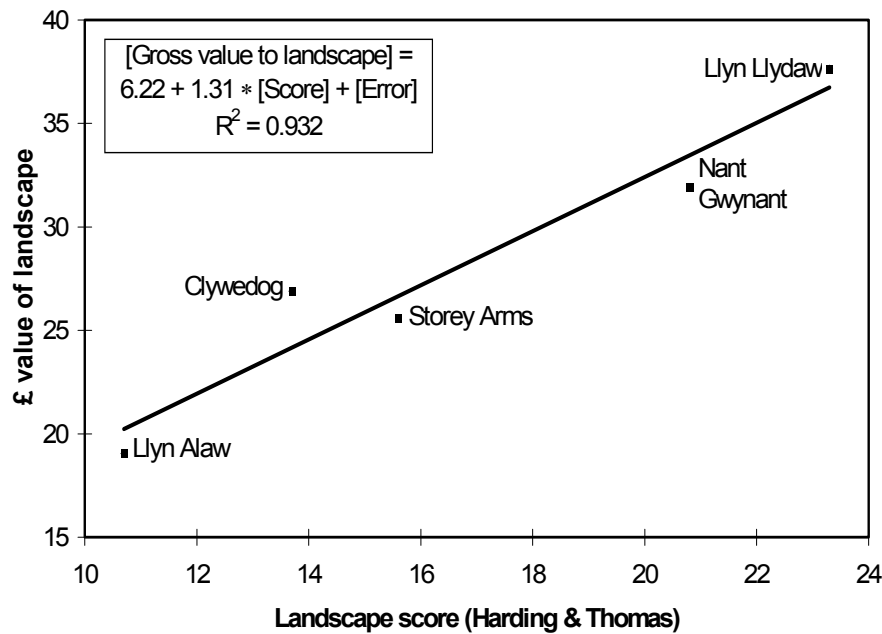

Thinning penalty = £5.00 / cu.m

Landscape

A separate component of the programme evaluates public preference between continuous cover forestry and rotational forestry. Replies suggested preferences for "naturalness", as embodied in continuous cover, and for views, as embodied in rotational forestry, and aversion to felling, as embodied in both. The more widespread preference for continuous cover forestry generally speaking persisted even when presented as a sequence of views, in which rotational forestry showed greater variation **between** views.

As to monetisation, Hanley and Ruffell (1993) provide a contingent evaluation of variety. But this work did not identify the effect of variety **between** views, only that **within** them, and so gives no basis for comparing the different scales of variation offered by continuous cover forestry and rotational forestry.

A very different basis for valuation is provided by relationships between subjectively assessed aesthetic quality, on a well-established and tested scale of 0–30, and willingness to pay to travel to different types of landscape (Bergin and Price, 1994; Price and Thomas, 2001). The correlation, based on travel costs for car-borne parties averaging three persons per car, is far from perfect, but it provides a rough-and-ready basis for valuing improvement to landscape, 44p per person per day being attributed to a one-point advance up the landscape quality scale.
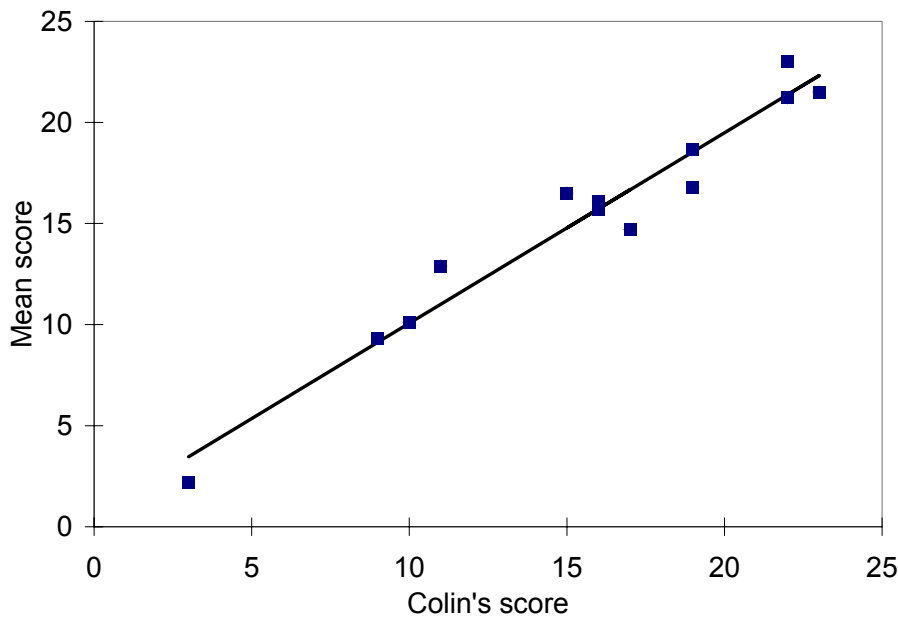
Figure 8: Landscape quality and willingness to pay

$$[\text{Gross value to landscape}] = 6.22 + 1.31 * [\text{Score}] + [\text{Error}]$$
$$R^2 = 0.932$$

To translate the quality of different landscapes into cash values requires mapping from the scale used in the landscape component of the Altman Project, to the 0–30 Harding and Thomas scale (a variant on Fines's 1968 scale) used for the work quoted above.

In general, the correlation between subjective Harding and Thomas scores, even for untrained evaluators, is remarkably good, despite the perception that "subjective" implies "unsystematic. In particular, evaluators calibrated to the preferences of groups may be able to estimate their scores remarkably well, as shown in figure 9, *for landscapes of different quality*.

Figure 9: Relationship of subjective scores

Such does not seem to be the case for valuation of landscape *types*, as evidenced in a my own personal preference for the portfolio of experiences offered by rotational forestry in the landscape preferences questionnaire.

Given this different slant of preferences, it is not possible to map from scores on the 0–10 scale as expressed in the questionnaire, to scores on the 0–30 Harding and Thomas scale, as assigned by myself and quite at odds with those emerging from averages of the landscape questionnaire. As an expedient, scores on the two scales were sorted by rising magnitude and related, giving scope to compare ranges and sensitivities. The slope coefficient was 3.5, indicating that each point rise on the 0–10 scale translated into 3.5 points rise in the 0–30 scale. There was nothing to suggest that the relationship was other than linear. The mean score for the continuous cover forestry photographic set was 1.2 points higher than for the rotational forestry set. The illustrative value of preference for continuous cover forestry rather than rotational forestry was thus as given in table 4.

Table 4: Mapping landscape scores to landscape values

Additional landscape points for continuous cover forestry	1.2
Coefficient to convert to Harding and Thomas scale	× 3.5
Value per point per day	× £0.44
Scale up for change in retail price index from 1994 to 2007	/ 83.8 × 104.6
Aesthetic value for continuous cover forestry on a day's visit	= £2.31
Number of forest visits per year (Anon., 2004)	× 200,000,000
Hectares of forest	÷ 2,840,000
"Days" per visit (Anon., 2004) (hours/visit:hours/active-day	× 0.25
Value per hectare per year	£41

Considering the number of speculative steps, this might be regarded as a quite reasonable figure. It accords in magnitude with the willingness to pay for all the services of "natural" woodland evinced in voluntary subscriptions to the Woodland Trust (Price, C., 2007).

It is, of course, a mean, and would vary by several orders of magnitudes between least and most visited forest sites.

If I am less confident about this result than for any other landscape valuation I have ever made, it is not only because my own judgements seem – unusually – to be at variance with those of a wider population. There are clearly several more or less tenuous steps in converting scales. It is by no means certain that the photographic set gave a representation of the experience of a forest walk. And the value is probably applicable in any case only to those parts of forest visits deliberately chosen as such: those which just happen in passing by might have a different evaluation.

Biodiversity and ecosystem functions

Whether continuous cover forestry is good for biodiversity conservation depends not a little on what is being conserved. How valuable that effect is, depends on what it is being conserved *for*. Some species are celebrated for being favoured by clear felling and even-aged replanting: nightjars and short-eared owls, for instance. The medium scale interspersal of age-classes seems particularly to suit roe deer, to the extent that they are regarded as, at the least, a nuisance by most UK foresters. On the other hand, for species such as red squirrels which proceed through the canopy rather than along the ground, the intimate mixture of age classes represented by continuous cover forestry provides an amenable environment.
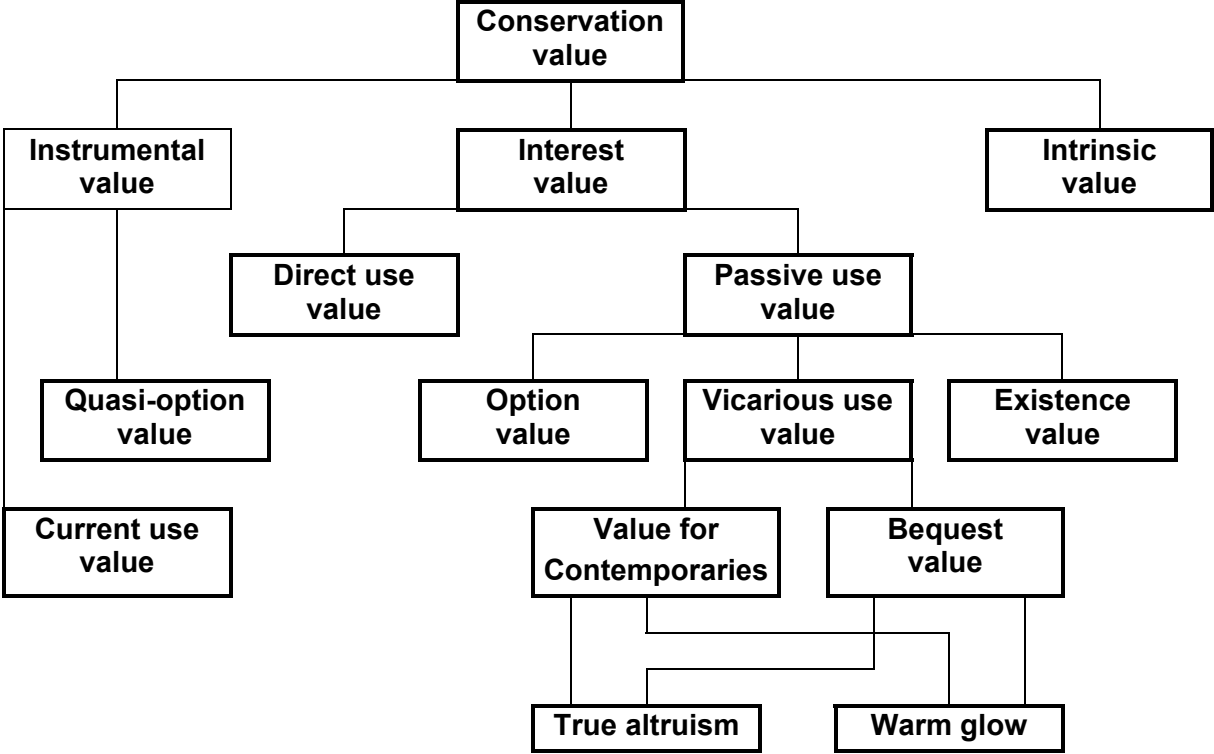
There may be a perception that continuous cover forestry is almost near-to-nature forestry, but the fact is that it entails about 10-12 harvesting interventions per growth cycle,

whereas unthinned rotational forestry may entail only one, thus favouring species for which undisturbed forest habitat is the main requirement.

Very much as with agroforestry, some forms of continuous cover forestry provide an abundance of edge habitat. Whether this is in general a prime and rare habitat in a landscape of greatly fragmented patches is debatable (Price, 1995). Then there is the question of the purpose of conservation.

Figure 10: Schematic taxonomy of biodiversity values

The three major categories of conservation value shown in figure 10 may be distinguished as below.

- **Instrumental value** comprises contributions to material well-being that could acceptably be provided by other means. For example, net photosynthesis by forests reduces atmospheric CO_2; but as far as global climate is concerned the reduction could just as well be achieved by reduced use of fossil fuels.

- **Interest value** is the source of pleasure to people which **habitats or species themselves** provide. This rather superficial-sounding term is also intended to embrace deeply felt cultural and spiritual values attributed to sites and species.

- **Intrinsic value** is whatever good is held to subsist in **the very being** of the habitats or species, independent of any human experience or knowledge of them.

Current use value might be approximated by Costanza et al. (1997)'s celebrated, though controversial estimate of ecosystem service values, amounting to thousands of pounds per hectare. However, this is a very coarse figure, and cannot be related to the relatively subtle differences between continuous cover forestry and rotational forestry. Such services are best valued, as has been done above for water and carbon dioxide, on a highly individual basis.

Within UK forestry at present the sourcing of berries and mushrooms does not assume the importance that it has in parts of continental Europe. (Saastamoinen (1997) quotes a value of around FIM 335 million for Finland in 1995, the equivalent of around £55 million in

today's £ values, or only about £2.50 per hectare of Finnish forest, with a similar value for hunting.) The Countryside and Rights of Way Act of 2000, making it illegal to sell collected produce, unintentionally obstructs derivation of a market value. It seems unlikely that such values will constitute a very general case for continuous cover forestry.

On PAWS sites, management which is closer to natural light regimes is more likely to be favourable to retention of unknown genes that are embraced in quasi-option value. Simpson et al. (1996) have suggested that such quasi-option values may not have the $1000 per hectare figure sometimes claimed for tropical moist forests, but may be as low as 20 cents per hectare. Caution should therefore be applied to using top-of-the-range figures derived from the more enthusiastic literature.

Direct use interest values are encompassed in recreation value, of which approximately 35% was attributed to "viewing wildlife" by Benson and Willis (1992).

It is easy enough to derive by contingent valuation an impressive passive use value for the conservation of almost any species or habitat type presented in interview, even up to tens of thousands of pounds per hectare. Such values are often, arguably, symbolic, representing a wish to identify positively with the conservation cause (Price, 2001).

To achieve a believable value for **one form of habitat rather than another** is a much more difficult task, and is likely to prove the more difficult, when the habitats are rather similar. It may be helpful to specify the categories into which conservation values may be divided, as in figure 10. A good rule of thumb derived from experience, would be to use a zero difference of value, rather than the extravagant figures which habitually emerge from contingent valuations.

Intrinsic values are deeply misunderstood by both economists and conservationists. (A rational account is given in Stenmark (2002).) These values arguably have nothing to do with rarity, and everything to do with biomass of sentient organisms, and from this point of view there may be little to choose between continuous cover forestry and rotational forestry: the sentient biomass just comes in differently shaped or coloured or textured packages. The biggest misconception is that it makes any sense to attempt to apply a cash quantification to these values. This is a step beyond the frontier at which cost–benefit analysis makes quantitative sense (Price, 2005).
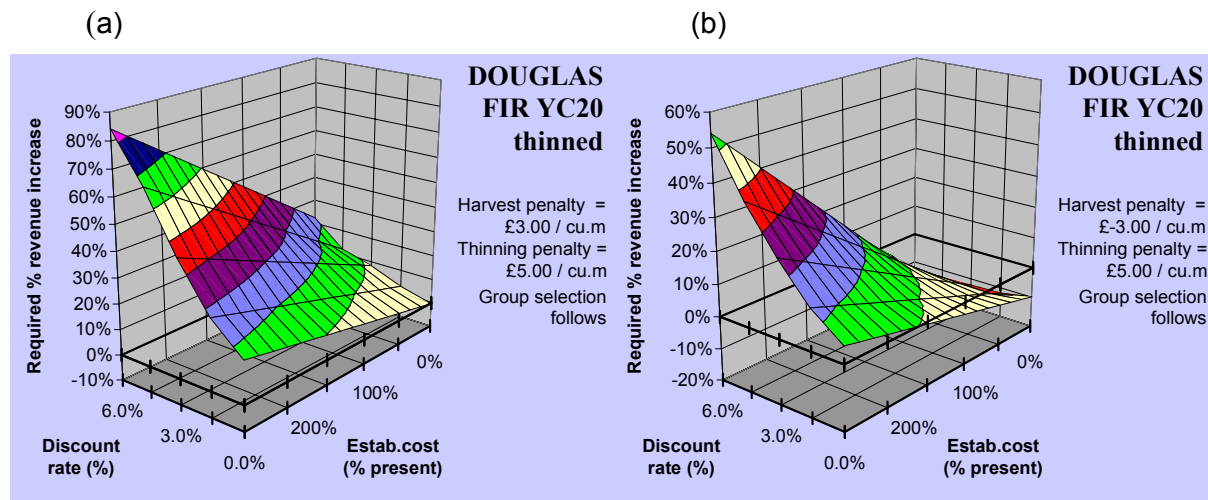
Discounting

Discounting is the process which cost–benefit analysis uses to aggregate different time periods. It has been one of the most controversial aspects of cost–benefit analysis (Price, 1993). Its influence is pervasive in forestry and environmental economics. In evaluation of continuous cover forestry it has three particular influences, on:
1. short-term costs during transformation versus long-term benefits – particularly if a better timber assortment can be obtained – once in place;
2. short-term advantages of economic thinning versus possible long-term dysgenic effects;
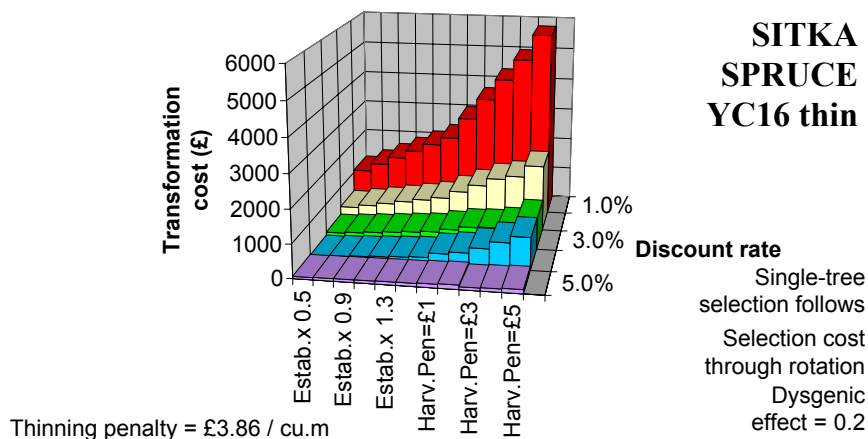3. short-term costs versus slow-in-developing environmental values.

The first effect is seen in figures 11a and 11b, which depict the required improvement in revenue to cover the costs of transformation (11a), and reverse transformation (11b). At a high discount rate **both** may require large benefits from the change, to cover the costs of felling at other-than-optimal time.

Figure 11: Revenue requirement to compensate for costs of transformation (a) and reverse transformation (b)

(a)

(b)

DOUGLAS FIR YC20 thinned

Harvest penalty = £3.00 / cu.m
Thinning penalty = £5.00 / cu.m
Group selection follows

DOUGLAS FIR YC20 thinned

Harvest penalty = £-3.00 / cu.m
Thinning penalty = £5.00 / cu.m
Group selection follows

The second effect is shown in figure 12, where the dysgenic effect is of little account at high discount rates.

Figure 12: Low discount rate and the cost of transforming by single tree selection

SITKA SPRUCE YC16 thin

Single-tree selection follows

Selection cost through rotation

Dysgenic effect = 0.2

Thinning penalty = £3.86 / cu.m

Figure 7 illustrated the third effect.

Other authors (e.g. Hanewinkel, 2001) have noted the effect of discounting on transformation, though they do not necessarily attribute it to the same causes.

In recent years the UK Treasury (undated) has begun to advocate a tariff of discount rates that declines through time. This may or may not reflect to a degree the private discount rates that are used in long-term estate management. The effect is to give more weight than has been done by customary discounting protocols, to the longer-term effects of transformation.

Distribution weights: aggregating across stakeholders

Distribution has been little incorporated into cost–benefit analysis as practised in the UK. While the theory is well-known, actual values to be used to adjust for distributional effects are disputed. There is no very obvious reason why there should be a strong differential

distributional effect between the gainers and losers from transformation to continuous cover forestry, unless it be in the form of subsidy – or non-subsidy – given to actors.

Aggregating across scenarios

There has been some work on the effect of market volatility on the risk-proofing status of continuous cover forestry (Knoke et al., 2001). This presumes that transformation is advantageous, because it spaces out revenues more evenly. Equal evening-out, however, could be achieved by somewhat premature or delayed felling of an even-aged crop, and a well-distributed age-sequence of even-aged stands, once established, provides equal risk-proofing.

Continuous cover forestry may offer advantages in retarding spread of stage-specific pathogens or insects, but not the kind of advantages of "free commercial thinning" that are presented by species mixtures in even-aged stands.

Concluding comments

The decision to favour various percentages of national forestry estates to continuous cover forestry seems to have been taken on political rather than economic – or even technical – grounds. Certainly when these decisions were taken, time did not seem to have been allowed for reflection. To propose conversion of 50% of an estate (National Assembly for Wales, 1999), when the rotation period is in excess of 50 years, is suggestive of a lack of understanding of the dynamics of forest stands.

The survey above suggests that there are costs as well as benefits in continuous cover forestry, compared with the baseline provided by rotational forestry. The differences, positive and negative, typically run into hundreds of pounds per hectare. But the values vary immensely with location, the version of continuous cover forestry considered, and the mode of transformation to that version. Figures for value given without specification of all these factors ought to be disregarded: they are likely to prove misleading as general results.

More research is needed, of course, but not any old research. Some research on continuous cover forestry has had a "promotional" feeling to it: the search has been for supporting evidence, rather than for the subject matter of a balanced appraisal. This project component has sought to identify the relative effects of continuous cover forestry and rotational forestry, whether they are costs or benefits, and to indicate lines along which their economic evaluation might be pursued. Much remains to be done, and I do not doubt that the results would benefit from sceptical scrutiny.

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