Centre for Ecology and Hydrology
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Report to the Deer Commission for Scotland
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MANAGEMENT OF DEER IN WOODLANDS
Literature review of decision making and Report on Decision Modelling Workshop

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Executive Summary

1. Decision making process of different practitioners

1. We review how decisions are influenced by management objective, scale of ownership, deer species present, available resources and information on woodland damage and deer populations.

2. A primary management objective will be deciding how many animals should be culled, by sex and age class, that will satisfy management aims.

3. In commercial forestry, reducing deer populations to a level where damage is acceptable is usual management. Alternatives include increase natural food availability and reduce population to a level where food is sufficient to avoid serious damage. This can be achieved by providing alternative browse. Feeding deer and reduce damage while maintaining artificially high populations is another option. But general opinion is that any benefit will be limited and will depend on the type of forest and distribution of artificial food. Some forests provide plenty natural food for deer and animals are not attracted to supplementary food. The cost of providing food is expensive and would have to be justified as having a major reduction in damage.

4. Deer control can be carried out by employ full-time professional staff, the costs of deer management and control being offset against income from venison sales, let stalking and supervised stalking. One alternative is to let deer stalking to tenants who pay for hunting, this should generate income, after management supervisory costs are accounted for, and could turn potential loss into profit. Another alternative is to employ full time professional staff but let much of the stalking to paying clients. Such alternative approaches do seem to merit attention.

5. The main argument given in favour of estimating deer population size is that deer management should be predictive, rather than retrospective. In many areas, land managers lack the basic information on the size or density of woodland deer populations, which it is suggested, are necessary for assessing changes in populations and setting cull targets. Ideally, estimates of density, fertility and survival rates are modelled to predict changes in numbers and sex and age classes of discrete deer populations. Such information can be used to set target population size and the annual cull. This information is likely to be of more benefit to larger estates where deer are resident and discrete populations may occur.

6. Tree damage is a main driver of deer management in commercial forestry, and such information is frequently used in final management decisions. Information on tree damage also has economic value to a forester and can be used to predict future income, to decide on the species composition of a tree crop and whether to fence or not. For some deer managers' tree damage may be the only information they have for setting cull targets

2. Decision modelling workshop

7. The study needed to document the factors which practicing deer managers take into account when determining what assessment and control methods to use. We chose to use a structured approach to this, commonly referred to as Decision Modelling.

8. Two one-day workshops were held in the Waverly Hotel in Perth. Workshop 1 on the 7th of November and Workshop 2 on the 29th November 2002. In total 19 'experts' participated, 12 in Workshop 1 and 7 in Workshop 2. The workshops were split into two stages. In Stage 1 'Deer and Deer Damage' we sought opinion on the usefulness on criteria that could be important in understanding deer populations and deer damage. In Stage 2 'Estate Management' we wanted opinion on the benefits and costs of criteria and use them to evaluated different management scenarios.

9. The decision modelling format was new to all delegates and given the amount that they were expected to achieve they worked very hard. We were impressed by the amount of lively, informed critical and constructive debate that took place during the workshops. Much thought went into making individual scores for the different criteria, and when delegates broke into their sub-groups discussion within these groups often went into great detail.

10. During the course of the workshop, we developed the concept of a 'law of diminishing returns', in which we would use the workshop results to rank the benefit to cost importance of the different Deer and Deer Damage criteria, and thus provide guidelines that recommended other users incorporate the less effective and more costly in that order, to the extent they felt they needed, and were able to.

11. This attractive concept has been rather spoiled by the actual results, as illustrated in Figure 4, as this shows that, apart from the four obviously important 'presence of deer species X' criteria and the universal relegation of the assessment method 'live deer counts', the spread of importance ranks is such that there does not seem to be any sensible ordering of the other 17 criteria which could be reliably followed in all circumstances.

12. We conclude that considerable degrees of expert knowledge are needed in complex combination with the overall aims of estate management and the topography, landscape and habitats of particular estates before the complex issues of 'deer management' can be appropriately optimised at a 'local' level.

13. These results from the Estate Management criteria strongly support the general conclusion, reached with the narrower set of Deer and Deer Damage criteria, that there is enormous variation between the views of different experts as to which criteria are most important. It further emphasises that this variation is in both aspects of the problem, the 'pros' or benefits, as well as the 'cons' or costs.

14. With hindsight it is perhaps not so surprising that such a complex issue, involving multiple aims and objectives in widely differing environments and habitats and with widely differing resources (both human and monetary) should not be susceptible to a single, universal assessment procedure. If people are trying to optimise different

things, they are very likely to judge both the cost and the success of their efforts by similarly different criteria.

15. We conclude that objectives and situations were very variable between expert practitioners and greatly affected the relative importance of the criteria within our lists on which they base their decisions most heavily.

16. Because most practitioners felt resources were limiting their deer management we would recommend that guidance be given in terms of Good, Adequate and Affordable practice rather than an ideal ‘Best Practice’ which many could not aspire to.
What affordable good practice will amount to will vary a lot with the owners’ aims and situations.

1. Decision making process of different practitioners

Literature review

An understanding of the decision-making processes used by woodland deer managers to reach final decisions on such things as cull targets is thought useful by the DCS. We review how decisions are influenced by management objective, scale of ownership, deer species present, available resources and information on woodland damage and deer populations. For the purposes of this report we focus on the objectives of managing deer in woodland, although we recognise that this may not always be the overriding objective for an estate landowner.

1.1 Management objectives

There are three generally recognised main objectives in woodland deer management:

1. To prevent damage
2. To exploit the deer resource
3. To regulate populations

Although the wordings and importance of each may vary there seems to be general consensus over these 3 objectives (Prior 1985; Ratcliffe 1987a; Ratcliffe & Mayle 1992; Prior 1995). The first includes preventing damage to trees, natural vegetation of conservation interest and farm crops and grasslands. The second includes trophy hunting and venison production. The third is dependent on the belief that, in the absence of other predators, man has some ethical responsibility for preventing deer populations from self-regulation. Deer welfare is probably a more widely accepted description as a management objective (Chapman & Chapman 1975; Prior 1983 1995; Springthorpe & Myhill 1994; ADMG Website 27/11/02). However, it should be noted that the objective of maintaining healthy deer in balance with their habitat is inconsistent with the management of most other British mammals (Ratcliffe & Mayle 1992).

A primary management objective will be deciding how many animals should be culled, by sex and age class, that will satisfy management aims (Mitchell, Staines & Welch 1977). For example, the Forestry Commission approach to large-scale deer management is based primarily on two objectives, efficient crop protection and the welfare of deer (Springthorpe & Myhill 1994). An estates` primary objective may be to benefit from both sporting interests and venison production (Mitchell et al. 1977) but animal welfare will also be seen as important. Cull targets are therefore set relative to management objectives.

Prior (1983) suggests, that if it is accepted that deer must be kept within the capacity of the forest to support them without undue damage then three alternative management decisions are available:

1. Reduce deer population to a level where damage is acceptable.
2. Increase natural food availability and reduce population to a level where food is sufficient to avoid serious damage.
3. Feed deer and reduce damage while maintaining artificially high populations.

It is more usual that the first alternative is used in commercial forestry management. Although ‘acceptable damage’ is commonly used it has different meaning for each practitioner (Mitchell et al. 1977; Melville, Tee & Rennolls 1983; Wigan 1993; SNH 1994). If control of deer populations is to be undertaken then balancing or offsetting the costs of damage and management with the benefits from a sustainable harvest is often a management objective. (Prior 1983, 1985; Ratcliffe, Henderson & Balharry 2001).

The second alternative requires active management to improve ground vegetation and existing browse (Prior 1983). Planting alternative browse, mowing access paths in wide rides and retaining areas of heather are all suggested (Prior 1983). Increased food availability is more likely to occur where natural heritage interest dictates that deer populations are reduced, and maintained at low levels, to allow regeneration of native woodland or recovery of ground vegetation. In this case however increased food availability is a consequence of reducing deer numbers (Beaumont et al. 1995). Although woodland design involving the creation of glades could be argued as increasing food available, their purpose is usually for deer control.

The third alternative is used by estates with an interest in trophy hunting and usually is confined to feeding red deer stags. Generally the aims are to prevent emigration and maintain condition of animals rather than reduce tree damage. The pros and cons of diversionary feeding have been commented on by several authors; including Mitchell et al. (1977), Clutton-Brock & Albon (1989), Ratcliffe et al. (2001) and Milner, Alexander & Griffin (2002). The general opinion is that any benefit will be limited and will depend on the type of forest and distribution of artificial food. Some forests provide plenty natural food for deer (Catt & Staines 1987) and animals are not attracted to supplementary food (pers. obs.). The cost of providing food is expensive (Ratcliffe et al. 2001) and would have to be justified as having a major reduction in damage.

1.2 Scale of ownership
Because of the differences in estate sizes deer populations may range across areas of land under different ownership and with different objectives. From the perspective of deer management some form of collaboration might be thought beneficial. DMGs could be viewed as a vehicle for collaborative management and setting of cull targets, but because they include people with a wide diversity of interests and objectives this is probably rarely achieved to the satisfaction of all. For small estates the likelihood is that they will have some shared deer populations with their neighbours and may only cull a small number of deer. The likelihood is that while information on tree damage could be useful to a small estate, estimating deer numbers may be less so. Large estates might want to know the size and composition of their deer herds as greater income is generated from deer management. Along with estate size the scale of woodland must also influence decision-making. Estates with a high dependency on forestry income or native woodland regeneration may want to achieve relatively lower densities of deer compared with estates with small scale forestry or woodland interests (Beaumont et al. 1995).

1.3 Resources
Resources for deer management will be influenced by the amount of money an owner is willing to invest. Forest Enterprise employ full-time professional deer managers and rangers, the costs of deer management and control being partly offset against income from venison sales, let stalking and supervised stalking (Gill, Webber &

Peace 2000; Ratcliffe et al. 2001). In the private sector there are a variety of different approaches. One alternative is to let deer stalking to tenants who pay for hunting, this should generate income, after management supervisory costs are accounted for, and could turn potential loss into profit (Ratcliffe et al. 2001). Another alternative is to employ full time professional staff but let much of the stalking to paying clients (Pickering 1998; Ratcliffe et al. 2001). Such alternative approaches do seem to merit attention. Ratcliffe et al. note that the cost of killing each deer increases as density declines, escalating exponentially at very low densities. They argue that this makes deer management of native woodland for natural heritage purposes particularly difficult and expensive and suggest engaging fee-paying hunters could be an attractive alternative. For some conservation bodies funded by subscription this choice might pose ethical problems, as the views of their mainly urban subscribers are often anti-hunting, and letting shooting may not be acceptable to them. Experience of this is much greater in North America where urban deer are an issue (Green, Askins & West 1997; Stout, Knuth & Curtis 1997). Arguments as to the efficiency in deer control and relative benefits to the rural economy of each approach are beyond the scope of this review but are clearly issues that have to be considered.

1.4 Deer species present

The deer species present will influence the type of damage suffered by trees (Gill 1992a) and numbers of deer present will affect the selection of trees for planting (McIntosh 1995), and potential cost to the forester (Gill et al. 2000). The causes and effects of deer damage are reviewed by Gill (1992a, 1992b). In forest plantations some small areas will have to be left unplanted to act as deer glades to aid deer control. In 2nd rotation forests deer will already be present and greater culling effort may be needed to protect restocks. Deer when provided with the shelter of woodland and food often grow larger and become more productive (Ratcliffe 1984).

Roe deer damage, through browsing and fraying, is usually confined to the early years of tree growth (Prior 1983; Staines & Welch 1984). A combination of protecting trees by fencing and culling may be necessary to allow establishment or restocking, especially at high density (McIntosh 1995). Red and sika deer damage trees, either by browsing, fraying or stripping bark, through all the stages of commercial forest growth (Staines & Welch 1984). Sika typically occur in thicket stage mixed deciduous and conifer forests. Sika deer are more difficult to control and manage than red deer because they are often nocturnal and make better use of concealing habitats such as thicket woodland (Ratcliffe 1987b; McLean 1992). The use of small deer glades has been shown to be effective in aiding culling of sika deer (McLean 1992). Control of sika populations may not be achievable because of the manpower required for shooting (SNH 1994). Fallow deer prefer more open pole stage and semi-mature woodland (Batcheler 1960; Prior 1983) and although they are mainly grazers, are known to cause damage mainly by browsing and fraying although some bark stripping has been reported (Mayle 1994). Fallow deer can become an agricultural pest and feed on neighbouring crops (Mayle 1994). However, whichever deer species or combination of species is present long-term management of the populations will be necessary. An offset for this might be a sustainable income from culling.

The discussion above has generally assumed that deer are resident within woodlands, but another problem exists in the control of marauding deer from adjacent open-range. It is difficult to manage deer populations if there are frequent, uncontrolled and often unknown intrusions from peripheral populations. Fencing may be an option, but it is expensive and experience shows that total exclusion is not realistic, although on newly afforested ground fencing will slow the rate of colonisation (Pepper 1992). Fencing may prevent deer from optimal use of their traditional range or exclude them from traditional wintering grounds (SNH 1994). Knowledge on the range use of local deer herds is needed (SNH 1994). The current debate on fencing between forest and open hill highlights the concerns of different practitioners (Fraser 2002).

1.5 Information on deer population and woodland damage

The main argument given in favour of estimating deer population size is that deer management should be predictive (Ratcliffe1987a; Mayle 1996), rather than retrospective. In many areas, land managers lack the basic information on the size or density of woodland deer populations, which it is suggested, are necessary for assessing changes in populations and setting cull targets (Ratcliffe1987a; Mayle et al. 1999). Ideally, estimates of density, fertility and survival rates are modelled to predict changes in numbers and sex and age classes of discrete deer populations (Mayle 1996). Such information can be used to set target population size and the annual cull. This information is likely to be of more benefit to larger estates where deer are resident and discrete populations may occur.

Many estates rely on DCS open hill counts for their estimates of red deer population size (Milner et al. 2002). These may occur only once every 8-10 years but are of insufficient regularity to be of benefit to estate management (Milner et al. 2002). To be of benefit to management counts need to be done more regularly. These authors point out that while accurate counting maybe desirable it may become an obsession and in reality any count will only ever be a guide to numbers on the ground.

Target densities and culls have to be set that can realistically meet the needs of management and take account of the approach and resources available for achieving the cull. For maintaining relatively self-contained woodland deer populations at a target level Buckland (1992) suggested the following five management objectives as a minimum requirement:

1. Determine target population size and age and sex structure.
2. Estimate actual population size and age and sex structure.
3. Determine deer cull by age and sex class required to achieve target population.
4. Assign numbers to be culled to each forest block comprising the forest area, and carry out coordinated culls.
5. Assess the success of the management plan.

Buckland, defines forest area to mean an area with a more or less self-contained deer population, with little movement across its boundaries. The area definition may vary for different deer species. Such plans are only likely to succeed across areas where neighbours have similar aims. A concerted management strategy for a single deer population is unlikely to succeed if neighbours have differing objectives.

In his review Gill (1992a) notes that browsing damage was not regularly surveyed in Britain and he was unable to comment on the severity of damage in different regions, years or on tree species. Tree damage is a main driver of deer management in commercial forestry, and such information is frequently used in final management decisions (McIntosh 1995). Information on tree damage also has economic value to a forester and can be used to predict future income, to decide on the species composition of a tree crop (McIntosh 1995) and whether to fence or not (Mayle 1996). For some deer managers tree damage may be the only information they have for setting cull targets (Prior 1995). He notes that with the potential use of cohort analysis to give information on deer populations "For most deer managers faced with the need to formulate their cull plans on little more than their own experience, a process of experiment based on increasing the cull until there is noticeably less impact may be the only expedient until records have built up."

Native woodland managers also use information on damage in their decision-making, possibly because the effect of damage is obvious. At Abernethy Forest grazing pressure from deer and sheep was identified as suppressing regeneration and accordingly sheep were removed. Data were collected on deer numbers and a cull set to achieve a rapid reduction in the red deer population. Monitoring of tree regeneration and damage are used as part of the deer management plan along with estimates of deer density (Beaumont et al. 1995).

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2. Decision Modelling Workshop

2.1 Rationale

The study needed to document the factors which practicing deer managers take into account when determining what assessment and control methods to use. We chose to use a structured approach to this, commonly referred to as Decision Modelling. These methods allowed us to elicit from the experts participating in the workshops clearly defined sets of criteria, whose relative importance to their decisions we were able to semi-quantify. Although time for the workshops was short, the discussions between experts ensured that they had a common understanding of the problems and exercises.

In brief, we adapted approaches based on Multiple Criteria Analysis (MCA), and evaluated criteria and options following the Multiple Attribute Value Function (MAVF): an introduction to these methods can be found in Belton (1990). Given the relatively short discussion time for the complex issues involved, we followed Phillips (1984) concepts of 'requisite' decision modelling by only evaluating a few fairly extreme scenarios, in order to cover a large range of outcomes in a short assessment.

A full-scale decision modelling exercise would allow the expert participants to generate the problem definition and choose both the evaluation criteria and the scenarios to evaluate from scratch. This contract did not permit such a time consuming approach. Accordingly CEH staff developed the two main themes for the workshop, and for each of these provided initial lists of criteria as a starting point for the discussions with the deer experts.

The two chosen themes were:

1. Criteria for assessing deer numbers and deer damage to forestry.
2. Criteria for assessing wider estate management practices, including assessment of social, conservation and other goals. This latter exercise progressed to using the criteria to evaluate some exemplar management scenarios (see below), to investigate if the chosen criteria performed reasonably.

2.2 Workshop preparation

Two one-day workshops were held in the Waverly Hotel in Perth. Workshop 1 on the 7th of November and Workshop 2 on the 29th November 2002. In total 19 'experts' participated, 12 in Workshop 1 and 7 in Workshop 2. The workshops were split into two stages. In Stage 1 'Deer and Deer Damage' we sought opinion on the usefulness on criteria that could be important in understanding deer populations and deer damage. In Stage 2 'Estate Management' we wanted opinion on the benefits and costs of criteria and use them to evaluated different management scenarios.

Because of the limited time busy experts had available, we wished to 'anticipate the obvious' for the first workshop and chose to define initial criteria and model scenarios beforehand to save time. The delegates were asked use these as a starting point, but were free to add, remove or amend criteria or scenarios.

Our initial lists of criteria for Deer Damage in Stage 1 are given in Appendix 1. The benefit and cost criteria used for Estate Management Assessment in Stage 2 are given in Appendix 2 and 3. The Original definitions for the scenarios used in Stage 2b are presented in Appendix 4.

The original contract specified four user groups, from which four representatives from each group were to be 'interviewed'. A fifth was later added, which we have called 'Deer Consultants'. Ideally we would have had equal numbers of representatives from the user-groups present at both workshops. For practical reasons this was not possible, but only one group (Forest Enterprise Senior Rangers) did not have representation at both workshops. The user-groups participating were:

User-group	Discussion Group
(i) Private Sector Forest Managers	BLUE
(ii) FE Senior Rangers	ORANGE
(iii) Private Landowners or their representative	BLUE
(iv) NGOs and Public bodies	GREEN
(v) Deer Consultants.	BLUE or ORANGE

Within each user group delegates were selected to give representative geographical cover of Scotland.

Prior to the workshops we allocated delegates into sub-groups of 3, 4 or 5 people of broadly similar background in order to facilitate discussion. Within these sub-groups there were considerable ranges in individual situations, aims and objectives. In Workshop 1 we had three sub-groups 'Green' 'Blue' and 'Orange'. Members of the green group had representatives from NGOs and Public bodies user-group with an interest in native woodland management. The blue group had representatives from the Private Landowners, Private Sector Forest Managers and Deer Consultants and the Orange group had representatives from FE Senior Rangers and Deer Consultants user groups.

In Workshop 2 we had a Green and Blue group, their make-ups coming from representatives of the same user groups defined above.

Analyses are based on original sub-group assignment, as post-hoc sub-groups would be biased towards spurious similarities.

Building a decision model would more normally be done over a 2-day period, with plenty of time for discussion, definition and reaching full and detailed mutual understanging at all stages. A key aspect of the process is to iterate the procedure, and re-visit former decisions in the light of subsequent learning. This was not possible in the limited time available to us.

The programme we devised for the first workshop proved very full, given the extensive discussions of most aspects which the delegates found necessary. Indeed, during the workshop we decided we had to curtail the initial programme. We decided that delegates would not (i) discuss their individual weighting scores to get a revised consensus for the 'Benefit and Cost components' of the 'Deer and Deer Damage Criteria' (Stage 1b) or (ii) their individual scores for the 'Estate Model' (stage 2b) to form a consensus model. We approximated a consensus view for groups in workshop 1 by subsequently averaging the revised results of individuals within the groups.

Analysis of the results has since suggested that the diversity of opinion within sub-groups is such that 'consensus' results may be somewhat artificial. However, the discussion they generate is important to reduce apparent differences between individual experts due to misunderstandings.

At the second workshop we chose to save time by concentrating on the more informative second stage of the 'Deer and Deer Damage' exercise, and to use the time saved to allow discussion of the Estate Management Scenario exercise, to give us more confidence in the revised scores of the individuals, as well as producing a consensus model.

Brief over-view of the structure of a simple Decision Model.

Figure 1 : Thee key elements of a Decision Model : Criteria, Options, Result.

Criteria		Criteria WT	Choice Options, Scenarios (types of car)			
			Land Rover	Mini	Rolls	Porsche
Purchase Price	C	50	45	20	100	75
Theft Risk	C	40	30	20	40	100
Running Costs	C	100	35	10	100	85
Insurance	C	90	60	25	80	100
Luggage Space	B	90	100	25	60	45
Number of Seats	B	10	80	40	100	60
Top Speed	B	20	70	45	95	100
Comfort	B	5	50	40	100	60
4*4	B	100	100	0	0	0
RESULT : B/C ratio			**2.16**	**0.92**	**0.46**	**0.34**

Figure 1 above illustrates the three key aspects of a simple decision model.

1. At the left (light grey box) are two sets of criteria, representing the benefits and costs, or the pros and cons, which might be used to evaluate a set of choices. In this simple example the criteria relate to using a car (for a specific but here undefined purpose). Within the set of costs and benefits, each criterion is given a relative importance Weight, on a scale of 100 = most important and 0 = not at all important. More than one criterion can be scored 100, and zero is not essential.
2. At the right (white box) is a set of choice columns, in this simple example types of car. For each car there is a set of scores, representing its performance rating (again on a scale 0 ~ 100) for each criterion.
3. At the bottom are the results of the comparison (dark grey row). The number represents the benefit / cost ratio of the separate sums of the benefit and costs, scores weighted by their importance values and scaled according to the sums of their importances (the MAVF formula, see, eg Belton 1990). A value above

1 indicates benefits exceed costs (on this defined scale), a value of less than one that costs exceed benefits. The highest value thus represents the most appropriate choice of the options evaluated.

2.3 Decision Modelling and Deer Management Assessment.
The contract required us to assess the decisions made by deer experts when choosing how to manage different situations. We chose to use decision modelling to quantify, in terms of the 'importance weights', the perceptions of different experts about the relative merits of criteria which they take into account when managing deer populations, forests damaged by deer and wider aspects of estate management, such as stalking and public access.

Our broad approach was to first concentrate on Deer and Deer Damage. **Stage 1a** of the workshop invited the experts to develop (amend our initial) a list of criteria about how to assess deer populations and the amount of forest damage they were causing. This used the classic decision model approach illustrated above to elicit the importance weights, but did not immediately go on to evaluate choices.

Given the complex nature of a 'criterion' such as 'estimate population densities by doing dung counts', which has both benefit elements (the management information gained at the end of the study) and costs (the costs of getting and interpreting the information), we decided to explore these criteria in greater depth. Thus, at **Stage 1b** we further asked the delegates to give importance weights to those same criteria, but now considering both their benefit and cost aspects separately. And we asked them to do this for both small and large estates, to see if estate size would affect their assessment of the relative importance of criteria.

We still did not ask them to use these criteria to evaluate scenarios, as we felt that other management factors would be important as well. Given the limited time for the workshops we could not simply add those criteria to the existing list of 'Deer and Deer Damage Criteria', as the scoring would then have taken far too long.

Instead, we developed a simplified list of Deer criteria, to which we added a few others relating to broader management aims. Thus in stage two the delegates were first asked to expand our initial list, and then to give importance weights for these Estate Management **Cost** and **Benefit** criteria. We wished to use that expanded list of criteria to get a feel for the extent to which non-deer related aspects influenced their broader decisions.

Finally, we presented them with half a dozen extreme scenarios (Table 1) of estates and different types of deer population that required managing, and asked them to evaluate the extent to which those different situations could be 'satisfactorily' managed. We did this as we considered it important to investigate whether the criteria chosen produced broadly sensible evaluations; for it they did not, it might imply that the list of criteria was seriously inadequate (identifying such inadequacies by comparing the Decision Model evaluations to experts' instincts and gut-feelings, and then looking for causes of any serious discrepancies, is a key reason for wanting to **iterate** the discussion processes in full decision modelling exercise. (We note we did not have time for any such iterations).

Table 1 Final list of Scenarios used in Stage 2b

Stage IIb Management Scenarios for Multi-purpose Forestry with an emphasis on commercial timber production.

Scenario 1 **(LHR)**
A **Large** (>1000ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you have 200 ha of restock (aged 1-8) a year. There are **High** densities of **Resident** red and roe deer (both >30 per km^2). Neighbours include arable farmers and sheep farmers. You employ 1 person full time for deer culling and vermin control plus other general duties. You get some income from paying guests for trophy hunting both red and roe.

Scenario 2 **(LHS)**
A **Large** (>1000ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you have 200 ha of restock (aged 1-8) a year. There are **High** densities of **Shared** red deer and resident roe deer (both >30 per km^2). Neighbours arable farmers, moorland. You employ 1 person full time for deer culling and vermin control plus other general duties. You make some income from paying guests from trophy hunting roe only.

Scenario 3 **(LLR)**
A **Large** (>1000ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you have 200 ha of restock (aged 1-8) a year. There are **Low** densities of **Resident** red and roe deer (both <5 per km^2). Neighbours arable farmers and sheep farmers. You let deer culling and seasonally employ for vermin control and other general duties.

Scenario 4 **(SHR)**
A **Small** (<100ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you plant 2.5 ha of restock a year. There are **High** densities of **Resident** red and roe deer (both >30 per km^2). Neighbours include arable farmers and sheep farmers. You employ 1 person full time for deer culling and vermin control plus other general duties.

Scenario 5 **(SLS)**
A **Small** (<100ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you plant 2.5 ha of restock a year. There are **High** densities of **Shared** red deer and resident roe deer (both >30 per km^2). Neighbours arable farmers. You employ 1 person full time for deer culling and vermin control plus other general duties.

Scenario 6 **(SLR)**
A **Small** (<100ha) 2nd rotation Commercial plantation of sitka spruce with trees of even age. On average you plant 2.5 ha of restock a year. There are **Low** densities of **Resident** red and roe deer (both <5 per km^2). Neighbours arable farmers and sheep farmers. You let deer culling and seasonally employ for vermin control and other general duties.

Stage IIb Management Scenarios for Native Woodland

Objective: Managing Native Woodlands for Biodiversity and People

Scenario 1 **(LHRN)**
A **Large** >3000 ha estate. Mix of open hill and native pinewood. There are **High** densities of **Resident** red and roe deer (both >15 per km^2). Neighbours include sporting estate. You employ 1.5 staff to cull deer. You have a **No** fence policy because woodland grouse are present.

Scenario 2 **(LHRF)**
A **Large** >3000 ha estate. Mix of open hill and native pinewood. There are **High** densities of **resident** red and roe deer (both >15 per km^2). Neighbours include sporting estate. You employ 1.5 staff to cull deer. You have a **Fencing** policy.

Scenario 3 **(LHSN)**
A **Large** >3000 ha estate. Mix of open hill and native pinewood. There are **High** densities of resident roe deer and a **Shared** population of red deer (both >15 per km^2). Neighbours include sporting estate. You employ 1.5 staff to cull deer. You have a **No** fence policy because woodland grouse are present.

Scenario 4 **(LLRN)**
A **Large** >3000 ha estate with a mix of open hill and native pinewood. There are **Low** densities of **Resident** red and roe deer (both <5 per km^2). Neighbours include sporting estate. You employ 1 person to cull deer and have a limited sporting take of male deer. You have a **No** fence policy because woodland grouse are present.

Scenario 5 **(SHSN)**
A **Small** <100ha estate with a mix of open hill and native pinewood. There are **High** densities of resident roe and **Shared** red deer (both >15 per km^2). Neighbours include forestry. Deer-control carried out by local contractor with no income or costs. You have a **No** fence policy because woodland grouse are present.

Scenario 6 **(SLRN)**
A **Small** <100ha estate with a mix of open hill and native pinewood. There are **Low** densities of **Resident** red and roe deer (both <5 per km^2). Neighbours include forestry. Deer-control carried out by local contractor with no income or costs. You have a **No** fence policy because woodland grouse are present.

Format of the discussions.
The schedule for creating the decision model is for participants to independently record their initial views, eg criterion weighting values, as to the importance of individual criteria. Delegates are asked to weight each criterion between 0 and 100, with the most important scoring 100. If delegates feel that separate individual criteria

are equally important then they can allocate the same weighting to them, thus for example several criteria could be given a weighting of 100.

Next participants form into small sub-groups, a chair-person is selected, and delegates discuss their individual scores. This is a crucial aspect of the process, providing a common basis of understanding **after** they have got an initial, individual over-view of the task and model. The discussion gives them the opportunity to change their mind, in the light of new opinions or explanations advanced by their peers. Such discussion is also particularly important because scoring so many criteria, particularly in a short time, is quite challenging; it is easy to forget things, misunderstand or have limited knowledge of some aspects: discussion allows delegates to revise their score to one they subsequently believe to be more realistic. However, the delegates were encouraged to 'stick to their guns' if, after discussion, they genuinely felt their experience was leading them to a different evaluation from those of their colleagues.

Each criterion is discussed by first finding the delegates with the highest and lowest scores; if these extreme scores differ markedly, then the delegates discuss the reasoning behind their scores. After discussion participants then record their revised scores for the criterion. Next a group consensus is reached in the light of the revised scores, which are normally (slightly) closer than the original scores. After discussing and individually revising each criterion, the chairperson tries to record a group 'consensus score'. This is often quite easy, but was an appreciable source of contention at these Deer Management discussions. We concluded (see below) that the difficulty of agreeing a consensus score for our Deer Evaluation exercise arose from genuine, firmly held and well argued reasons why the aims, objectives and situations of the different experts really lead them to reach different decisions and assessments.

Most of our chairpersons managed to record some form of consensus score, but most did so in the knowledge that these represented 'best compromises' rather than a genuine 'homing in on a true common position'. The discussions generated much debate and revealed many deeply held opinions. Interestingly, at least for the extreme Estate Management scenarios evaluated at the end of exercise 2, there subjectively seemed to us more agreement about the merits of the different situations than the disagreement of the importance of the criteria needed to effectively manage it had initially suggested.

2.4 Workshop results

Participants reactions.
The decision modelling format was new to all delegates and given the amount that they were expected to achieve they worked very hard. We were impressed by the amount of lively, informed critical and constructive debate that took place during the workshops. Much thought went into making individual scores for the different criteria, and when delegates broke into their sub-groups discussion within these groups often went into great detail. A couple of delegates, used to making different decisions in different circumstances according to their clients' objectives, found it difficult at first to know under which circumstance they should score the criteria. However, most delegates were used to only one situation. Thus delegates had diverse,

firmly held and firmly founded beliefs based on their individual experiences from different geographical areas of Scotland.

Although the group discussions displayed a strong common understanding of fundamental principles, personal views were usually firmly retained. A common comment during detailed discussion was "Yes, I can see just what you mean, and in your situation I would agree with you: but my situation is different, so my assessment has to be different". The FE Rangers particularly liked the format of the workshop, as they felt it allowed them to express their opinions more fully than in previous discussions and deliberations.

2.5 Delegate's assessment of the workshop.

Delegates were asked to complete a brief questionnaire about the workshop (Appendix 5), and the responses are summarised in Table 2.

Most delegates found the level of the workshop about right, many felt that they had learned usefully from the experience and several would have recommended colleagues to attend similar workshops given the opportunity. The latter result was gratifying, as we had expected the formal numerical approach might well have been off-putting to some delegates.

Table 2. Results from questionnaire. Responses from 18 out of 19 delegates

		Total	%
Workshop length	Too long	3	16
	About right	11	61
	Not long enough	4	22
Questions covered	Too complex	9.5	53
	About right	8	44
	Too superficial	0.5	3
Learn anything	A lot	3	17
	Moderate amount	15	83
	Little	0	0
Usefulness	High	7	39
	Moderate	9	50
	Low	2	11
Encourage others to participate	Greatly	8	44
	Slightly	10	56
	Not at all	0	0

In detail the questionnaire responses revealed that participants in workshop 1 were more enthusiastic about the format. This may be because they were more actively involved in choosing and developing the criteria scored and the estate management options evaluated, and thus had more of a stake in the process. In contrast participants in the second workshop, were encouraged to work with the criteria lists developed in workshop 1, unless they had strong contrary views (otherwise comparing the results across the two workshops would have been problematic, if one had used criteria the other had not...). Thus all seven participants in workshop 2 found the questions covered too complex, whereas the majority of participants in workshop 1 thought the questions about right. However, all the delegates felt they learnt new things from each other during the structured discussion sessions. We found this particularly encouraging, as the main aim of the meetings was for us to learn from them!

2.6 Evaluating Deer populations and Deer Damage to forests (STAGE 1 a,b)

Our original list of twelve criteria was expanded during workshop 1. Delegates added a further 7 and split one (Exact density of deer) into four separate criteria to represent the four deer species for which information was required. This gave a total of 22 criteria, of which the following were added at the first workshop:

Exact densities of red deer
Exact densities of roe deer
Exact densities of sika deer
Exact densities of fallow deer
Deer hefted to ground
Core or peripheral ground
Tree species and habitat composition of woodland
Neighbours objectives and management
Damage to trees by species other than deer
Density of tree regeneration
Severity of apical damage

In the summary discussion following workshop 2, a few participants suggested there may have been too many criteria in stages 1, and that perhaps it might have been better to concentrate on the more important ones. However, we both wanted to evaluate how much less-important these 'unimportant criteria' really were and how their perceived importance varied between delegates and groups of delegates. We also needed to be able to compare the results across both workshops. Clearly it would have been better if the delegates at the second workshop had participated in the choice of criteria, but that was unfortunately not possible. That said, the delegates at workshop 2 proposed another criterion 'Forest structure' which related to carrying capacity.

Human decisions are commonly thought to be frequently based on only a few 'key' criteria. Our aim was to provide a framework to evaluate the perceived importance of a large number of criteria, and provide a method that would allow more rigorous assessment of the consequences of omitting a set of 'minor' criteria. It is easy to imagine situations where a large set of minor criteria might out-weight the difference between a few key ones when the differences between choice options are small.

A complete listing of the final criteria used in stage 1, at both workshops, and their definitions are given in Table 3.

Table 3. Definitions of criteria used in stages 1a and 1b for deer and deer damage

Aspect	Information	Definition
Deer	Presence of Red deer	Importance of knowing if Red deer present on the ground
Deer	Presence of Roe deer	Importance of knowing if Roe deer on the ground
Deer	Presence of Sika deer	Importance of knowing if Sika deer on the ground
Deer	Presence of Fallow deer	Importance of knowing if Fallow deer on the ground
Deer	Accurate densities of Red deer	Importance of having an accurate estimate of Red deer density
Deer	Accurate densities of Roe deer	Importance of having an accurate estimate of Roe deer density
Deer	Accurate densities of Sika deer	Importance of having an accurate estimate of Sika deer density
Deer	Accurate densities of Fallow deer	Importance of having an accurate estimate of Fallow deer density
Deer	Target density (for trivial damage)	Importance of a target density
Deer	Live deer counts (drives, etc)	How useful are live deer counts for estimating deer density
Deer	Indirect counts (dung counts, tracks, etc)	How useful are dung counts for estimating deer density
Deer	Keeper Knowledge	Importance of keeper knowledge on local deer populations
Deer	Cull data analysis (age, sex, weight)	How useful are cull data for estimating deer density
Deer	Hefted to the ground or not	How important is it to know if deer are resident or not
Deer	Core / periphery of the deers' range	Are populations locatable and stable or peripheral
Forestry	Perceived level of tree damage	Subjective guesstimate of damage levels
Forestry	Accurate estimated of tree damage	How important is it to have good estimates of tree damage
Forestry	% damage NOT by deer	Identify damage by other animals
Forestry	Density of tree regeneration	How successful is tree regeneration and growth
Forestry	Severity (%) of severe apical damage	Are trees being killed, or checked in growth
Forestry	Tree species /composition	Tree species present and composition and stage of forest habitats
Control	Effectiveness of Neighbour's deer control	Do neighbours have the same objectives for deer control

Deer and Deer Damage : Importance weights of the criteria.

Stage 1a was only undertaken in workshop 1, and delegates recorded their initial individual scores (weighting) for each of the 22 criteria. Delegates were asked to judge between the criteria as to which they perceived to be the most important information to have and the least important using the following classification as a guide:

100	Most important
75-99	Fairly important
50-74	Intermediate
25-49	Fairly unimportant
0-24	Unimportant

This guidance classification was used for all stages. After recording their individual scores delegates broke into their sub-groups to discuss their scores, revise them if necessary and record a group consensus score. The strategy used to discuss scores varied between groups; some chose to discuss them in order while others tried to identify the criteria with the highest scores and discuss them first. On a few occasions delegates' scores were similar and little discussion was needed to reach consensus.

The scoring form used for Stage 1a is given in Appendix 6.

Stage 1b used the same 22 criteria formulated in stage 1a. This time delegates were asked to give their opinion on the relative benefits of having data and costs for getting the data, for each criteria, for a small (<100 ha) and large (>1000 ha) estate. The same weighting procedure was used as before, this time a weighting of 100 represented the greatest benefit or cost. Delegates first filled in the column for the benefits for a small estate weighting the criteria relative to each other as for stage 1a. Then the relative benefits were compared with those for a large estate, the delegate reflecting whether they viewed the benefits to be the same or different in their weighting. The same procedure was then repeated for the costs.

Given the complexity of the 'criteria', and the fact that most had costs as well as benefits associated with them, we wished to further explore this area. In workshop 1, after giving general importance scores to each criterion, the delegates were then asked to both (a) similarly rank both their benefits and their costs separately and (b) to make these evaluations for both small and large estates, as we wished to assess if estate size affected the perceived importance of any criteria as requited by the contract.

Initial analysis of the results from Workshop 1 suggested the more detailed approach (benefit and cost, rather than 'general importance') was more informative, so we went straight to that in Workshop 2. The scoring form used for Stage 1b is given in Appendix 7.

2.7 Results.

Deer and Deer Damage criteria.
At workshop one, the top pair of graphs in Figure 2 above shows that while there was general agreement that the criteria had correlated importances on estates of different sizes, the overall relationship is less than unity (criteria have **equal** importance on estates of different sizes) , with the regression coefficients (through the origin) being respectively 0.67 and 0.43 for the Blue and Green groups respectively. This result arises due to a concentration of 'unimportant' criteria near the origin, and a smaller set (some 8 criteria) away from the origin, exerting high leverage on the position of the (linear) regression line. Further, the Green group's results show some appreciable deviations about the regression line, indicating wider variation in importance assessment for small and large estates.

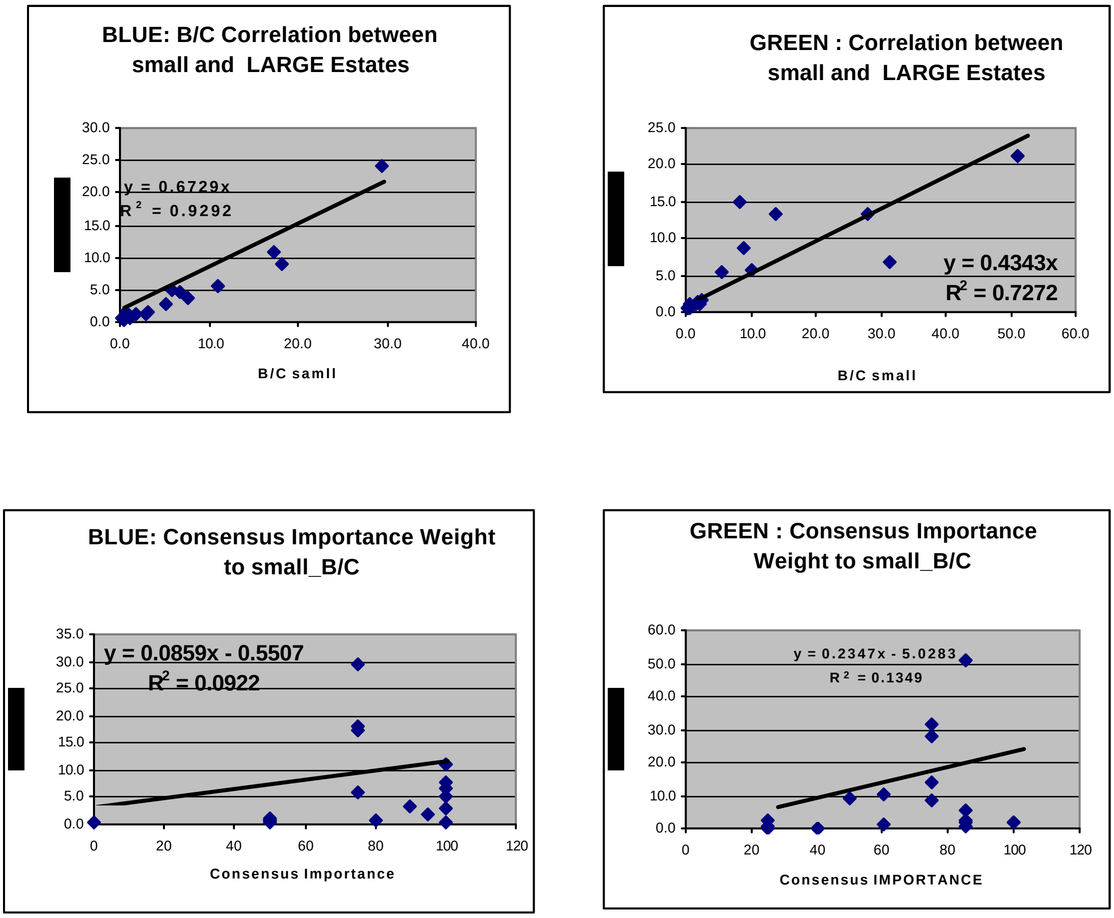
When comparing the two methods of assessing the criteria (bottom pair of graphs, Figure 2), there was a surprising lack of correlation indicated by the results of workshop 1. The scatter diagrams show a broad spread of points, and there is no significant linear correlation, nor any indication of a non-linear trend.

Figure 2. Workshop 1: Importance of deer damage criteria.

Results are illustrated for the Blue group (left pair of graphs) and the Green group (right pair).

The top pair of graphs contrasts results between **small and large** estates. The graphs show the scatter diagram and linear correlation between the Importance Weights as evaluated for small and large estates. Both groups show, high correlation, as expected. The relationship for the Blue group is a very close($p < 0.001$), explaining 93% of the variation; that for the Green group is less tight ($p < 0.001$), explaining 72% of variation. For the green group some points well above the regression line represent criteria evaluated as appreciably more important on large estates.

The bottom pair of graphs contrast the two different methods of assessing the complex ‘criteria’ for the Deer and Deer Damage exercise, the Benefit and Cost method as opposed to the standard Decision Model Importance Score method. Rather surprisingly these relationships are very weak; neither are statistically significant ($p > 0.05$) and they explain only 9% and 13% of variation respectively.



We interpreted these combined findings as suggesting that the complexity of the 'criteria' in the complex situation of deer management probably meant that the conceptual leap of defining an overall 'importance' to them was perhaps too complex. As they have both cost and benefit aspects (costs of collecting the data and management value of the information once analysed), it seemed likely that the delegates initial thoughts had been swayed more one way than the other.

At the second workshop we thus chose to concentrate on the more detailed approach. The results from workshop 2 are illustrated for the Blue and Green groups in Figure 3. The wider spread of values within the graphs, the very tight relationship of 18 of the 22 points and the appreciable deviations of the remaining four points from regression lines with slopes very close to unity as expected reinforce our prior expectation that the more detailed approach was usefully more informative given the complex issues underlying deer management. We take the results of Figure 3 to imply that most of the key criteria (18/22) have importances that are independent of estate size, but that the importance of four criteria varies appreciably with estate size.

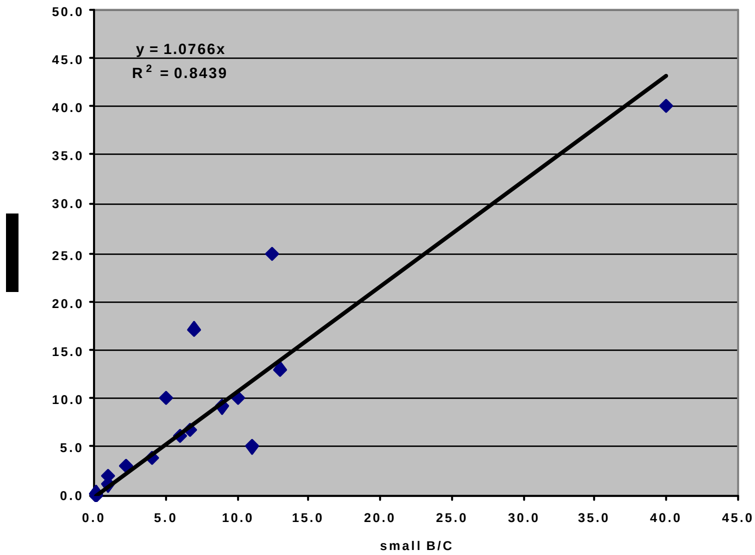
We note from Figure 3 that the magnitude of the Benefit to cost ratios differed appreciably between the Blue and Green groups. Even omitting the outlier with an B/C ratio of 40 from the Blue group, several of its ratios 9 of its 22 criteria exceed a B/C ratio of 5.0, whereas none of the Green Group's exceeded 5.0. This implies that different viewpoint groups may have very differing assessments of the same methods of deer and deer damage assessment, presumable due to their different aims and objectives. We will return to this point below.

Figure 3. Workshop 2, Deer and Deer Damage between small and large estates, evaluated using just the more rigorous Benefit to Cost approach.

Blue Group (top graph). The regression is highly significant ($p << 0.001$), explaining 84% of the variation, and with an estimated slope of 1.077 commensurate with most criteria having the similar importance between small and large estates. However, the graph shows four outliers from the regression line, highlighting those few criteria now evaluated to have different importance depending on estate size

Green Group (lower graph). A similar picture to the results for the Blue group. The regression is highly significant ($p << 0.001$) and explains 78% of variation, with an estimated slope of 0.99, or almost exactly 1.00. This is again commensurate with most criteria having similar importance irrespective of estate size. However, as with results for the Blue group, four extreme outliers from the otherwise very tight regression line identify criteria assessed to have different importances, as benefit to cost ratios, depending on estate size.

Deer Damage, WK2, Blue : B/C for small versus Large Estates



Deer Damage, WK2 Green : B/C for small versus Large Estates

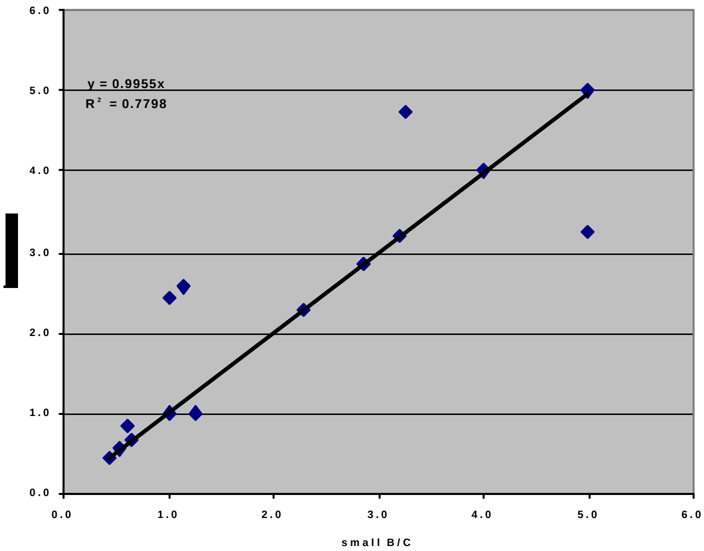
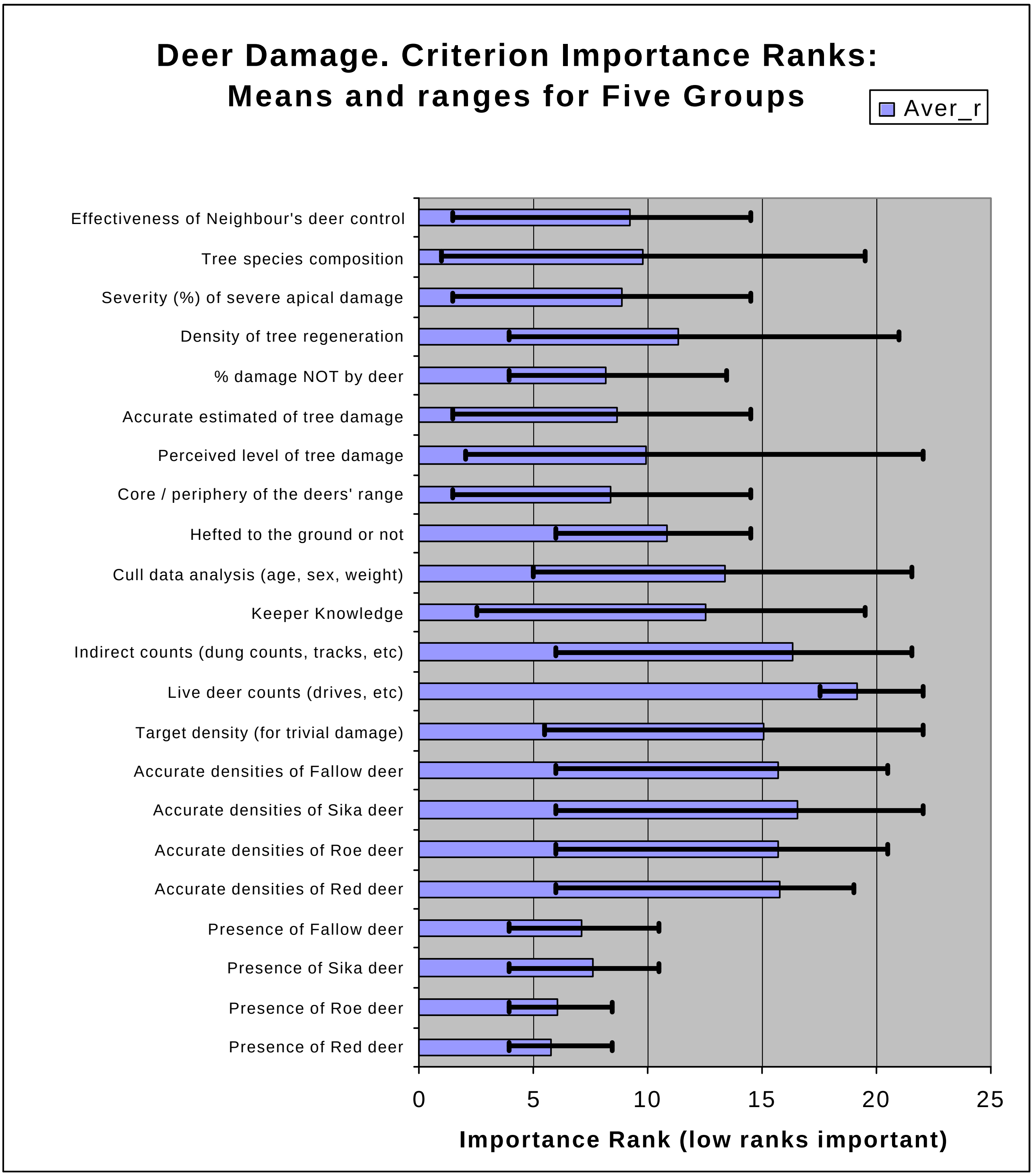


Figure 4: Deer and Deer Damage results from both workshops, showing the ranges of ranked Criteria Importance Weights for five sub-groups of delegates. The solid bars show the mean importance ranks, the bold black lines the minima and the maxima, for each of the 22 criteria. Note the very widespread of importance evaluations for most criteria.



The relative importance of the Deer and Deer Damage criteria.

In order to compare the Deer and Deer Damage results between workshops 1 and 2, which had been derived by different methods, we have, within each sub-group at each workshop, ordered the individual's assessments, assigned them ranks from 1 to 22 (1 being the most important), and then calculated average ranks within the sub-groups. We note in passing that averages of ranks can result in mean ranks that are fractions, and that such 'tied-ranks' can also prevent some ranks appearing as often as expected.

The results are illustrated in Figure 4, which shows the most important criteria as the shorter bars (first ranks). There is clearly enormous variation within criteria as to how important they were considered to be. This is even more striking when one remembers that these results are subsequent to the 'revision process' which aims to reduce variation due to misunderstanding and uncertainty and that they represent the consensus, or average, scores of groups of two to five delegates, and not the revised individual scores, which were even more variable.

Only two features stand out clearly from this graph. Firstly, the basic criteria about the presence of the different deer species were consistently highly ranked by all groups, having mean ranks within groups between 4 and 11, with presence of Red and Roe deer appearing a bit more important than knowing about Sika and Fallow. While it is rather obvious that these fundamental criteria were universally rated as important, it is at first sight rather surprising that there was so little consistency about any of the others.

The only other criterion with a small range, similarly of some 5 ranks, was 'Live Deer counts', which was consistently rated as unimportant (ranks 17.5 to 22).

Of the other criteria, six have rank-ranges that span over half the range of possible ranks, and the other eleven have rank-ranges of 15, almost three quarters of the possible range.

The simplest explanation is that the range of situations and objectives represented by our different experts genuinely lead to extreme differences of opinion as to which criteria were most important. Indeed, as mentioned above, during the discussions among delegates, a discussant would often admit that, in the other's situation s/he would rate the criterion being considered very differently, but not in her/his own situation. We briefly consider a handful of criteria below.

Tree species / composition got average importance ranks between 1 and 19. The group scoring it highly were familiar with situations where varied woodland types and species affected both deer distribution and deer damage; they thus rated its information as important, the cost of getting such obvious information tiny and thus its overall importance as very high. The group rating it very low were familiar with a more uniform, monoculture situation, where habitat and species variation were largely trivial and irrelevant.

Density of Tree Regeneration was rated highly (rank 4) by 'conservation groups' for whom it was a main aim, whereas commercial foresters who generally replant trees assessed it as unimportant (rank 22).

Keeper knowledge received assessment ranks between 2.5 and 19, and one high evaluation came from a group of managers. The discussions suggested that some managers deal with areas where detailed local knowledge is not critical to successful stalking and control, whereas others deal with situations where such knowledge, as well as knowledge about localised damage and risk of damage, is very important.

Finally in this assessment of the Deer and Deer Damage Criteria, we consider those criteria thought to vary in importance between estates of different sizes. These were particularly clearly illustrated during workshop 2, and we present the tables of their results (on which Figures 3 are based) in Table 4 below. Table 4a shows the result for the green group, and highlights both the **names** of the factors they felt varied in importance and, in the previous column the factors the blue group felt to vary (See table 4b for details of the Blue Group results).

The green group assessed 'target deer density for trivial damage', ' Cull data analysis' and 'Accurate estimates of tree damage' to be appreciably more important criteria on large than on small estates. In contrast, they considered that 'Effectiveness of Neighbour's deer control' was less important on a large estate (where it affected mainly the periphery, rather than most of the estate).

The Blue group similarly thought 'Cull data analysis' and 'Effectivness of Neighbour's deer control' to be respectively more and less important on large estates. However, they disagreed about 'Target densities' and 'Accurate Estimates of Damage', but considered that 'Hefted to the ground or not' and 'Core / periphery of deer's range' were both more important on large estates.

Conclusions – Deer and Deer Damage.

During the course of the workshop, we developed the concept of a 'law of diminishing returns', in which we would use the workshop results to rank the benefit to cost importance of the different Deer and Deer Damage criteria, and thus provide guidelines that recommended other users incorporate the less effective and more costly in that order, to the extent they felt they needed, and were able to.

This attractive concept has been rather spoiled by the actual results, as illustrated in Figure 4, as this shows that, apart from the four obviously important 'presence of deer species X' criteria and the universal relegation of the assessment method 'live deer counts', the spread of importance ranks is such that there does not seem to be any sensible ordering of the other 17 criteria which could be reliably followed in all circumstances.

We conclude that considerable degrees of expert knowledge are needed in complex combination with the overall aims of estate management and the topography, landscape and habitats of particular estates before the complex issues of 'deer management' can be appropriately optimised at a 'local' level.

Table 4.a

WK_2 : Deer Damage, comparing GREEN and BLUE.
Evaluating Deer and Deer Damage

GROUP : GREEN

Stage : G_C **CONSENSUS SCORE**

Score DOWN columns
: -give 100 to most important
: -give X to least important, BUT AVOID ZERO (costs) and be careful of very small COSTS…
: - scale others in between

			Scoring ORDER	*1*	*2*	*3*	*4*				
				Benefits	**Benefits**	**Costs**	**Costs**	**B/C ratio**	**B/C ratio**	**Linear Trend**	
C#	**Aspect**	**Sp**	**Information**	B Small	B Large	C Small	C Large	B/C Small	B/C Large	Lg Pred.	Residual
1	Deer		Presence of Red deer	100	100	35	35	**2.86**	**2.86**	2.84	0.01
2	Deer		Presence of Roe deer	100	100	35	35	**2.86**	**2.86**	2.84	0.01
3	Deer		Presence of Sika deer	100	100	35	35	**2.86**	**2.86**	2.84	0.01
4	Deer		Presence of Fallow deer	100	100	35	35	**2.86**	**2.86**	2.84	0.01
5	Deer		Accurate densities of Red deer	60	85	100	100	**0.60**	**0.85**	0.60	0.25
6	Deer		Accurate densities of Roe deer	65	65	100	100	**0.65**	**0.65**	0.65	0.00
7	Deer		Accurate densities of Sika deer	60	85	100	100	**0.60**	**0.85**	0.60	0.25
8	Deer		Accurate densities of Fallow deer	65	65	100	100	**0.65**	**0.65**	0.65	0.00
9	Deer		Target density (for trivial damage)	**40**	90	**35**	35	**1.14**	**2.57**	1.14	1.43
10	Deer	X	Live deer counts (drives, etc)	35	35	**80**	80	**0.44**	**0.44**	0.44	0.00
11	Deer	X	Indirect counts (dung counts, tracks, etc)	60	85	**100**	100	**0.60**	**0.85**	0.60	0.25
12	Deer	X	Keeper Knowledge	80	80	20	20	**4.00**	**4.00**	3.98	0.02
13	Deer	X	Cull data analysis (age, sex, weight)	65	95	20	20	**3.25**	**4.75**	3.24	1.51
14	Deer	X	Hefted to the ground or not	80	80	**25**	25	**3.20**	**3.20**	3.19	0.01
15	Deer	X	Core / periphery of the deers' range	50	50	**10**	10	**5.00**	**5.00**	4.98	0.02
16	Forestry	X	Perceived level of tree damage	80	80	35	35	**2.29**	**2.29**	2.28	0.01
17	Forestry	X	Accurate estimated of tree damage	85	85	85	35	**1.00**	**2.43**	1.00	1.43
18	Forestry		% damage NOT by deer	50	50	40	50	**1.25**	**1.00**	1.24	-0.24
19	Forestry		Density of tree regeneration	35	35	65	65	**0.54**	**0.54**	0.54	0.00
20	Forestry		Severity (%) of severe apical damage	70	70	70	70	**1.00**	**1.00**	1.00	0.00
21	Forestry		Tree species composition	80	80	20	20	**4.00**	**4.00**	3.98	0.02
22	Control		Effectiveness of Neighbour's deer control	100	65	**20**	20	**5.00**	**3.25**	4.98	-1.73
			any SUMS	**1560**	**1680**	**1165**	**1125**	**46.63**	**49.74**		

Blue Groups

Green Group's estate size differences

More important on Large Estates
Less important on Large Estates

Table 4.b

GROUP :		Worskhop 2, BLUE.	: -give X to least important, BUT AVOID ZERO (costs) and be careful of very small COSTS…								
Stage :		**CONSENSUS**	: - scale others in between								
		Scoring ORDER	*1*	*2*	*3*	*4*			PRED	Residual	
			Benefits	**Benefits**	**Costs**	**Costs**	**B/C ratio**	**B/C ratio**	**Linear Trend**		
Aspect	**Sp**	**Information**	B Small	B Large	C Small	C Large	B/C Small	B/C Large	Lg PRED	Residual	
1 Deer		Presence of Red deer	100	100	10	10	**10.00**	**10.00**	10.75903	-0.76	
2 Deer		Presence of Roe deer	90	90	10	10	**9.00**	**9.00**	9.683139	-0.68	
3 Deer		Presence of Sika deer	100	100	15	15	**6.67**	**6.67**	7.172927	-0.51	
4 Deer		Presence of Fallow deer	90	90	10	10	**9.00**	**9.00**	9.683139	-0.68	
5 Deer		Accurate densities of Red deer	10	25	75	100	**0.13**	**0.25**	0.143479	0.11	
6 Deer		Accurate densities of Roe deer	8	17	75	100	**0.11**	**0.17**	0.114786	0.06	
7 Deer		Accurate densities of Sika deer	8	27	80	100	**0.10**	**0.27**	0.107612	0.16	
8 Deer		Accurate densities of Fallow deer	8	20	75	100	**0.11**	**0.20**	0.114786	0.09	
9 Deer		Target density (for trivial damage)	**5**	10	**5**	5	**1.00**	**2.00**	1.076	0.92	
10 Deer	X	Live deer counts (drives, etc)	5	5	**40**	50	**0.13**	**0.10**	0.134524	-0.03	
11 Deer	X	Indirect counts (dung counts, tracks, etc)	15	15	**100**	100	**0.15**	**0.15**	0.161409	-0.01	
12 Deer	X	Keeper Knowledge	90	90	90	85	**1.00**	**1.06**	1.076	-0.02	
13 Deer	X	Cull data analysis (age, sex, weight)	35	85	5	5	**7.00**	**17.00**	7.530709	9.47	
14 Deer	X	Hefted to the ground or not	25	50	**5**	5	**5.00**	**10.00**	5.379139	4.62	
15 Deer	X	Core / periphery of the deers' range	25	50	**2**	2	**12.49**	**25.00**	13.44382	11.56	
16 Forestry	X	Perceived level of tree damage	65	65	5	5	**13.00**	**13.00**	13.98542	-0.99	
17 Forestry	X	Accurate estimated of tree damage	90	90	40	30	**2.25**	**3.00**	2.420966	0.58	
18 Forestry		% damage NOT by deer	90	90	40	30	**2.25**	**3.00**	2.420966	0.58	
19 Forestry		Density of tree regeneration	60	60	15	15	**4.00**	**4.00**	4.303785	-0.30	
20 Forestry		Severity (%) of severe apical damage	90	90	15	15	**6.00**	**6.00**	6.455641	-0.46	
21 Forestry		Tree species composition	80	80	2	2	**39.98**	**40.00**	43.01903	-3.02	
22 Control		Effectiveness of Neighbour's deer control	55	25	**5**	5	**11.00**	**5.00**	11.83385	-6.83	
		any SUMS	**1144**	**1274**	**719**	**799**	**140.35**	**164.87**			

More important on Large Estates

Less important on Large Estates

2.9 Stage 2 a,b. Estate Manangement

In workshop 1 delegates' were given the opportunity to add to the list of benefit and cost criteria that we had prepared in advance. Originally we suggested 13 benefit criteria, a further 6 were added on the day:

Animal welfare
Sustainable habitat achieved
Socio-economic benefits to the wider community
Social value of conservation
Uk Assurance Scheme accreditation
Deer Management Groups and deer management plans

The final list of Benefit criteria, as used in Stage 2, together with their definitions are given in Table 5.

Table 5. Definitions of Benefit criteria used in stage 2 "Estate Management" model

Aspect	C/B	Criterion	Definition
Cull	B	Number of deer culled	Benefits in reduced damage
Deer	B	Income from stalking	Income from paying guests, and let stalking
Deer	B	Income from deer management grants	Income from current deer management grants for SSSI etc.
Deer	B	Animal welfare	Preventing populations from self regulating, humane control etc.
Deer	B	Income from venison	Income from venison returns
Forestry	B	Income from undamaged timber	Income from undamaged timber will be greater than for damaged timber
Forestry	B	Income from forestry grants	Includes grants for planting new land, planting or regenerating broadleaves & native pine or commercial conifer, planting on farmland, restocking or regenerating existing woodlands, annual management grants and woodland improvement grants
Forestry	B	Sustainable habitat achieved	Habitat and deer in balance
Other	B	Other income	Fishing, caravan parks, campsites
Other	B	Social value of Recreation	Benefits forwalking/hiking, nature walks, cycling, horse riding
Other	B	Social value of Landscape	Value for tourism and natural heritage
Other	B	Tax advantages / Liabilities	No income tax from sales of timber, most grants schemes tax free, Increase in value of standing timber not subject to Capital Gains Tax, 100% Business Property Relief on Inheritance tax.
Other	B	Conservation grants	Native woodland grant, SNH agreements
Other	B	Feel good factors	Enjoyment of the countryside
Other	B	Neighbours	Benefits in collaboration, sharing costs, shared control
Other	B	Socio-economic benefits to wider community	Providing employment, attracting visitors, benefits to local businesses
Conserv	B	Social value of conservation	Improved water quality for fish & fishing,
Forest	B	UK Assurance Scheme accreditation	Benefits gained from accreditation to a national scheme
Deer	B	Deer Management Group	Benefits gained from membership of local DMG

Originally we suggested 9 cost criteria, however one was dropped (male:female ratio) and 7 were added.

Access for deer control and carcase extraction
Cost of habitat monitoring
Grants forgone due to deer damage
Infrastructure
Equipment
Uk Assurance Scheme accreditation
Deer Management Groups and deer management plans

The last two criteria added above appear under both benefits and costs, which was the specific wish of the delegates at workshop 1. This gave us 19 benefits and 15 costs, making a fairly complex model that took a long time to evaluate for the six example ‘management scenarios’.

The final list of Cost criteria, as used in Stage 2, together with their definitions is given in Table 6.

Table 6. Definitions of Cost criteria used in stage 2 “Estate Management” model

Aspect	**C/B**	**Criterion**	**Definition**
Deer	C	Cost of getting deer management data	Wages, equipment required, lost time, health & safety issues
Deer	C	Access for control and extraction	Cost of creating stalking paths and carcase extraction routes
Deer	C	Loss from damage to forest	Annual loss in timber value due to bark stripping damage
Staff	C	Keeper costs (wages/day * days/year)	Staff costs
Forestry	C	Deer glades etc. % lost area	Costs of creating, maintaining glades, loss of timber production
Forestry	C	Deer fencing costs,	Deer fencing costs to protect young trees and annual maintenance
Forestry	C	Cost of habitat monitoring	Cost of habitat monitoring surveys for deer impacts
Forestry	C	Grants forgone due to deer damage	Loss of grant money due to deer damage
Forestry	C	Cost of delayed harvest due to damage	Long term cost of excessive deer browsing to leading shoots causing delay in growth in early life
Other	C	Cost of recreation	Areas used by public not easily hunted, loss of timber production on campsites etc, cost of car parks, visitor signage, creating nature walks
Other	C	Infrastructure (EXCLUDE vehicles, etc)	Deer Larder, training, health & safety, roads,
Other	C	Equipment, all-terrain vehicles	Equipment such as vehicle and ATV vehicle, protective clothing, rifle
Conserv	C	Cost of conservation	Streamside buffer zones
Forest	C	UK Assurance Scheme accreditation	Cost required to get accreditation
Deer	C	Deer Management Groups	Time spent at meetings, work resulting from membership

2.10 The management scenarios.

In order to model "expert opinion" on differing objectives we created two sets of six scenarios, one for multi-purpose commercial forestry and the other for native woodland management. While other objectives for forestry may exist it was not possible to explore them given the limited time we had.

Within the multi-purpose forestry scenarios we compare size of estate, deer densities and whether populations are resident or not. These scenarios were devised prior to workshop 1 and on the day delegates made no changes to them, although they were given opportunity to.

Within the native woodland scenarios the same three factors were explored but a forth was added to take account of fencing policy. In the case of the native woodland objective delegates at workshop 1 redefined the scenarios and included a no fencing policy, therefore one of the scenarios had a fencing policy added in order to get a wider range of circumstances.

As seemed more appropriate to their experiences, the green groups assessed the native woodland scenarios and the 'blue' groups scored the scenarios for multi-purpose commercial forestry, as did the 'orange' group in workshop 1. Members of the green groups had experience of deer management in native woodlands, whereas experience of members from the other groups tended to be more toward commercial forestry. Separate lists of the benefit criteria and cost criteria, agreed in workshop 1, were used in both workshops. As before, each delegate first worked through both lists giving their individual importance weights to each criterion, whilst bearing the agreed management objective of their group in mind, and then joined their group to discuss and revise their scores and provide a single set of consensus results, as previously described.

We note that in this Estate Management exercise, the Blue group delegates at workshop two felt the disparity between them was too great to achieve consensus, and we agreed they should split into two sub-groups. The results for the criteria evaluation thus refer to six, and not five, sub-groups.

2.11 Results – Assessments of Estate Management Criteria.

The results are presented in graphical form for the Estate Mangement Benefit criteria as Figure 5 and contrasting Costs as Figure 6. We emphasise that these figures use the Criterion Importance Scale of 0~100, so the biggest, most important, cost and benefit values are to the right of these two figures (whereas the *ranks* used in Figure 4 put the most important to the *left*).

Importance evaluations of the Estate Management Benefit criteria.

As with the narrower set of 'Deer and Deer Damage' criteria, the first impression from Figure 5 is of extreme variability, as indicated by the extensive black 'range lines' around the overall group means (the ends of the wide bars).

Figure 5. Estate management Benefit evaluation.

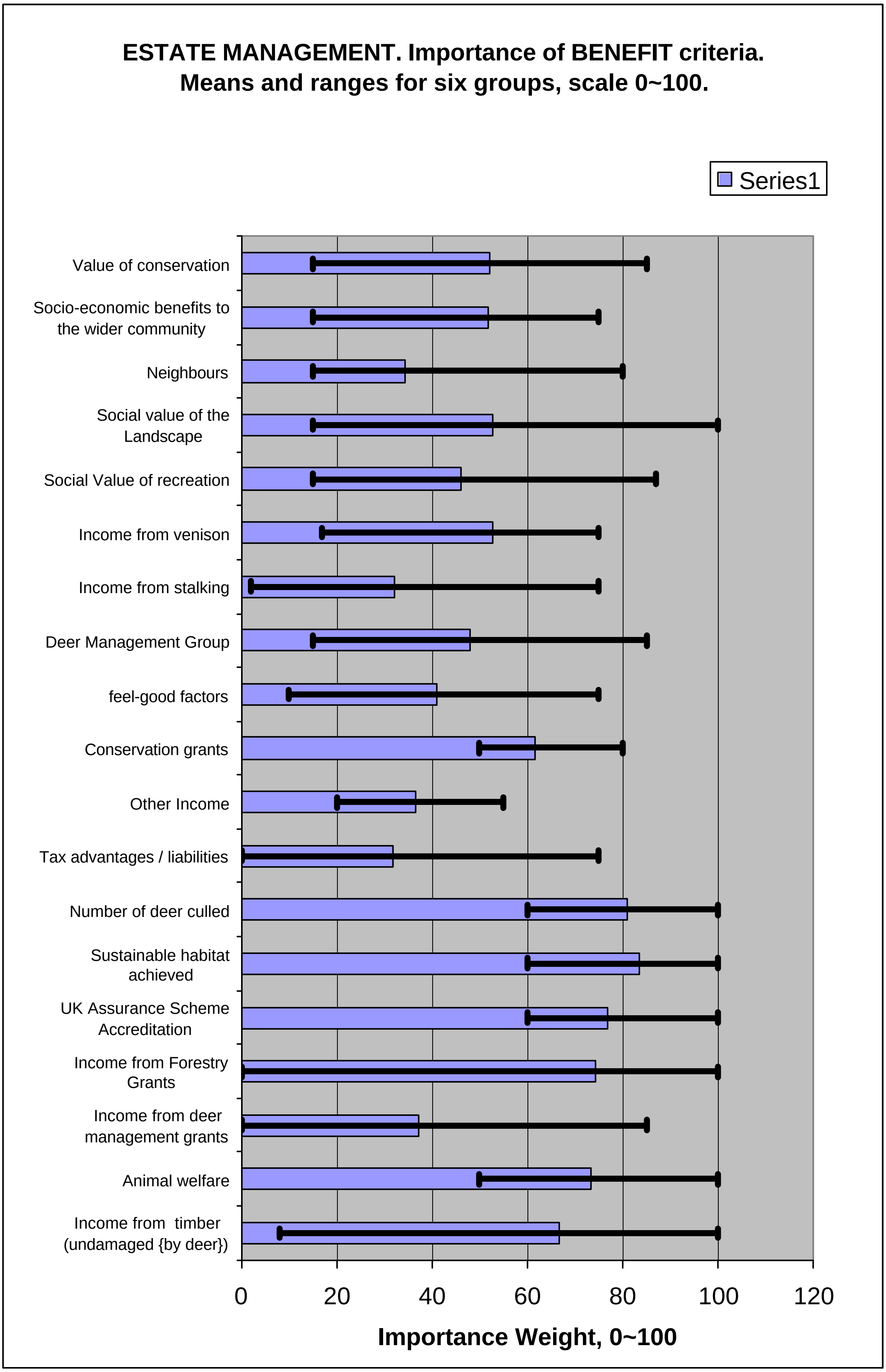
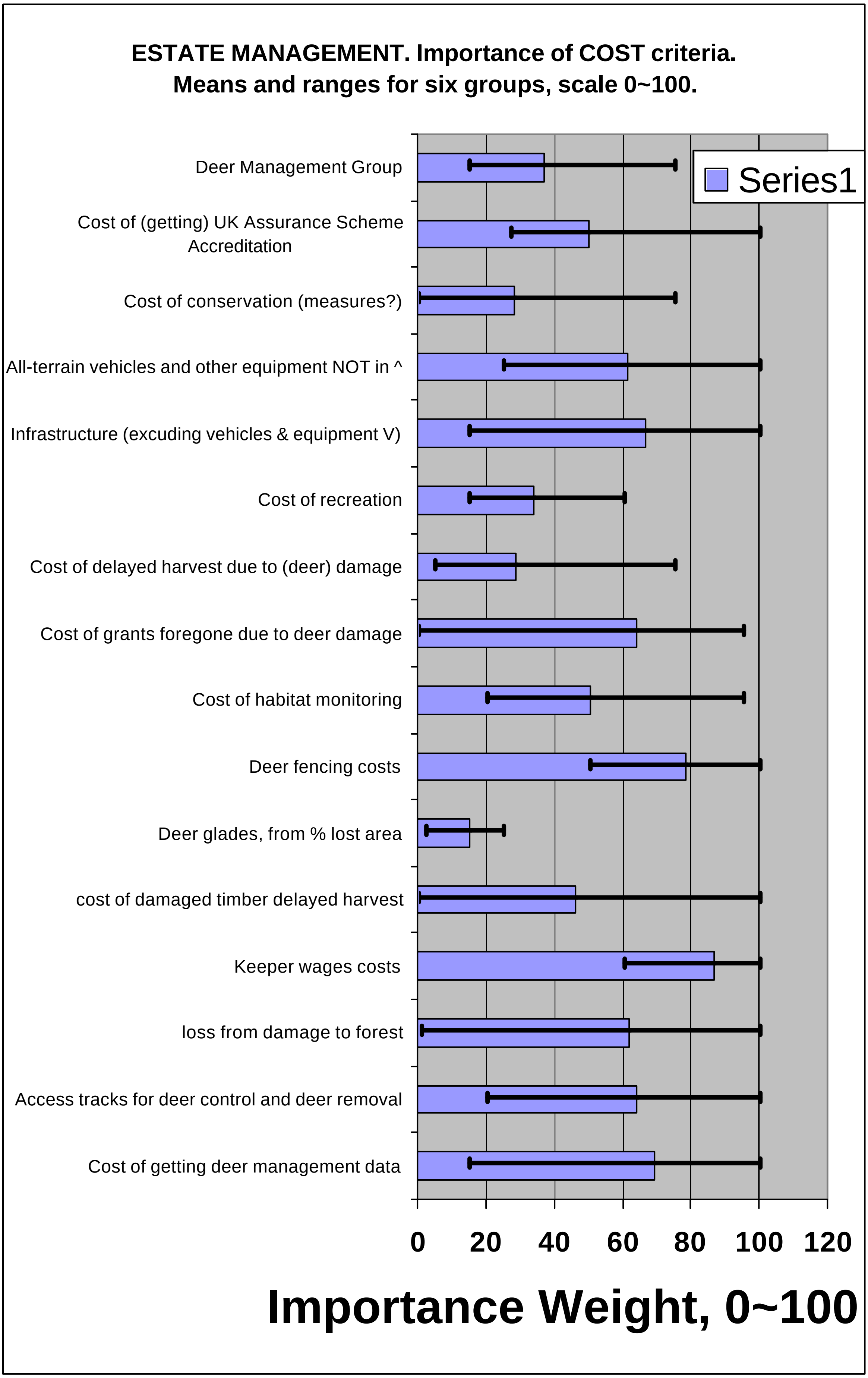


Figure 6. Estate management Cost Criteria evaluation.



Striving to interpret this, we first draw attention to six factors with relatively narrow range bars (albeit a range of some 40 units, or 40% of the total possible range). Three of these (Sustainable Habitat; Number of deer culled; UK Assurance Scheme) have benefit levels of 80%. They are closely followed by Animal Welfare at around 75%, Conservation grants and 60% and Other income at nearly 40%.

All other criteria show importance **ranges** between **groups** of over 70% of the available importance score range.

Importance evaluations of the Estate Management Cost criteria.
Only four of the sixteen criteria have ranges of group-mean scores that fall within 40% of the total available importance score range. These are, in order of overall-mean importance: Keeper wages, at 85%; deer-fencing costs at 80%; cost of recreation at 30%; and deer-glades at some 15%. All other criteria have group-importance evaluations that span over 70% of the available range of scores.

2.12 Conclusions : importance of Estate Management criteria.

These results strongly support the general conclusion, reached with the narrower set of Deer and Deer Damage criteria, that there is enormous variation between the views of different experts as to which criteria are most important. It further emphasises that this variation is in both aspects of the problem, the 'pros' or benefits, as well as the 'cons' or costs.

With hindsight it is perhaps not so surprising that such a complex issue, involving multiple aims and objectives in widely differing environments and habitats and with widely differing resources (both human and monetary) should not be susceptible to a single, universal assessment procedure. If people are trying to optimise different things, they are very likely to judge both the cost and the success of their efforts by similarly different criteria.

2.13 Estate Management Scenario evaluations.

For each benefit and cost criterion individual scenarios were compared and scored by first deciding which scenario received the greatest benefit or cost. This was then given a weighting score of 100. It was possible for more than one scenario to have the same score. Delegates then decided for the criterion being scored which scenario received the least benefit or cost and scored that accordingly. The remaining scenarios were then scored in sequence of their importance between the lowest and highest scores.

In workshop 1, delegates' only had enough time to record their individual scores for this stage. In workshop 2, given the same time constraints, we decided to forgo individual scores to get consensus scores for the models. Delegates therefore discussed each criterion for each scenario and gave a consensus score based on their combined opinion using the scoring rules described above.

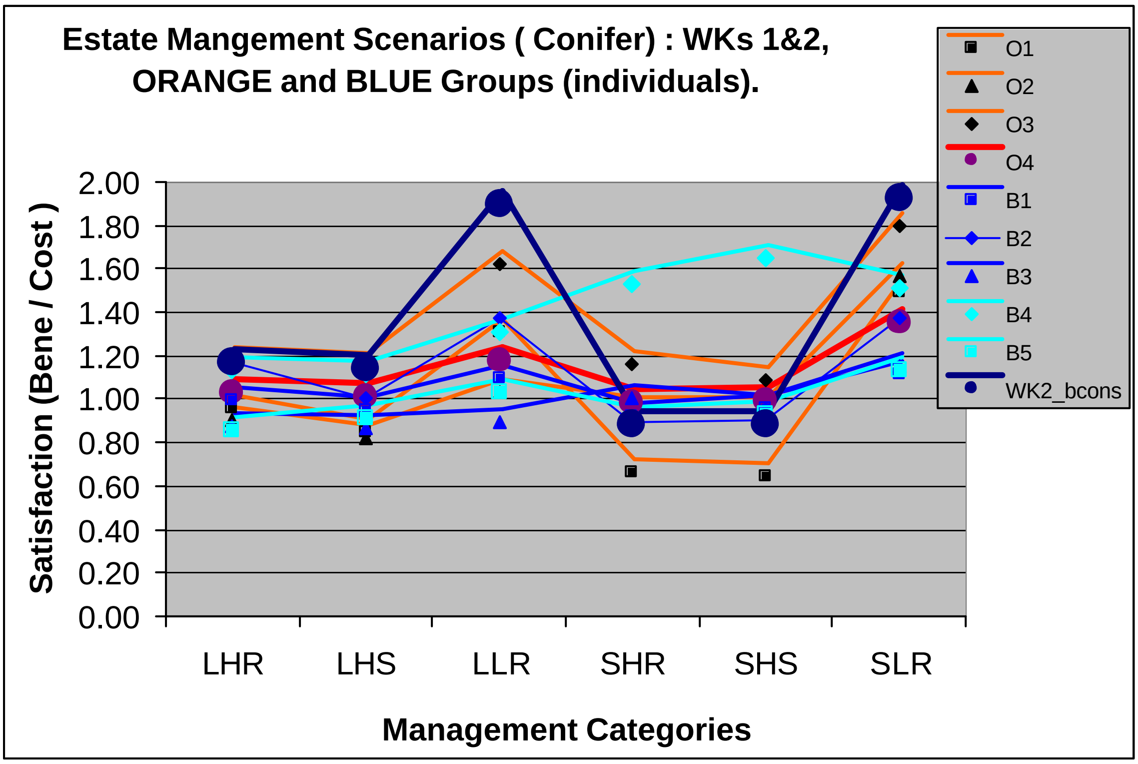
2.14 Results of the Estate Management Scenario evaluations.

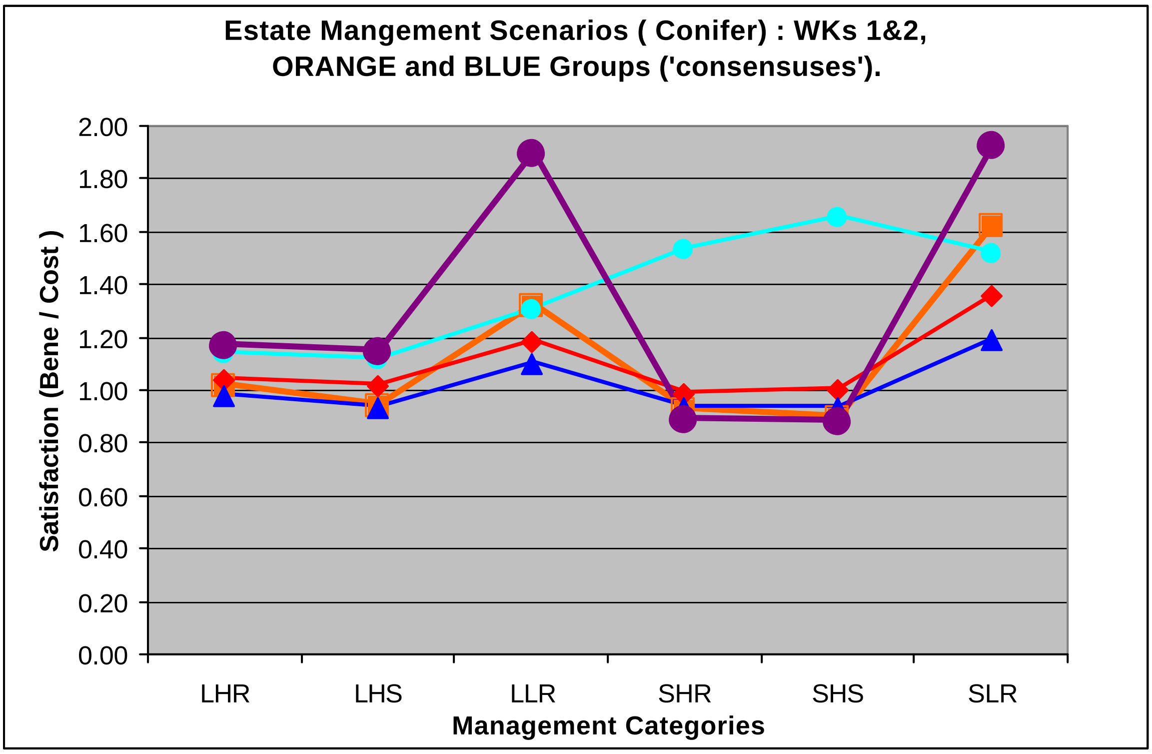
The results are illustrated in Figure 7, which shows the different Management Scenario options on the horizontal axis and their evaluated 'Decision model weighted' benefit to cost ratio scores vertically. The decision model results can be thought of as expressing the relative 'satisfaction' of the delegate/ sub-group, with each of the assessed Management Scenarios. More particularly, as a Benefit/Cost ratio of 1.00 means benefits are equal to costs, values above 1.00 represent scenarios having a net 'benefit' or satisfaction, while values below 1.00 are scenarios showing a net 'cost', or dissatisfaction.

Figure 7a shows the results for nine individual's revised scores from workshop 1 and the single consensus result from workshop 2. For four of the conifer scenario options (LHR, LHS, SHR and SHS) most of the delegates' evaluations fell in the range of 0.80 to 1.20. The other two options, LLR and SLR, show slightly higher, and distinctly more variable, satisfaction values (respectively averaging some 1.4 and 1.5).

Figure 7. Conifer Management Scenario Evaluation.

Top Figure, 7.a. Evaluations of the six conifer management scenarios (letters, X axis) according to the Decision Model derived overall weighted Benefit to Cost ratios of each, for nine individual's revised assessments and one (workshop 2) consensus. **Lower Figure, 7.b**. As above, but for the 'consensus' models of five groups.





The fact that the range of 'satisfactions' is generally benefit to cost ratios of 0.8 to 1.8 suggests the models are plausible (ie not producing unrealistically high or low evaluations). The fact that most of the evaluations cluster close to 1.00 indicates that, even for the extreme scenarios we scored, most experts feel that 'Deer and Forest Management' is very close to a break-even situation, rather than accruing massive benefits or sustaining massive losses).

Figure 7.b shows the same information but summarised for the five 'consensus' models. The pattern is extremely similar to that for the individual assessment shown in 7.a.

The LLR and SLR scenarios represent Large estate Low-density Resident deer populations and Small estate Low-density Resident deer populations. Not surprisingly these two scenarios were judged by most delegates to give the biggest benefits, as they represented the extreme where we might expect to get most benefit from naturally low deer populations.

Estate Mangement Scenario Evaluations, Native Pine Woods.
The results are illustrated in Figure 8, and are directly comparable to the graphs of Figure 7, although the scenarios now refer to completely different situations in native woodland.

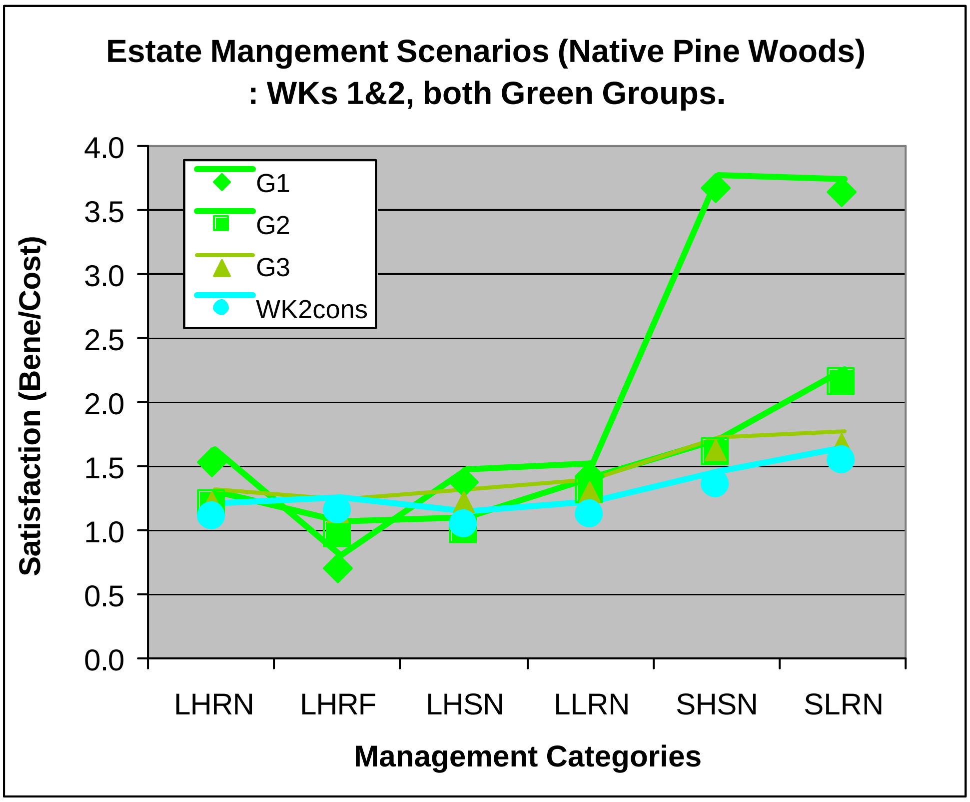
Once again, the majority of evaluations lie in the benefit to cost ratio range of 0.9 to 1.4. Individual G1 showed rather more variation than the other delegates, and was particularly, perhaps overly, optimistic about the scenarios SHSN and SRN, rating them more about twice as favourable as anybody else.

Otherwise, there is again a strong consistency of evaluations of these scenarios by different individuals and groups, despite the appreciable differences in their assessments of the importance of the criteria they were using, which were an identical list with common, agreed definitions.

The LLRN and SLRN scenarios represent Large estate Low-density Resident deer populations and Small estate Low-density Resident deer populations both with no fencing. The delegates judged that for large estates the benefits were not much different from the other scenarios. The greatest benefit was judged to be for the small estate.

The one scenario with a fencing policy LHRF (Large estate High-density Resident deer population with Fencing) showed differences in opinion between delegates. Some viewed fencing as having a marginal benefit, the benefit of having a fence being at least equal to the cost. Others perceived fencing as more of a cost, presumably being in favour of not fencing because of its impacts on wildlife and the landscape.

Figure 8: Estate Mangement Scenario Evaluations, Native Pine Woods.



2.15 General conclusions for Estate Management Scenarios.
Broadly speaking, the Estate Evaluation results give us confidence that the criteria were indeed an adequate set with which all delegates were able to reflect their main

views, and with which they were able, even at first trying, to show some consistency in evaluating clearly defined management situations.

2.16 Summary conclusions to the Decision Workshops.

Key aims

We used decision modelling to describe experts' decision-making processes on deer population and damage assessments and managing woodland estates. These experts decided the main criteria they felt important (Tables 3, 5 and 6) and scored them according to their perceived importance (Figures 4, 5 and 6). The results revealed great variability between experts and there was no consistent consensus as to the relative importance of individual criterion.

Question	Answer	Reason
Management objectives	Extremely important (Figures 4, 5 & 6)	Eg. Don't estimate tree regeneration unless you want trees to regenerate naturally
Scale of ownership	Not very much (Figure 3)	Only 5 of the 22 assessment criteria were thought to vary in importance with estate size
Assemblage of deer species	Crucial (Figure 4)	Presence of each deer species are the only criteria consistently ranked as very important and of high benefit to cost ratio
Available resources	Probably limiting (Figures 7 & 8)	Most of the extreme estate scenarios assessed showed benefits approximately equal to costs implying little scope for expensive methods
Woodland damage assessment	Having some extra data is very important (Figures 4, 5 & 6)	But what extra you need depends on management objectives and the situation of your estate.
Deer population assessment	Having some extra data is very important (Figures 4, 5 & 6)	But what extra you need depends on management objectives and the situation of your estate.

We would conclude that the criteria defined during the workshops (Figures 4, 5 & 6) are an adequate list of those normally used by most expert practitioners. However, apart from the presence of deer species their relative importance depends on the management aims and objectives in very complex ways making it impossible to produce a single ranked list following the law of diminishing returns. Not only do the decision model results point to this conclusion, but the expert participants told us this repeatedly during the workshops.

2.17 Overall Conclusions.

- Objectives and situations were very variable between expert practitioners and greatly affected the relative importance of the criteria within our lists on which they base their decisions most heavily.
- Because most practitioners felt resources were limiting their deer management we would recommend that guidance be given in terms of Good, Adequate and Affordable practice rather than an ideal 'Best Practice' which many could not aspire to.
- What affordable good practice will amount to will vary a lot with the owners' aims and situations.

APPENDICES

Appendix 1: Initial list of criteria for assessing deer and deer damage in Stage 1.

STAGE I: Evaluating Deer and Deer Damage

NAME :

GROUP :

		IMPORTANCE			
		Individual		Revised	Group
Aspect	**Information**	**Weight**	**Certainty**	**Weight**	**Weight**
Deer	Presence of red deer				
Deer	Presence of roe deer				
Deer	Presence of sika deer				
Deer	Presence of fallow deer				
Deer	Exact nos.				
Deer	Target density (for trivial damage)				
Deer	Live Deer counts (Drives etc)				
Deer	Indirect (dung counts, tracks etc)				
Deer	Keeper Knowledge				
Deer	Cull data analysis (age, sex, weight)				
Forestry	Perceived level of tree damage				
Forestry	Accurate estimates of damage				

Appendix 2: Original Benefit criteria list for stage 2 Estate Model

STAGE II a. Criteria for Cost / Benefit Assessment for Woodland Management: BENEFITS

NAME :

GROUP :

				Individual		Revised	Group
Aspect	**Criterion**	**C/B**	**Units**	**Weight**	**Certainty**	**Weight**	**Weight**
Cull	No. of deer culled	B	No/ha/yr				
Deer	Income from let stalking	B	£/ha/yr				
Deer	Income from Deer Management Grants	B	£/ha/yr				
Deer	Income from venison	B	£/ha/yr				
Forestry	Income from Undamaged Timber	B	£/ha/yr				
Forestry	Income from Forestry Grants	B	£/ha/yr				
Other	Other Income	B	£/ha/yr				
Other	Social value of Recreation	B	£/ha/yr				
Other	Social value of Landscape	B					
Other	Tax advantages/liabilities	B	£				
Other	Income from Conservation Grants	B	£/ha/yr				
Other	Feel good factors	B					
Other	Neighbours	B					

Appendix 3. Original Cost criteria list for stage 2 Estate Model

STAGE II a. Criteria for Cost / Benefit Assessment for Woodland Management: COSTS

NAME :

GROUP :

				Individual		Revised	Group
Aspect	**Criterion**	**C/B**	**Units**	**Weight**	**Certainty**	**Weight**	**Weight**
Deer	Cost of getting deer management data	C	£/ha/yr				
Deer	Loss from damage to forest	C	£/ha/yr				
Staff	Keeper costs (wages/day * days/year)	C	£/yr				
Forestry	Cull costs additional to stalker wages	C	£/ha/yr				
Forestry	Cost of damaged timber	C	£/ha/yr				
Forestry	Deer glades etc. % lost area	C	ha				
Forestry	Deer fencing costs,	C	£/ha/yr				
Forestry	Cost of delayed harvest due to damage	C	£/ha/yr				
Other	Cost of recreation	C					
Deer	Stag / Hind ratio	-					

Appendix 4: Initial definitions of scenarios used in Stage 2b

Stage IIb Management Scenarios for Multi-purpose Forestry with an emphasis on commercial timber production.

Scenario 1
A **Large** (>1000ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you have 200 ha of restock (aged 1-8) a year. There are **High** densities of **Resident** red and roe deer (both >30 per km^2). Neighbours include arable farmers and sheep farmers. You employ 1 person full time for deer culling and vermin control plus other general duties. You get some income from paying guests for trophy hunting both red and roe.

Scenario 2
A **Large** (>1000ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you have 200 ha of restock (aged 1-8) a year. There are **High** densities of **Shared** red deer and resident roe deer (both >30 per km^2). Neighbours arable farmers, moorland. You employ 1 person full time for deer culling and vermin control plus other general duties. You make some income from paying guests from trophy hunting roe only.

Scenario 3
A **Large** (>1000ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you have 200 ha of restock (aged 1-8) a year. There are **Low** densities of **Resident** red and roe deer (both <5 per km^2). Neighbours arable farmers and sheep farmers. You let deer culling and seasonally employ for vermin control and other general duties.

Scenario 4
A **Small** (<100ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you plant 2.5 ha of restock a year. There are **High** densities of **Resident** red and roe deer (both >30 per km^2). Neighbours include arable farmers and sheep farmers. You employ 1 person full time for deer culling and vermin control plus other general duties.

Scenario 5
A **Small** (<100ha) 2nd rotation Commercial plantation of sitka spruce with a mix of age classes. On average you plant 2.5 ha of restock a year. There are **High** densities of **Shared** red deer and resident roe deer (both >30 per km^2). Neighbours arable farmers. You employ 1 person full time for deer culling and vermin control plus other general duties.

Scenario 6
A **Small** (<100ha) 2nd rotation Commercial plantation of sitka spruce with trees of even age. On average you plant 2.5 ha of restock a year. There are **Low** densities of **Resident** red and roe deer (both <5 per km^2). Neighbours arable farmers and sheep farmers. You let deer culling and seasonally employ for vermin control and other general duties.

Appendix 4 contd.

Stage IIb Management Scenarios for Native Woodland

Scenario 1

A large (>1000 ha) estate with a mix of open hill and native pinewood. There are high densities of resident red and roe deer (both >30 per km^2). Neighbours include upland deer forest. You employ staff to cull deer

Scenario 2

A large (>1000 ha) estate with a mix of open hill and native pinewood. There are high densities of non-resident red deer and resident roe deer (both >30 per km^2). Neighbours include upland deer forest

Scenario 3

A large (>1000 ha) estate with a mix of open hill and native pinewood. There are low densities of resident red and roe deer (both <5 per km^2). You let deer culling and seasonally employ for vermin control and other general duties.

Scenario 4

A small (<100ha) estate with a mix of open hill and native pinewood. There are high densities of resident red and roe deer (both >30 per km^2). Neighbours include upland deer forest. You employ staff to cull deer.

Scenario 5

A small (<100ha) estate with a mix of open hill and native pinewood. There are high densities of non-resident red deer and resident roe deer (both >30 per km^2). Neighbours include upland deer forest.

Scenario 6

A small (<100ha) estate with a mix of open hill and native pinewood. There are low densities of resident red and roe deer (both <5 per km^2). You let deer culling and seasonally employ for vermin control and other general duties.

Appendix 5. Workshop Questionnaire

WORKSHOP QUESTIONNAIRE

We would like to get your feedback in the workshop. Please spend a few minutes to let us know your views. Please tick appropriate boxes.

1. Workshop length ? 1)Too long ☐ 2)About right ☐ 3) Not long enough ☐

Comments……………………………………………………………………………

2. Questions covered ? 1)Too complex ☐ 2)About right ☐ 3)Too superficial ☐

Comments……………………………………………………………………………

3. Would you say that you have learnt anything from the meeting

1)A lot ☐ 2) Amoderate amoun ☐ 3)Little or nothi ☐

Comments……………………………………………………………………………

4. Overall usefulness of the workshop? . 1)High ☐ 2)Moderate ☐ 3)Low ☐

Comments……………………………………………………………………………

5. Would you encourage other people to participate in similar experiences?

1)Greatly ☐ 2)Slightly ☐ 3)Not at all ☐

Comments…………………………………………………………………………..

6. Was the room comfortable for working in?

1)Very ☐ 2)Moderate ☐ 3)Not at all ☐

Comments……………………………………………………………………………

7. Were the facilities / meals / coffee etc. satisfactory.

1)Very ☐ 2)Slightly ☐ 3)Not at all ☐

Comments……………………………………………………………………………

Any other points?

Percentage	Comment
100%	Most important
	(At least one)
75%	Fairly important
50%	Intermediate
25%	Fairly unimportant
0%	Unimportant

Appendix 6. Final list of criteria used in stage 1a and 1b.

STAGE I: Evaluating Deer and Deer Damage
NAME :
GROUP :

		IMPORTANCE			
		Individual		Revised	Group
Aspect	**Information**	**Weight**	**Certainty**	**Weight**	**Weight**
Deer	Presence of red deer				
Deer	Presence of roe deer				
Deer	Presence of sika deer				
Deer	Presence of fallow deer				
Deer	Accurate densities of Red				
Deer	Accurate densities of Roe				
Deer	Accurate densities of Sika				
Deer	Accurate densities of Fallow				
Deer	Target density (for trivial damage)				
Deer	Live Deer counts (Drives etc)				
Deer	Indirect (dung counts, tracks etc)				
Deer	Keeper Knowledge				
Deer	Cull data analysis (age, sex, weight)				
Deer	Hefted to ground or not				
Deer	Core / periphery of Deer Range				
Forestry	Perceived level of tree damage				
Forestry	Accurate estimates of damage				
Forestry	% Damage not by deer				
Forestry	Density of Tree Regeneration				
Forestry	Severity (%) severe apical damage				
Forestry	Tree Species Composition				
Control	Effectiveness of neighbours control				

Appendix 7. Benefit and Costs data sheet used in Stage 1b

		BENIFITS of having data			COSTS of getting the data		
			Small	Large		Small	Large
Aspect	Information	Units	Estate	Estate	Units	Estate	Estate
			<100 ha	>1000 ha		<100 ha	>1000 ha
Deer	Presence of red deer						
Deer	Presence of roe deer						
Deer	Presence of sika deer						
Deer	Presence of fallow deer						
Deer	Accurate densities of Red						
Deer	Accurate densities of Roe						
Deer	Accurate densities of Sika						
Deer	Accurate densities of Fallow						
Deer	Target density (for trivial damage)	£/km^{-2} /yr			£/km^{-2} /yr		
Deer	Live Deer counts (Drives etc)	£/km^{-2} /yr			£/km^{-2} /yr		
Deer	Indirect (dung counts, tracks etc)	£/km^{-2} /yr			£/km^{-2} /yr		
Deer	Keeper Knowledge	£/km^{-2} /yr			£/km^{-2} /yr		
Deer	Cull data analysis (age, sex, weight)	£/km^{-2} /yr			£/km^{-2} /yr		
Deer	Hefted to ground or not						
Deer	Core / periphery of Deer Range						
Forestry	Perceived level of tree damage	£/km^{-2} /yr			£/km^{-2} /yr		
Forestry	Accurate estimates of damage	£/km^{-2} /yr			£/km^{-2} /yr		
Forestry	% Damage not by deer						
Forestry	Density of Tree Regeneration						
Forestry	Severity (%) severe apical damage						
Forestry	Tree Species Composition						
Control	Effectiveness of neighbours control						