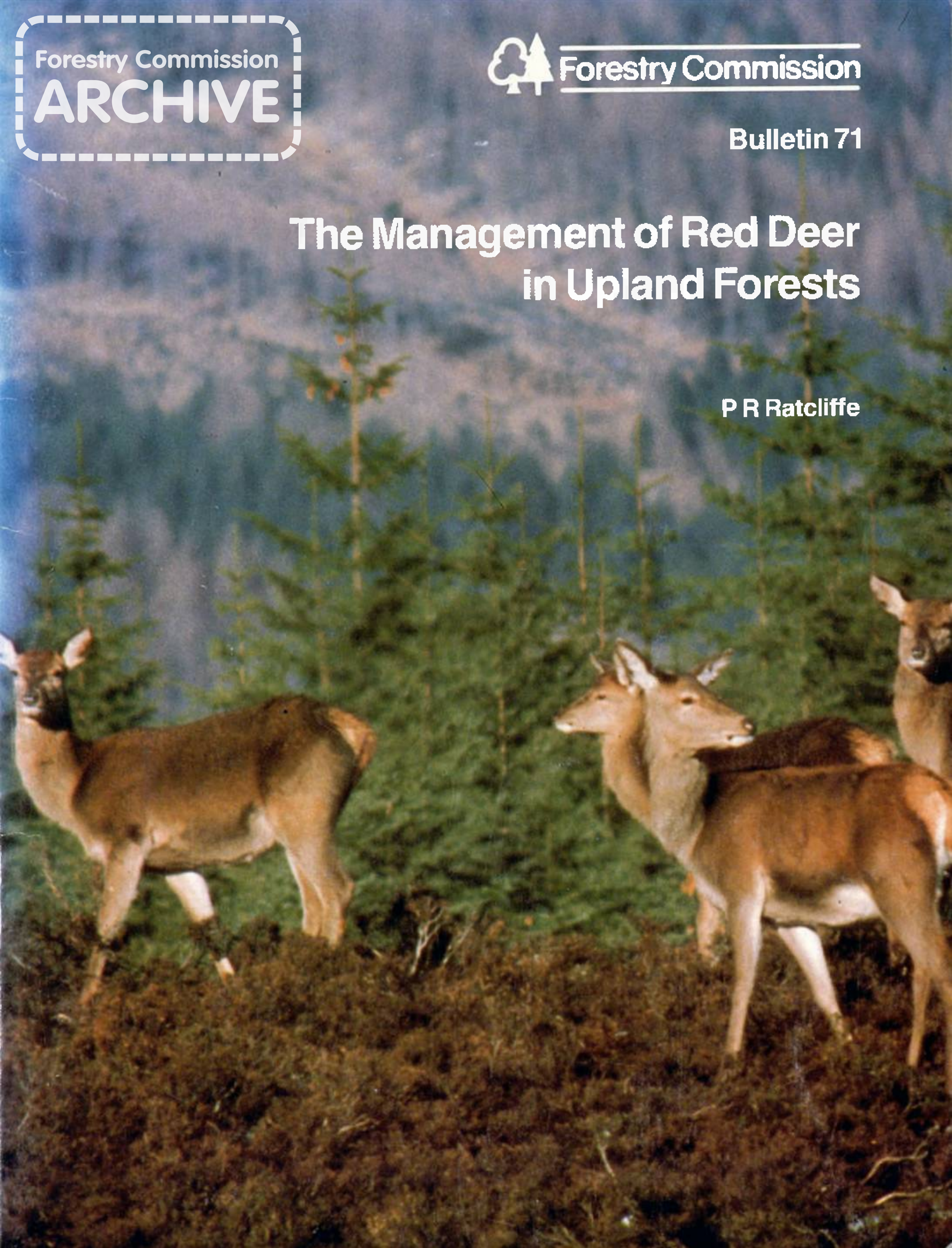
Forestry Commission

Bulletin 71

The Management of Red Deer in Upland Forests

P R Ratcliffe



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FRONT COVER: A typical red deer family group. Groups occupying dense woodlands do not often aggregate into large herds as they commonly do on open-range. Group size is no indication of population density. (*Don MacCaskill*)

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The Management of Red Deer in Upland Forests

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Introduction

Virtually all attempts to manage red deer in commercial forests have involved a reaction to 'unacceptable' deer damage by fencing and by unplanned shooting, aimed at reducing the number of culprits and thereby reducing the economic loss. In many cases this approach has failed to satisfy the objectives. Such failures demonstrate an urgent need for more information and a better understanding of red deer population dynamics and their relationship with the sequential changes in the age classes of the forest.

Since prehistoric times there has been continual removal of Britain's native forests. The deforestation accelerated considerably during the 18th century but the trend was reversed following the creation of the Forestry Commission in 1919, since when there has been a steady increase in the area of afforested land. The greatest expansion has been in the uplands over the last 25 years (Holmes, 1979). In Scotland, the average rate of planting has been between 20 000 and 30 000 hectares per year in recent years (Forestry Commission, 1986) with an increasing proportion being planted by private landowners.

Five million hectares (75 per cent) of Scotland's land area remain treeless and most of this land is used extensively for hill sheep production. About half of this is also occupied by red deer. The ecology of red deer occupying treeless moorland in Scotland has been the subject of intensive studies over the past 20 years. This work was reviewed by Mitchell *et al.* (1977). The management of red deer populations as a primary form of land use is discussed in *Red deer management* (Red Deer Commission, 1981). There is considerable potential for a land use change to forestry and it is estimated that a further 1.7 million hectares could be afforested (Holmes, 1979).

The considerable damage that red deer can inflict on commercial forests is well documented (Mitchell *et al.*, 1977; Cooper and Mutch, 1979; Ratcliffe and Staines, 1982). Cooper and Mutch (1979) emphasised the potential problems associated with attempts to afforest uplands on or adjacent to high density red deer range, where perimeter fencing is the major control strategy. It is not generally realised, however, that almost 240 000 ha (45 per cent) of State forests lying within the red deer range occur in the south and west of Scotland and do not have a problem of deer marauding from adjacent range and do not utilise perimeter deer fencing. Range expansion over the past 20–30 years has resulted in high density resident populations in these areas (Ratcliffe, 1984a). Even in fenced areas, colonisation has occurred and similar densities can be found.

This Bulletin is primarily concerned with the management of resident populations of red deer in commercial forests, and gives practical prescriptions for deer management based upon sound data collection and scientific method. All such prescriptions must be aimed at particular, well-defined deer populations occupying discrete ranges. There is an important emphasis throughout upon predictive management, rather than a retrospective 'shutting the stable door' response to unacceptable conditions. The assessment of population size and birth and death rates is explained together with their use as a basis for setting cull levels.

Two separate problems exist: i) the control of marauding deer from adjacent open-range, and ii) the management of endemic resident populations. Almost all the available literature refers principally to the former (Mitchell *et al.*, 1977; Cooper and Mutch, 1979; Red Deer Commission Annual Reports 1965–1981).

Deer are usually managed by attempts to control their numbers to achieve a reduction in damage and natural mortality, and by the exploitation of surpluses from venison and from trophy hunting. It is difficult to manage deer populations if there are frequent, uncontrolled and often unknown intrusions from peripheral populations, and whenever these are considered to be important effective perimeter fencing is necessary. But perimeter deer fencing is unlikely to exclude deer permanently, and total exclusion cannot normally be considered a realistic objective in areas of high deer pressure. However, on newly acquired land in such areas, fencing will considerably slow the rate of colonisation and will usually continue to limit incursions to manageable proportions in forests of second and subsequent rotations. Fencing with high tensile spring steel wire is recommended for both perimeter and internal deer fences; see Forestry Commission Leaflet 87 *Forest fencing* (Pepper and Tee, 1986). The inevitability of colonisation by red deer is due to unforeseen fence breakages, often at water-gates and gateways and also to adverse snow conditions. Sensible forest design and siting of perimeter fences can dramatically reduce the pressure which open range populations of deer place upon plantation fences. This aspect is covered in detail in *Red deer management* (Red Deer Commission, 1981). When 'break-ins' are noticed shortly after the event, the offending deer can often be driven out, or indeed will often make their own way out as the weather improves. Deer 'leaps' built into fences will help deer to make their way out of plantations (Red Deer Commission, 1981). Young deer, not yet firmly hefted to a range, are likely to be those that colonise the forest and go unnoticed for a time.

Damage

Damage by red deer may consist of pulling-out newly planted trees, browsing the leading shoots of young trees and stripping the bark from older trees. Fraying, rubbing and thrashing with antlers seldom causes significant damage. These forms of damage are relatively easy to recognise but browsing damage can be confused with that caused by other deer species and with sheep. Roe deer do not usually strip bark and such damage is almost certainly due to red or sika deer. In large upland forests, damage is sometimes overlooked, especially bark stripping in thicket areas which are seldom visited. It is strongly recommended that a formalised procedure of inspection of *all* vulnerable age-classes and tree species be implemented. If damage is located which is subjectively considered to be of concern, then an assessment of the amount of damage should be made; see Forestry Commission Leaflet 82 *Assessment of wildlife damage in forests* (Melville *et al.*, 1983).

Not all extensive browsing damage actually causes any long-term deleterious effect on the tree crop. This may be because trees, especially those growing vigorously, may be able to respond to damage by compensatory growth. The potential long-term effect is important when deciding whether to fence or not but at present such impacts can only be judged subjectively from local experience. An easy and effective method of assessing the effect of browsing damage on the crop is to place individual tree guards (*not* tree shelters) around a random selection of 100 trees, on newly planted or restocked sites. A subsequent comparison of height growth between protected and non-protected trees will indicate the ability of trees to recover from browsing, and any delay in reaching a height of 1 m will give some idea of the long-term effects, though further compensatory growth may occur later in the rotation.

Forest Structure

Herbivorous mammals are dependent upon the availability of food and shelter for their survival. As these factors alter with the sequential changes in forest structure, different species will be affected in different ways. It is important, therefore, to predict the effects of changing forest structure on deer populations, so that management decisions can be made in anticipation of problems.

Commercial forests in upland Britain are managed on rotations of 45–60 years except where they are subject to high risk from windblow, in which case shorter rotations are used. As the trees grow from establishment through the thicket stage to the pole stage, plant communities and the cover provided by the trees also change and this can have important effects on the numbers and behaviour of deer.

Growth rates and volume increments for commercial tree species can be predicted from age and top height using the yield class system. Yield classes can be expressed by a series of growth curves which predict volume production for a particular species, given information on age and top height. Graphs can thus be constructed relating age to sequential growth stages, which relate to successional changes affecting the deer (Ratcliffe, Hall and Allen, 1986) (Figure 1).

The proportion of early successional stages present in the forest will influence the availability of food and shelter to deer. The stages of importance to red deer occupying commerical forests in Scotland can be defined as follows:

a) Establishment

From time of planting until trees reach 1 m in height. A period of increasing food quality and abundance, but lacking cover from disturbance and weather (Plate 1).

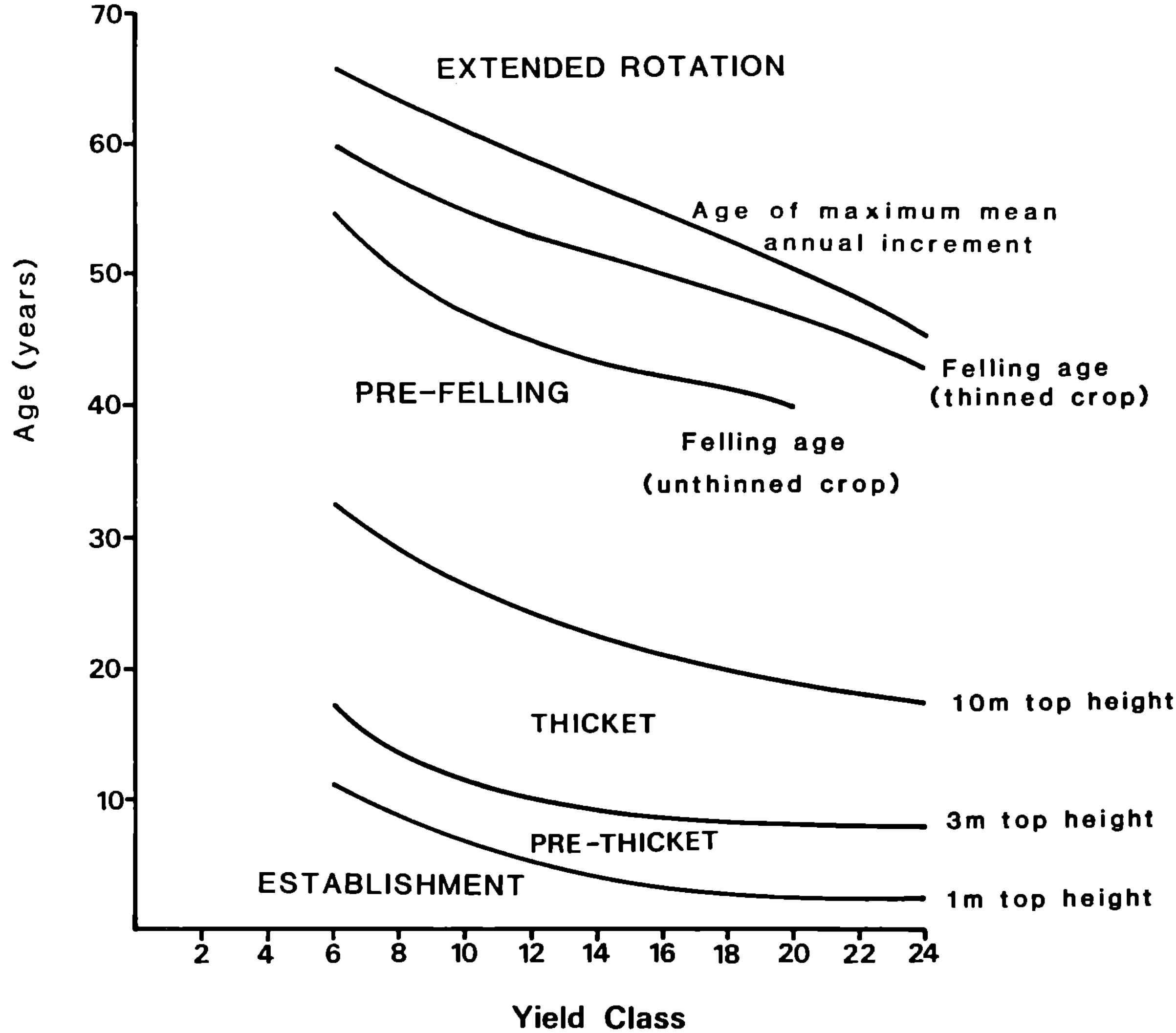
b) Pre-thicket

When the top heights of trees are between 1 and 3 m. A period of high food quality and abundance combined with increasing cover (Plate 2).

c) Thicket

Trees are between 3 and 10 m top height. A phase in which ground vegetation declines and disappears but

Figure 1. Model of structural change through a forest rotation.



variability in tree growth, possibly combined with the effect of herbivores, creates glades, offering food and security to deer. Canopy closure occurs during this phase (Plate 3).

d) Pre-felling

From 10 m top height to the age of felling. A limited ground flora returns but food quality and abundance is at a low level. Cover from disturbance is adequate but shelter from weather is below optimum (Plate 4).

The areas occupied by each stage at any particular time can be computed, based upon knowledge of the yield class. Predictions of changes in forest succession for two forests, in five-year intervals up to 1995, are presented here (Figures 2 and 3). The predictions assume the felling of crops at the age providing maximum net discounted revenue at a 5 per cent discount rate, and replanting in the following year.

At Glenbranter Forest, Argyll (Figure 2), a second rotation forest of relatively high diversity, the predicted increase in thicket stage crops up to 1990 may absorb increasing numbers of deer, but the decline in all the younger age classes at the expense of older forest after 1990 implies a decline in the capacity of the habitat to support deer, which may leave large numbers of deer without adequate food. Glenorchy Forest, Argyll (Figure 3) has a preponderance of young trees, recently estab-

Figure 2. Predicted changes in forest structure in a second rotation forest of high diversity.

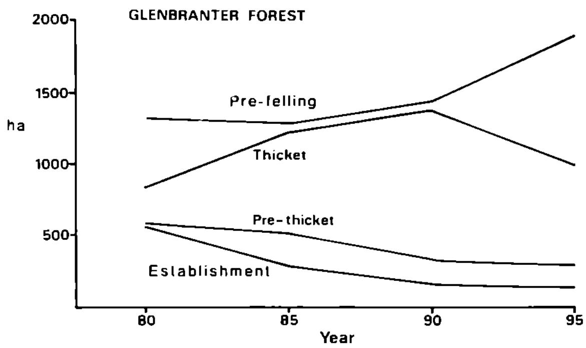
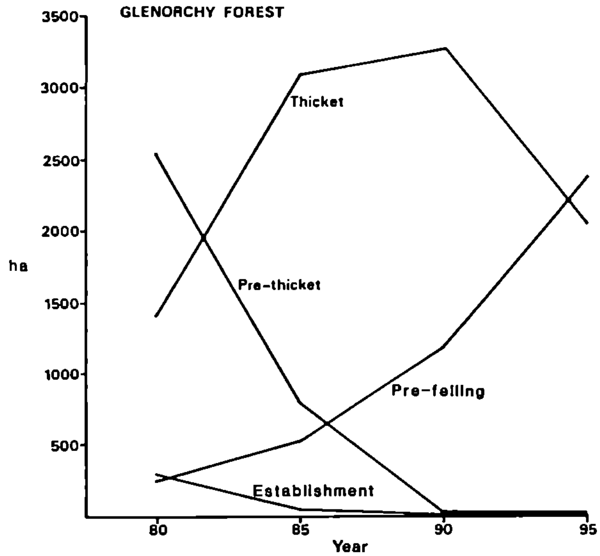


Figure 3. Predicted changes in forest structure in a recently established even-aged forest.



lished on moorland and predictions indicate massive changes in structure up to 1995. A low density resident red deer population has become established in this forest in spite of rigorous attempts to prevent it by perimeter fencing and by shooting. The increasing capacity of this forest to support red deer up to 1990 may maintain the expected increase in density. The rapid reduction of thicket areas between 1990 and 1995 will result in a reduction of the capacity of this forest to support deer, and this may in turn lead to increased damage to trees.

The Field Assessment of Deer Density

Obviously, some knowledge of deer numbers is necessary if a realistic shooting plan is to be formulated. This is probably the most difficult information to acquire, but it is possible to make estimates which are sufficiently precise to provide a basis for management. It is very important to check the accuracy of field estimates by keeping careful records of the numbers of each age and sex which are shot each year. This is called cohort analysis and gives unequivocal retrospective determination of population size which is essential to good deer management.

In dense forest habitats it is impossible to count total numbers over large areas of land, and some form of sampling is necessary. Such sampling must be based upon units of land which can be considered to support relatively uniform use by deer, and a knowledge of the distribution of the different growth stages already described is useful for this purpose. In any such sampling scheme the number of animals counted must be related to area to give density, and the number of deer per square kilometre (100 ha) is used here as a convenient unit of deer density.

Vantage point counts

Deer density can be assessed by means of sample counts taken from fixed vantage points over periods of not less than 2 hours and preferably of 2–3 hours (Ratcliffe, 1984b). Representative counts in all structural types present should be conducted individually. Experience suggests that the months of April and May are most suitable and that 0600–1000 and 1600–2100 span the best times of day for observing, especially when human disturbance is a problem.

During each count, areas of 80–120 ha are methodically scanned in order to locate deer. Binoculars (7–10 × 50 mm) and a telescope (15–60 × 60 mm) are used for location and classification into sex and age classes respectively, and are satisfactory at ranges up to 2 km. This method can only be used in hilly terrain where it is possible to view over areas of forest or across valleys. Deer occupying even the densest habitats can be seen, though often only for short periods of time as they cross areas of broken canopy. Watches of less than 2 hours duration do not allow sufficient time for the completion of rumination cycles and a commencement of feeding activity, which is when animals are most likely to be seen.

All sightings of deer are recorded, at the time, on a large-scale map, with the time and direction of movement (Figure 4) and also on a form (Figure 5). In the event of groups disappearing into thick cover, new groups are only added to the count if the time of emergence and the group composition suggests beyond all reasonable doubt that none of the animals have been previously counted.

Figure 4. Map of vantage point count area.

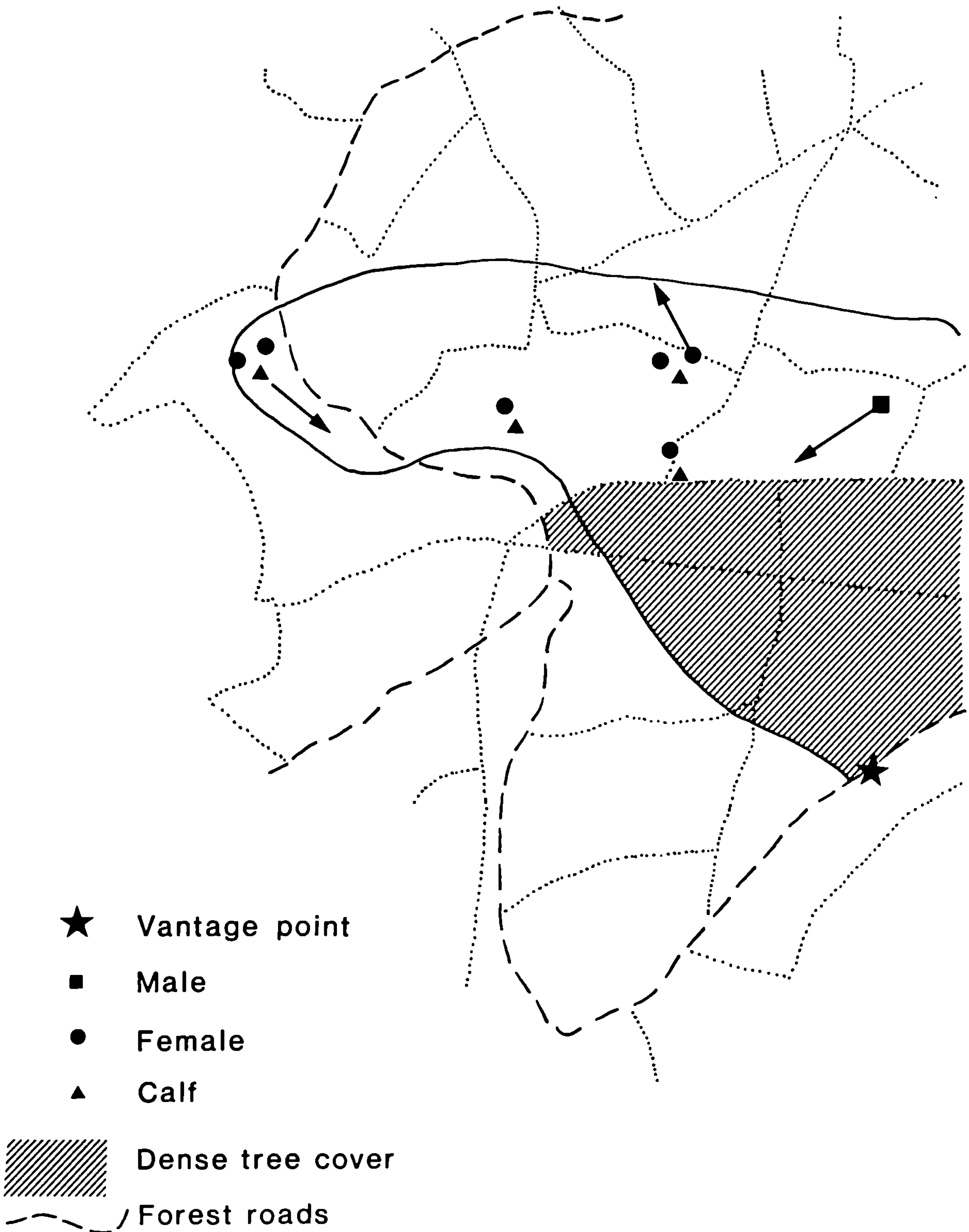


Figure 5. Form for recording vantage point counts.

DENSITY ESTIMATION FOR WOODLAND RED DEER OCCUPYING HILLY TERRAIN

Forest: Carrick   Conservancy: South Scotland   Observer(s): J. McLean

Location: Sron cruicte   Area: 110 ha   Structural Type: Thicket   P Yr: 73

Date: 16-4-86   Time on: 06:30   Time Off: 10·00

Weather Conditions and Visibility: Fine and clear following a frost

DEER SEEN

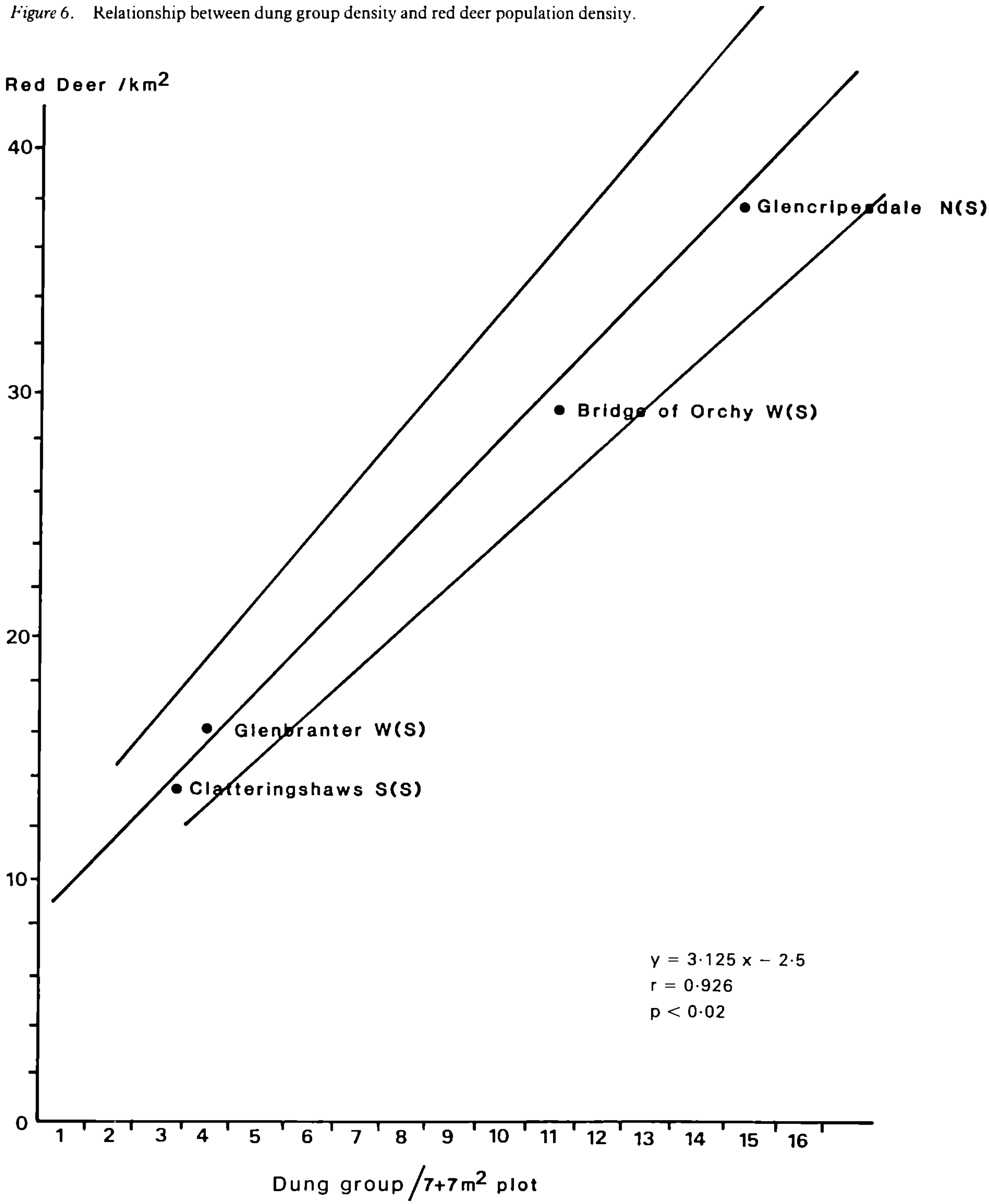
Time	Location	Spp	Adult Male	Adult Female	Yearlings Male	Yearlings Female	Calf/ Kid	Unclassified	Remarks
0710	Ride/River	Red		2		1	2		cumulative Total =5
0722	Check area in Compt 86	Red		1			1		cum Total =7
0730	Riverside	Red		2		1	2		same as 07·10
0733	"	Roe	1						cum Total =7
0752	Ride 86/87	Red		1		1	1		" " =10
0804	Check on edge of 87 (N)	Red		2			1		Possibly part of 07·10 group Cum T.=10
0815	Check·87	Red	1		1				Cum Total =12
0820	Riverside	Red		2		1	2		same as 0710
"	Check·87			2			1		same as 0804
0840	Ride 87/88	Roe		1			1		Cum Total = 12.
0845									

10·00 – Continued sightings of 0710 group plus intermitent views of others. No new sightings confirmed.

∴ 12 Red deer

= 10·9/100 ha

Figure 6. Relationship between dung group density and red deer population density.



At the end of the count period the minimum number of deer is related to the area under observation, and expressed as a density per square kilometre. Three or four repeat counts are conducted over the following mornings and evenings, and fresh counts in adjacent areas of the same, and other, structural types are made. Repeat counts are conducted to overcome the problems of variation in deer activity due to weather conditions and the maximum number recorded in any single count period should therefore be accepted. Mean densities for each structural type can then be applied to the area as a whole in relation to the component structural types present (Table 1).

Vantage point counts in forests throughout Scotland have frequently surprised local staff by revealing much higher numbers than expected and densities of 5–15 per square kilometre are common, particularly in the Sitka spruce and Lodgepole pine forests of the north and west. This is very similar to the range of densities found on open range (Mitchell, 1973). Pre-thicket and thicket stage crops with open or failed patches are the most favoured habitats and local densities of 30–40 per square kilometre have been observed in some of these areas (Table 1). Female red deer occupying dense forests do not usually move very far (Catt and Staines, 1987), hence movements in or out of vantage point areas cause few problems. However, this is not always so for stags, where movements are more variable. If the numbers of deer counted in vantage point counts include large proportions of stags, then less confidence can be placed upon the densities calculated.

Table 1. Deer density related to different growth stages

	Deer density (number per square kilometre)*		
Forest structure	Galloway	Glenbranter	Glencripesdale
Establishment	2	2	—
Pre-thicket	5	8	—
Thicket	10	12	40
Pre-felling	2	2	—
Checked-growth	2	2	—

*Mean values from vantage point counts

Dung counts

In some areas the absence of hilly terrain will prevent the use of vantage point counts. In such areas a less precise, but nevertheless very useful, means of estimating deer densities has been developed. This is simply based on the assumption that more deer in an area will result in a higher density of dung to be found on the ground. By conducting sample counts of dung density in areas where

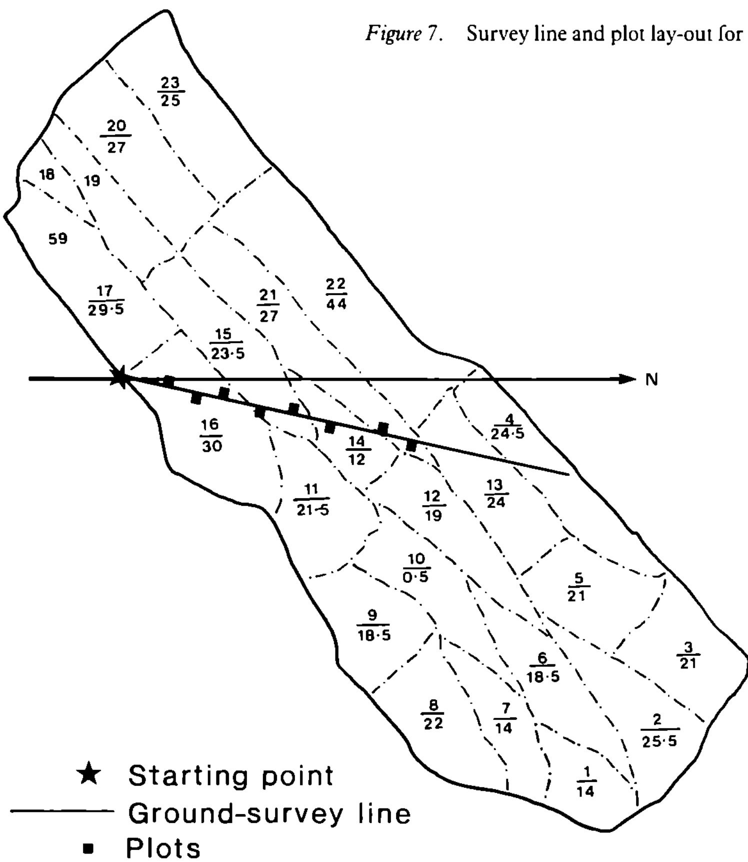


Figure 7. Survey line and plot lay-out for pellet group assessments.

deer density has been estimated from vantage point counts, it has been possible to relate dung density to deer density, empirically. This relationship is shown in Figure 6 and provides a useful basis for the estimation of deer density in areas of flat or rolling terrain.

Dung counts are conducted by first selecting crops in the planting years of the particular growth stages to be assessed (see pages 6 and 7). Blocks of these planting years are then outlined on a stock map and an easily locatable landmark, close to the perimeter, is selected as a starting point. A straight line drawn from the starting point, through the selected area, serves as a ground survey line (Figure 7). The starting point is located in the field and the map bearing corrected for magnetic variation to give a field bearing, which is then transferred to an orienteering compass. One hundred and ten paces (approximately 100 m) are marched along the compass bearing and a 7 × 7 m plot is laid down with its axis along the survey line, using a tape measure for distances and the compass for judging right angles (Figure 7).

The plot is then carefully and systematically searched in bands of about 1 m wide for the presence of pellet groups. The number of red deer pellet groups is counted and recorded. A pellet group is defined as a cluster of more than six pellets but only very infrequently are such low numbers found, and usually pellet groups are obvious large accumulations of individual pellets. Sometimes, long strings of pellets are found, caused by the animal defecating while on the move; these are generally easily identified and assessed. Occasionally, difficulties may be encountered in areas of high pellet group density when two or more pellet groups have been deposited on the same spot. Experience suggests that it is always possible to confidently separate these on the basis of individual pellet appearance, size and age. If pellet groups are found on the edge of a plot it is almost always possible to include or reject the group on the basis of how much of the group lies inside or outside of the plot; only occasionally are pellet groups found exactly on the edge, and in this case they should be alternately counted and rejected.

The identification of pellets from different species is not always easy and it is possible to confuse red deer pellets with those of other species of ungulates, mainly sheep and sika and roe deer. It is important, therefore, to check standards periodically with other users of this technique and also to check against pellets of known origin. This is particularly important in areas with several species of ungulates.

The compass bearing is followed for a further 110 paces and the procedure continued until eight plots have been assessed. The mean number of pellet groups per plot can now be related to the range of deer densities likely in the particular growth stage present (Figure 6). Preferably, several such assessments should be made for each growth stage.

Deer densities obtained from vantage point counts and pellet group counts can now be used to estimate a range of numbers of deer for each growth stage and for the area as a whole. Some thicket areas have become very open in structure due to differences in tree growth. This creates many secluded glades offering shelter and food for deer in close proximity, and very high densities of red deer often occur in these areas. Thicket areas vary considerably in their capacity to support deer and before multiplying density figures by area of thickets they should be classified into those of uniform structure with many glades (open thickets) and those which are uniform and dense. Densities obtained from vantage points or dung counts should only be applied to areas similar to those from which they were derived. Aerial photographs can be useful for classifying thicket areas in this way, and they also demonstrate how often gaps and glades occur in apparently fully stocked compartments. For example, the thickets at Glencripesdale (Table 1) were very open compared to those in Galloway.

Population Dynamics

In order to predict likely changes in the deer population it is necessary to estimate the rate at which the deer population is increasing or decreasing. The factors which will affect this are reproduction, mortality, immigration and emigration.

Hinds in forests do not usually move over large distances (Catt and Staines, 1987) and it is unlikely that the movement of hinds will cause problems in estimating numbers or in their contribution to a knowledge of population dynamics. Stag movements may be difficult to predict, but if a sufficiently large area is included in the management plan then this is unlikely to cause problems. In areas where deer maraud from adjacent open-range it is impossible to account for these.

The reproductive input to a population is estimated by assessing the pregnancy status of all females which are shot. It is, however, important also to relate this to age. Age is easily determined in red deer (see Appendix). Highest mortality occurs in the first year of life and this can be assessed indirectly by comparing estimates of fertility made during the shooting season with calf:hind ratios determined from spring vantage point counts. This linking of reproduction with mortality provides a measure of survival, and an estimate of the number of animals being recruited to the adult population.

Figure 8. Specimen entry in a ranger's notebook.

DEER CULL DATA SHEET

FOREST / DISTRICT Glentrool

DEER No.	DATE SHOT	LOCATION	SEX	JAW COLLECTED	EMBRYO PRESENT	EMBRYO SEX	OVARY c.l. PRESENT	MAMM. GLAND MILK PRESENT	CARCASE WEIGHT	COMMENTS
SGT 219	15·1·86	Rowantree Hill	F	✓	✓	♀	–	×	112	
220	15·1·86	Rowantree Hill	F	✓	✓	♂	–	×	113	
221	23·1·86	Rowantree Hill	F	✓	✓	♀	✓	×	98	
222	27·1·86	White Clauchire	F	✓	✓	?	✓	✓	112	
223	27·1·86	Kirriereoch	F	✓					60	
224	27·1·86	Rowantree Hill	F	✓	✓	♂	✓	✓	122	Jaw damaged
225	27·1·86	Rowantree Hill	F	✓					70	calf.
226	27·1·86	Ferter	F	✓	✓		✓	✓	130	
227	27·1·86	Ferter	F	✓					58	calf.
228	29·1·86	Lagg	F	✓	✓	♂	✓	–	106	
229	29·1·86	Craigenroy	F	✓	✓	♂	✓	–	126	
230	5·2·86	Kirriereoch	F	✓	✓	♀	✓	NO	132	
231	5·2·86	Kirriereoch	M	✓					79	calf.

Plate 1. Forest structure – establishment stage.

Plate 2. Forest structure – pre-thicket stage.

Plate 3. Forest structure – thicket stage.

Plate 4. Forest structure – pre-felling stage.

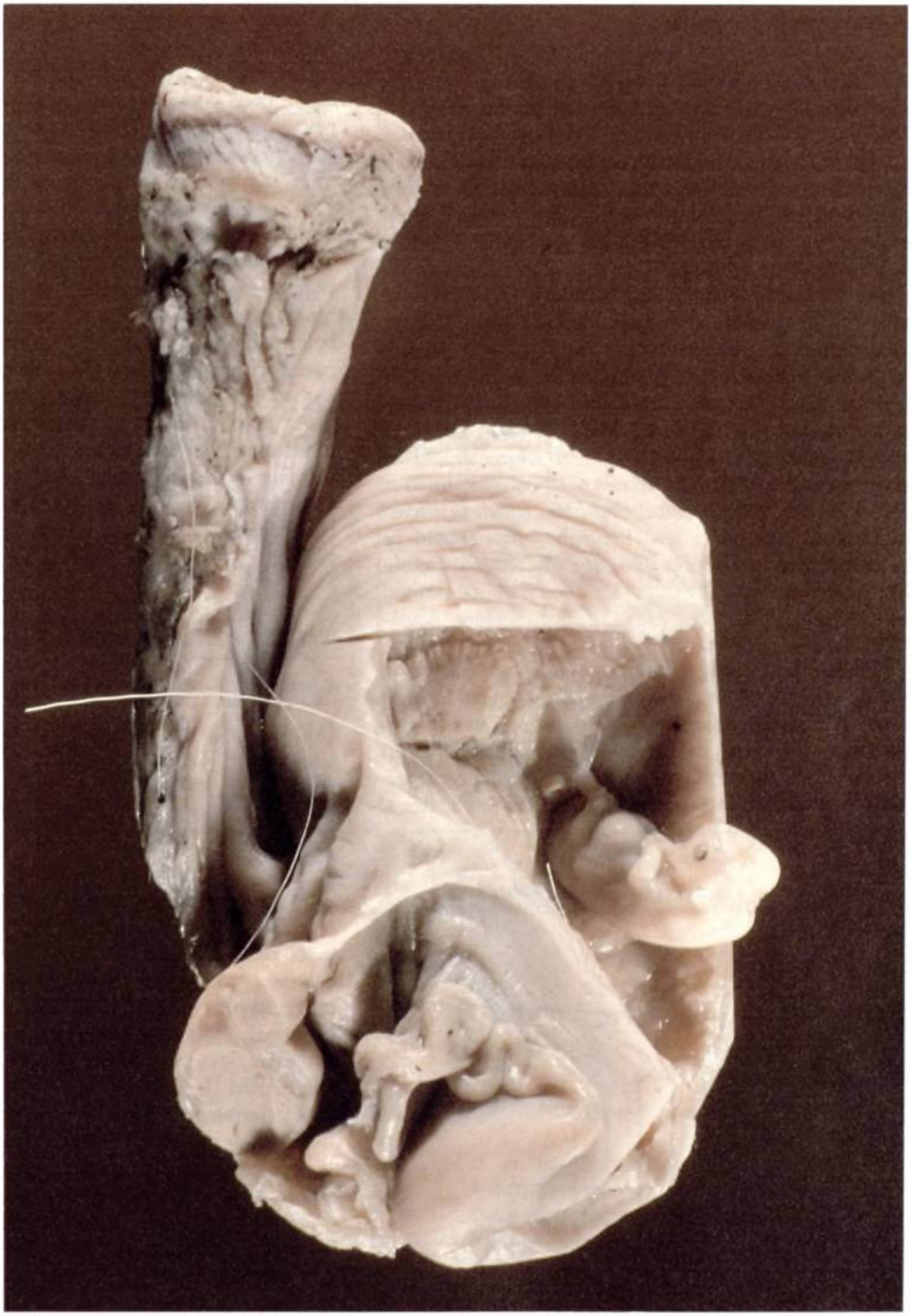


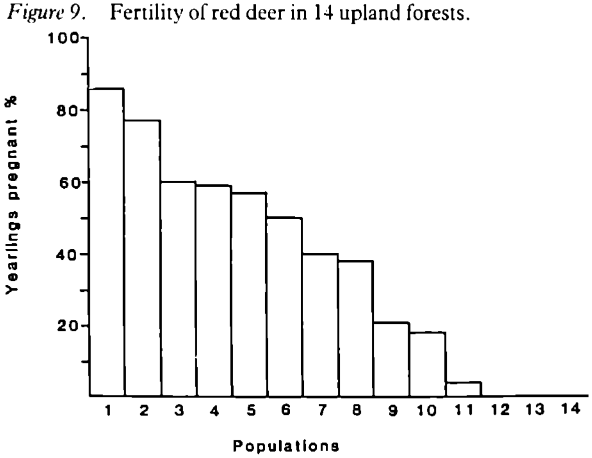
Plate 5. Dissection of red deer hind to show uterus (incised to show embryo), oviducts and ovaries. (*CS37307*)

Assessing Fertility

After shooting, bleeding and gralloching, the lower jaw should be removed from *all* deer. The reproductive system from *all* females (uterus, oviducts and ovaries) should be removed and the uterus cut open and examined (Plate 5). In most females shot during the open season, pregnancy can be determined from the presence of an embryo, but in the very early stages of pregnancy (before mid November) before an embryo is visible it is easier to detect pregnancy by examining the ovary for the presence of a corpus luteum. The corpus luteum is a yellowish gland which develops inside the ovary and only persists following fertilisation. It is easy to see if the ovary is sliced in half. The presence or absence of milk in the udder should also be noted and recorded. The deer should be given a reference number which should be recorded in the ranger or stalker's notebook (Figure 8) *at the time*, and also on a label (*indelible*) which is affixed *with wire* to the lower jaw. Pregnancy data should be recorded in the notebook alongside the reference number, date, location and weight. Labelled jawbones should be retained until after the end of the open seasons (April–May) when ages can be determined.

Yearlings are the age class most sensitive to changes in habitat quality and in many open-range populations they never become pregnant. A wide range of yearling pregnancies has been determined from different forest populations (Figure 9). Populations with high proportions of pregnant yearlings often exhibit very high rates of population increase.

Figure 9. Fertility of red deer in 14 upland forests.



Assessing Mortality

Direct searches for deer carcasses, such as those conducted on the Isle of Rhum by Lowe (1969), are inefficient in dense coniferous forest, and some indirect method for the estimation of mortality is required. Most red deer which are shot during routine culling operations are in good condition with fat deposits around the kidneys, in the abdominal cavity and under the skin. It can only be assumed, in the absence of evidence to the contrary, that in many forest populations natural mortality is very low in the middle age range but is higher in juveniles and old animals.

Post-winter vantage point counts at Glenbranter Forest suggest the presence of about 50–60 calves per 100 hinds, and for Galloway 55 per 100 hinds. However, before this can be compared with the fertility data, it is necessary to make adjustments for the female cull which has occurred during the winter. The effect of culling a lower ratio of calves to hinds than is present in the population is to increase the ratio of calves to hinds remaining in the population after the cull, and it is most important to make due allowance for this. Table 2 summarises cull data and ratios of calves to hinds in the cull from a number of forest areas.

Table 2. Calf:hind ratios in culled deer

Forest area	Years	Hinds	Calves	Calves/100 hinds
Galloway	1965–83	2936	1097	37
Glenbranter	1978–82	152	65	43
Argyll	1977–82	1042	371	36
N. Scotland	1978–82	1916	636	33

A constraint on the interpretation of reproduction and mortality data is the mis-classification of calves as hinds in the recordings of culled deer. This appears to be rather common in high performance populations which exhibit rapid juvenile growth rates. The age of culled deer is commonly assessed subjectively from carcass weight and body size, and the value of accurate age data is often not appreciated. It is important, therefore, only to use age data determined from an inspection of lower jaws after the shooting season.

It appears from previous studies that pre- and post-natal natural mortality can vary between 10–20 per cent, even in high performance populations from high quality habitats. To summarise, calf mortality should be assessed by comparing the proportion of calves per 100 hinds from fertility estimates with those obtained in spring vantage point counts, making due allowance for any effects of culling a different proportion of hinds to calves than is present in the population. In the absence of hard information it is possible to use a figure of 10–20 per cent calf mortality.

Modelling Population Changes

Having estimated deer density, recruitment and mortality, it is now possible to use this information to model the predicted changes in the population and to explore the culling requirements and options open to the manager.

Population modelling which predicts the numbers and age structure of a population based upon its current age structure and its fecundity and mortality, can be done more accurately with a computer but can also be done by hand. Two such examples are illustrated, showing the predicted changes to high performance population

Figure 10. Simulation of high performance woodland red deer population dynamics. (From Ratcliffe, 1984a)

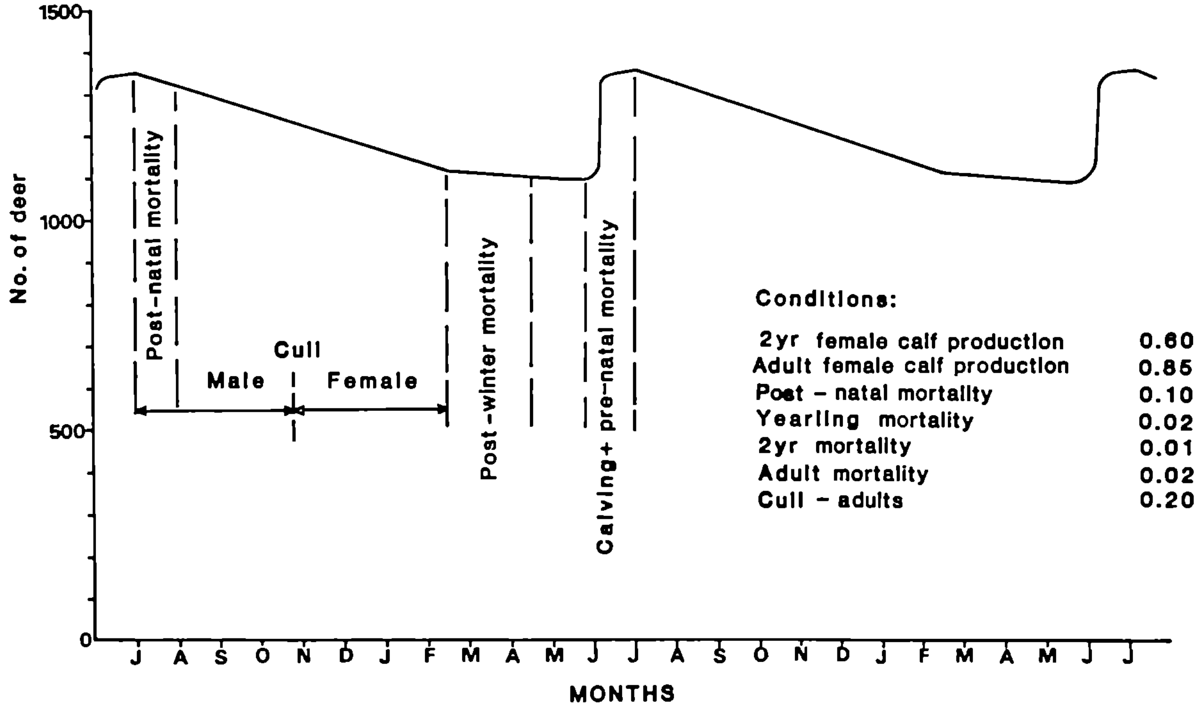


Figure 11. Simulation of low performance open range red deer population dynamics. (From Ratcliffe, 1984a, based on data from Mitchell and Crisp, 1981.)

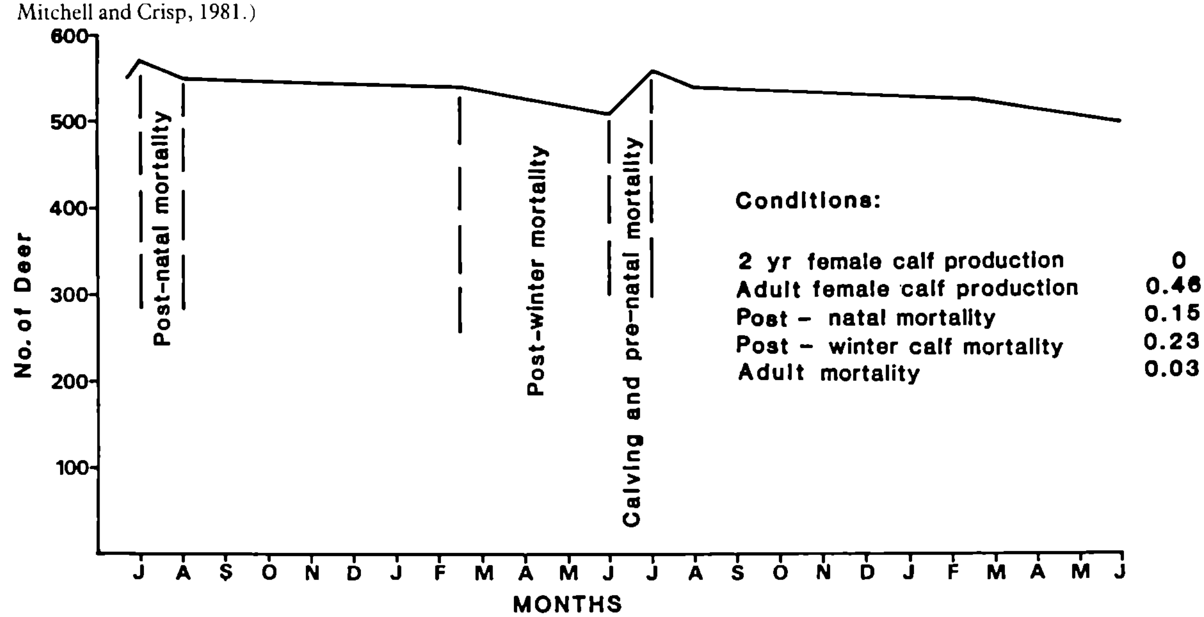


Figure 12. Progress of cull; 1976–77 hind season.

Target = 100 hinds + calves
Maximum time available = 84 days

Date	20	21	22	25	26	27	28	29	1	2	3	4	5	8	9	10	11	12	15	16	17
Target	1.19	2.38	3.57	4.76	5.95	7.14	8.33	9.52	10.71	11.90	13.09	14.29	15.48	16.67	17.86	19.05	20.24	21.43	22.62	23.81	25.00
Kill		1									(1) 2			(6) 8		(2) 10					
Variance			-3					-9					-13					-11			

Date	18	19	22	23	24	25	26	29	30	1	2	3	6	7	8	9	10	13	14	15	16
Target	26.19	27.38	28.57	29.76	30.95	32.14	33.33	34.52	35.71	36.90	38.09	39.29	40.47	41.67	42.86	44.05	45.23	46.42	47.62	48.81	50.00
Kill	(2) 12	(6) 18	(3) 21		(2) 23				(7) 30			(4) 34		(4) 38	(3) 41						
Variance		-9					-10					-5					-4				-9

Date	17	20	21	22	23	24	27	28	29	30	31	3	4	5	6	7	10	11	12	13	14
Target	51.19	52.38	53.57	54.76	55.95	57.14	58.33	59.92	60.71	61.90	63.09	64.29	65.48	66.67	67.86	69.05	70.24	71.43	72.62	73.81	75.00
Kill				(2) 43		(5) 48							(2) 50	(4) 54				(2) 56		(4) 60	(1) 61
Variance	-10					-9					-15					-15					-14

Date	17	18	19	20	21	24	25	26	27	28	31	1	2	3	4	7	8	9	10	11	14
Target	76.19	77.38	78.57	79.76	80.95	82.14	83.33	84.52	85.71	86.90	88.09	89.29	90.47	91.67	92.86	94.05	95.23	96.42	97.62	98.81	100.00
Kill				(2) 63		(2) 65				(4) 69		(6) 75		(3) 78							
Variance					-18					-18											-22

Extension of season to end of February with revised target figures.

Date	15	16	17	18	21	22	23	24	25	28
Target	2.2	(2) 4.4	6.6	8.8	11	13.2	15.4	17.8	20	22
Kill		(2) 2		(3) 5	(4) 9			(4) 13		
Variance				-4	-2	-4	-6	-5		-9

(Figure 10) and a very low performance population (Figure 11). It is unlikely that many forest populations of red deer are performing as poorly as the example in Figure 11, While many are performing similarly to the example in Figure 10. This suggests that very many forest populations are increasing at a rate of over 20 per cent each year, and therefore that a cull in excess of this is necessary to effect a reduction in numbers.

Setting the Cull

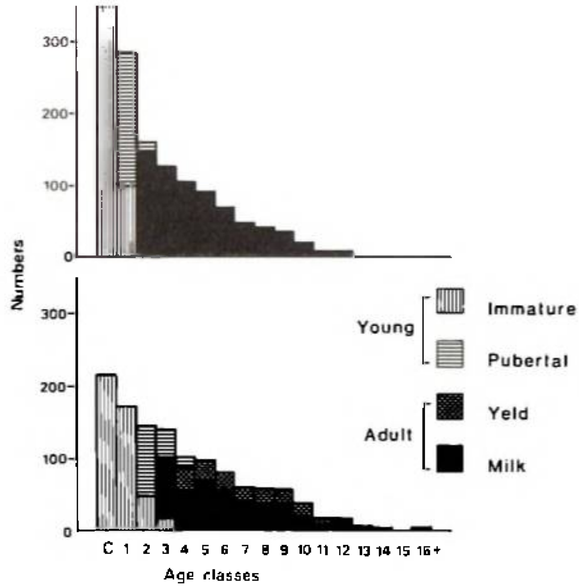
The number to cull each year should be firmly based upon a knowledge of the population dynamics and estimated future population, either using the results of population modelling or by referring to the rapid method outlined on p. 22. The target cull should be decided upon during the early summer following the assessment of spring densities and calf:hind ratios, and the analysis of previous years' fertility and age material. The cull figure should be broken down into numbers for males, adult females, yearling females and calves. It is important that most effort is devoted to the breeding age females, as this group will most seriously influence future population trends. Clear objectives for the ranger or stalker must be stated. For example if red deer population control is considered to be the most important duty, then other less important duties must not be allowed to conflict with this.

Progress of culling should be carefully monitored, preferably on a daily or, at least, on a weekly basis. A useful form for this purpose is shown in Figure 12. After deducting week-ends and holidays, the number of days available for red deer control can be shown against the planned cumulative cull for any point in time. In this way, problems (i.e. bad weather and illness preventing targets being achieved) are readily identified at an early stage and tactics can be modified immediately. This form should also be used to analyse difficulties after completion of the cull in order to foresee and forestall similar problems in forthcoming years.

Following the cull the fertility data from rangers' notebooks should be collated and pregnancy and lactation information recorded and used to update previous years' values. All jawbones should be examined and ages determined.

Consistency in age determination is best achieved by gathering the material together from a number of adjacent areas so that one person can estimate ages, or at least co-ordinate the efforts of a group. Age-class distributions can be readily presented in histogram form. A bias towards the younger age classes (Figure 13) is indicative of a population with high rates of reproduction and rapid turnover. An older age-class distribution (Figure 14) suggests that culling effort is low and turnover is slower.

Figures 13 & 14. Age class distribution of red deer in a high performance population (above) and a low performance population (below). C = calves. (From *Red deer management*, Red Deer Commission, 1981.)



Cohort Analysis

It is often suggested that minimum population size can be estimated from the numbers of each age and sex shot each year based upon the knowledge that a particular minimum number is required to produce the cull. But this will only be true if the population is neither increasing or decreasing and if control effort is constant over several years. Cohort analysis is a similar but much more reliable method which requires data collected over several years and is extremely valuable in providing a factual check of minimum population size.

A cohort is a collective name for all the animals born in a single year. Cohort analysis is simply a means of recording and accumulating the number of deer born in a particular year from a knowledge of the ages of the deer which have been shot. It provides an accurate retrospective check on population size. For example, given the age and sex of each deer shot during the year's cull, it is simple to calculate the year of birth for each individual. This can be illustrated by maintaining an annual record of the development of each cohort (Figure 15). By entering the number of animals belonging to each age class from the annual cull, in each vertical column, these can be added horizontally to give the cumulative number of deer shot for any particular cohort, e.g. the 1980/81 cull produced 71 deer, and by 1984 60 deer which were born in 1981 had already been recovered. Clearly, many deer born that year are still alive, but already we know that at least 60 calves were born in that year. If we go back 8 or 9 years we can be fairly certain that most deer from these years will have died and the retrodiction of deer born in those years is more precise. For example, 45 deer were recovered from the 1973 cohort and it is unlikely that any more deer born that year are still alive. This evidence indicates that the population is increasing rather quickly.

Figure 15. Cohort analysis, Carrick Forest, south Scotland (1984).

COHORT	CULL YEAR													AGE	NO. SHOT FROM COHORT
	1971/72	1972/73	1973/74	1974/75	1975/76	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82	1982/83	1983/84		
1971	9	5	5	7	2	1	0	3	0	0	0	0	0		32
1972		4	13	7	6	3	0	1	0	1	1	0	0	12	36
1973			11	12	8	7	1	4	1	1	0	0	0	11	45
1974				10	10	14	3	0	1	2	1	0	0	10	41
1975					13	9	2	3	2	0	1	0	1	9	31
1976						9	10	7	5	4	3	0	0	8	38
1977							7	13	4	9	6	3	3	7	45
1978								11	23	13	4	2	2	6	55
1979									20	24	4	6	4	5	58
1980										17	27	8	2	4	54
1981											11	30	19	3	60
1982												15	16	2	31
1983													14	1	14
1984														0	
TOTAL CULL				36	39	43	23	42	56	71	58	64	61		

It is now possible to estimate total minimum population size by calculating the number of adults necessary to produce the number of calves born in a particular year e.g. in 1973, at least 60 hinds would have been required to produce 45 calves. Assuming that there was an equal number of stags in the population, this gives a total minimum population of 165 deer. This is a minimum estimate because it does not take into account any deer dying naturally which are not recovered. However, we can incorporate estimates of natural mortality (Figures 10 and 11).

Cohort analysis will not start to yield useful data for 3 or 4 years but it is an immensely valuable deer management tool, and it is strongly recommended that all the relevant data be collected from the culls.

A Rapid Indication of the Required Cull

In the initial period of data collection, when sufficient sound data may be lacking, it it possible to base management on some basic rules of thumb which have emerged from previous research. These have produced average figures for red deer populations exhibiting different levels of fertility and mortality and at varying densities (Figure 16). Rapid estimates of the required cull can be made by first assessing the proportion of juveniles (the sum of 1 and 2 year olds) in the previous cull and reading this off in column 1. This will indicate the number of males, females and calves to be culled for each square kilometre of forest *in order to prevent an increase*. This number, multiplied by the area in square kilometres, will give the cull figure. As an example of the method, consider a forest of 4000 ha with a high performance/low mortality population of red deer, and that approximately 40 per cent of the cull is of juveniles:

a) select the high performance/low mortality table;
b) read along the 40 per cent juvenile line;
c) assume a density of between 10–15 deer per square kilometre;
d) the cull should be based upon between 0.97 and 1.46 breeding-age females per square kilometre or 39–58 adult hinds.

Figure 16. Recommended kill for red deer (deer/100 ha).

		SPRING DENSITY (DEER/100 ha)															
		5			10			15			20			25			
Juv.% in kill M : F	M : F	M	F	C	M	F	C	M	F	C	M	F	C	M	F	C	% CULL
		HIGH PERFORMANCE LOW MORTALITY															
50 : 50	1 : 1	0.42	0.58	0.38	0.83	1.16	0.76	1.25	1.74	1.13	1.66	2.33	1.51	2.08	2.91	1.89	27
50 : 35	1 : 1.5	0.28	0.59	0.25	0.56	1.18	0.51	0.84	1.77	0.76	1.13	2.36	1.01	1.41	2.95	1.27	23
50 : 27	1 : 2.0	0.22	0.58	1.98	0.43	1.16	0.40	0.65	1.75	0.59	0.86	2.33	0.79	1.10	2.91	0.99	20
		LOW PERFORMANCE LOW MORTALITY															
50 : 50	1 : 1	0.46	0.46	0.30	0.93	0.93	0.60	1.39	1.39	0.90	1.85	1.85	1.20	2.30	2.30	1.50	24
50 : 35	1 : 1.5	0.31	0.52	0.23	0.62	1.05	0.45	0.93	1.60	0.68	1.24	2.10	0.91	1.60	2.64	1.13	21
50 : 27	1 : 2.0	0.23	0.53	0.18	0.47	1.08	0.37	0.70	1.62	0.55	0.93	2.20	0.73	1.17	2.69	0.91	19
		LOW PERFORMANCE HIGH MORTALITY															
50 : 50	1 : 1	0.52	0.52	0.45	1.04	1.04	0.87	1.56	1.56	1.31	2.08	2.08	1.75	2.60	2.60	2.19	30
50 : 35	1 : 1.5	0.36	0.61	0.34	0.71	1.21	0.68	1.07	1.82	1.02	1.43	2.43	1.35	1.78	3.03	1.69	26
50 : 27	1 : 2.0	0.27	0.62	0.27	0.54	1.24	0.53	0.81	1.86	0.80	1.08	2.47	1.07	1.34	3.09	1.33	23
		HIGH PERFORMANCE LOW MORTALITY															
20 : 20	1 : 1	0.25	0.28	0.07	0.51	0.56	0.15	0.76	0.84	0.22	1.02	1.12	0.29	1.27	1.40	0.37	12
25 : 25	1 : 1	0.29	0.34	0.11	0.57	0.69	0.22	0.86	1.03	0.33	1.14	1.37	0.43	1.43	1.71	0.54	15
30 : 30	1 : 1	0.32	0.38	0.14	0.63	0.75	0.28	0.95	1.14	0.42	1.26	1.51	0.55	1.58	1.89	0.69	17
35 : 35	1 : 1	0.34	0.45	0.19	0.68	0.89	0.38	1.03	1.34	0.58	1.37	1.78	0.77	1.71	2.23	0.96	20
40 : 40	1 : 1	0.37	0.49	0.24	0.75	0.97	0.49	1.12	1.46	0.73	1.49	1.94	0.97	1.87	2.43	1.21	22
45 : 45	1 : 1	0.39	0.55	0.31	0.78	1.09	0.63	1.17	1.64	0.94	1.56	2.19	1.25	1.95	2.73	1.56	25
50 : 50	1 : 1	0.42	0.58	0.38	0.83	1.16	0.76	1.25	1.74	1.13	1.66	2.33	1.51	2.08	2.91	1.89	27
55 : 55	1 : 1	0.42	0.64	0.47	0.85	1.27	0.93	1.27	1.91	1.40	1.70	2.55	1.87	2.12	3.18	2.33	31
60 : 60	1 : 1	0.43	0.69	0.56	0.86	1.37	1.12	1.29	2.06	1.68	1.71	2.74	2.25	2.14	3.43	2.81	34
65 : 65	1 : 1	0.43	0.73	0.67	0.86	1.46	1.33	1.29	2.19	2.00	1.72	2.92	2.66	2.15	3.65	3.33	37
70 : 70	1 : 1	0.43	0.77	0.77	0.85	1.52	1.53	1.28	2.30	2.31	1.70	3.07	3.08	2.13	3.83	3.85	39
75 : 75	1 : 1	0.41	0.81	0.90	0.81	1.63	1.81	1.22	2.44	2.71	1.63	3.26	3.62	2.04	4.07	4.52	43
		LOW PERFORMANCE LOW MORTALITY															
20 : 20	1 : 1	0.26	0.26	0.71	0.52	0.52	0.14	0.79	0.79	0.21	1.05	1.05	0.28	1.30	1.30	0.35	12
25 : 25	1 : 1	0.30	0.30	0.10	0.59	0.59	0.19	0.89	0.89	0.29	1.19	1.19	0.38	1.49	1.49	0.48	14
30 : 30	1 : 1	0.33	0.33	0.12	0.66	0.66	0.24	0.99	0.99	0.37	1.32	1.32	0.49	1.65	1.65	0.61	16
35 : 35	1 : 1	0.36	0.36	0.16	0.73	0.73	0.31	1.09	1.09	0.47	1.46	1.46	0.63	1.82	1.82	0.78	18
40 : 40	1 : 1	0.40	0.40	0.20	0.80	0.80	0.40	1.20	1.20	0.60	1.60	1.60	0.80	2.00	2.00	1.00	20
50 : 50	1 : 1	0.46	0.46	0.30	0.93	0.93	0.60	1.39	1.39	0.90	1.85	1.85	1.20	2.30	2.30	1.50	24
		LOW PERFORMANCE HIGH MORTALITY															
20 : 20	1 : 1	0.32	0.32	0.11	0.63	0.63	0.22	0.95	0.95	0.33	1.27	1.27	0.44	1.58	1.58	0.55	15
25 : 25	1 : 1	0.35	0.35	0.15	0.71	0.71	0.29	1.06	1.06	0.43	1.41	1.41	0.58	1.76	1.76	0.72	17
30 : 30	1 : 1	0.39	0.39	0.18	0.77	0.77	0.36	1.16	1.16	0.54	1.54	1.54	0.72	1.93	1.93	0.90	19
35 : 35	1 : 1	0.43	0.43	0.24	0.85	0.85	0.48	1.28	1.28	0.72	1.71	1.71	0.96	2.14	2.14	1.20	22
40 : 40	1 : 1	0.46	0.46	0.30	0.93	0.93	0.60	1.39	1.39	0.90	1.85	1.85	1.20	2.31	2.31	1.50	24

M = male F = female C = calf Juvenile = all 1 & 2 year olds

It must be emphasised that this method is a useful first approach only and that as time passes the collection of sound biological data must be incorporated to provide estimates of increasing precision.

Selective Control

No mention has so far been made of selective control. Clearly, if sick or poor quality deer are present in a population then they should be removed. However, in almost all forest populations these are very few and the population must be controlled by shooting healthy, good quality animals, especially hinds. Managers may wish to retain some good quality stags, but in woodlands quality is seldom lacking and usually improves with any reduction in numbers. The main criterion must always be the humane control of deer and this applies equally when out of season shooting is deemed to be necessary, and especially prior to the hind season when dependent calves may be orphaned.

Achieving the Cull

It will often be apparent that red deer are breeding so well, and densities are so high in forest habitats that cull targets are difficult, if not impossible, to achieve. This may be because the size of the problem was not obvious in the past or it may simply be because of an increasing area of thicket woodland and decreased sightings of deer. Poor access is often the cause of failure to achieve culls.

Whatever the cause, consideration must be given to finding the means to achieve the required cull targets. Forest design is a vital part of deer management and the provision of open areas for the purpose of improving the possibilities for killing deer is essential. This aspect is covered more fully in Forestry Commission Leaflet 86 *Glades for deer control in upland forests* (Ratcliffe, 1985), but essentially a system of glades connected by forest roads and stalking paths should be maintained. Where possible, glades should be areas where the deer themselves have shown a preference for herb-rich swards, and frequently these may be the areas of better quality land, but in some instances re-seeding may be necessary.

Forest rangers carrying out deer management must be skilled and well equipped. Training must be provided to ensure that rangers are competent to use firearms safely and to kill deer as humanely as possible. They should be equipped with rifles, binoculars and other equipment of a high quality, appropriate to full-time professional use. Transport and slaughtering facilities are also of great importance. The use of all-terrain vehicles greatly speeds up the recovery of deer and as a result increases the time available for stalking, and it reduces manual dragging in of deer. This minimises the most strenuous part of the ranger's job and it cuts down on the strains and back injuries often resulting. Well designed and equipped deer larders reduce physical effort and reduce loss of income by assisting good preparation of the carcass, and they allow for improved operator hygiene.

In hilly terrain, high-seats are often considered to be unnecessary but in woodlands they can be useful. The use of high-seats is covered in Forestry Commission Leaflet 74 *High seats for deer management* (Rowe, 1979) and in the *Forest ranger's handbook* (Springthorpe and Myhill, 1985).

The algorithm (Figure 17) provides a management approach to decision-making. If particular difficulties are foreseen, consideration should be given to extended seasons and/or night shooting. So long as the treatment of deer conforms to the same high standards of humaneness as in-season and daytime shooting, then these methods provide an excellent means to supplement the cull. Careful trials of night shooting conducted in south Scotland show that this method is at least as humane and effective as day-time shooting. Before undertaking night-shooting, personnel should be familiar with the Red Deer Commission's Code of Practice on the subject.

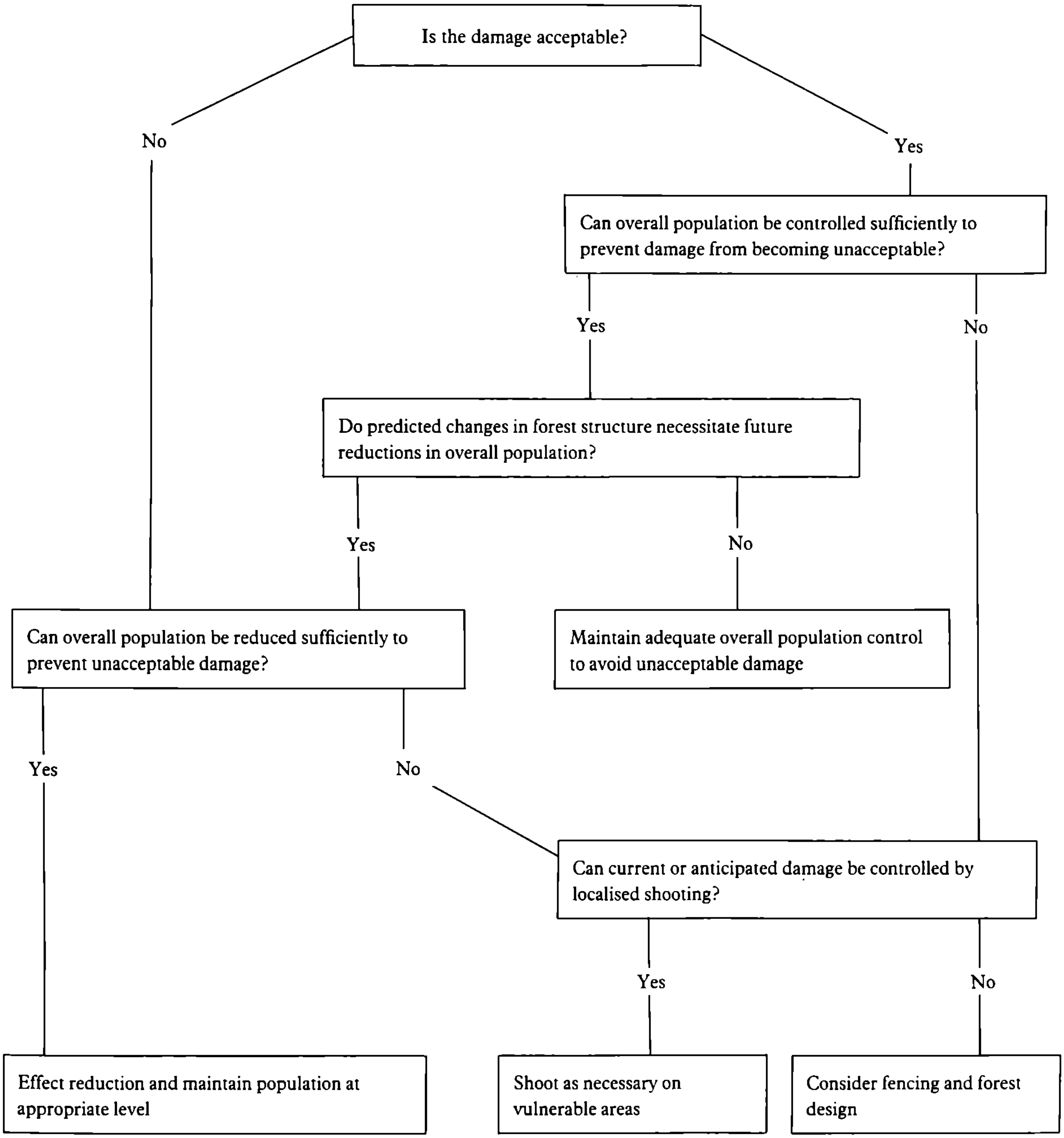
Deer Management Groups

Red deer are hefted to areas, often coinciding with watersheds, and do not adhere to geographical units of particular land ownership. For this reason it is recommended that land managers occupying particular areas of contiguous deer range should co-operate. If the separate objectives of adjacent land managers vary then there is likely to be more conflict of interests than, for example, if all the land is being managed for forestry. Whatever the land use objectives, a more workable deer management strategy is most likely to emanate from a forum of open discussion, and attempts to appreciate a neighbour's point of view. The Red Deer Commission can play a valuable rôle in assisting groups of individuals to set up such deer management groups, and are always ready to help and advise in such circumstances. It is strongly recommended that land managers whose land occupies a particular deer range should organise themselves into a deer management group in order to discuss management strategies and objectives.

Figure 17. Red deer management strategy.

Determine: Damage levels
Predicted changes in forest structure
Predicted changes in adjacent land-use
Population features – Reproductive performance
Seasonal immigration
Mortality/Emigration
Previous culls
Expected density

Evaluate:



Summary of Management Duties

1. Divide the forest area into sub-areas of discrete deer range, i.e. separate populations, irrespective of administrative boundaries. Consult neighbours if necessary in order to set up deer management groups.
2. Carry out damage inspections, followed by damage assessments, where and when necessary.
3. Predict changes in forest structure and the future impacts of these changes on deer populations.
4. Conduct vantage point counts each spring (March–May inclusive) to determine densities in blocks of similar structure and usage by deer.
5. Supplement vantage point counts with dung counts where necessary in areas with poor visibility and topography for vantage point counts. Use aerial photographs in classifying thickets.
6. Collect jawbones from *all* deer shot for age determination and future cohort analysis. Record: animal reference number, date shot, location, sex and weight. Fix label with reference number of jawbone.
7. For females, assess fertility by examining the reproductive tract:
   a) is a foetus present?
   b) sex of foetus?
   c) if no foetus, is a corpus luteum present?
   d) is there milk in the mammary gland?
   Record this information with animal reference number (6 above).
8. Record all groups of deer seen during March–May and analyse vantage point data for sex and age class, to obtain calf: hind ratios.
9. *End of season* (April–June)
   a) Determine ages from all jawbones and relate to animal reference numbers.
   b) Assess per cent pregnancy for yearlings and adults from rangers' notebooks.
   c) Assess density in different areas from vantage point and dung count data.
   d) Estimate calf mortality/survival by comparing spring calf: hind ratios with fertility rates after allowing for the cull.
   e) Estimate annual increase.
   f) Complete cohort analysis record for the year and re-calculate minimum population size for previous years.
   g) Compare numbers killed per 100 ha with Figure 16. Are culls being achieved?
10. On the basis of information gathered, set next year's culls.
11. Use the algorithm (Figure 17) to assist in decision-making.
12. Select suitable sites for glades.

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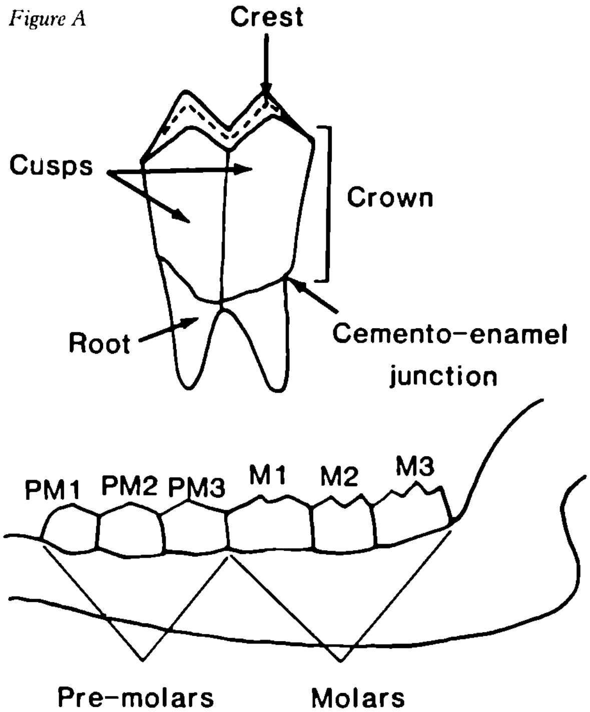
APPENDIX

Age Determination in Red Deer

The following key, represents the stages in tooth eruption and wear found in red deer (*Cervus elaphus*).

Tooth eruption, which continues up to and including the eighth year, should be used as the main criterion and the position of the cemento-enamel junction of the molar teeth in relation to the level of the jaw bone is of prime importance (see Figure A).

Figure A



The method is simple to use and requires no specialised equipment or preparation except that the jaw and cheek teeth must be thoroughly cleaned before examination.

Diagnostic features

Age class	Eruption	Wear
0	All pre-molars are milk teeth and PM3 is tripartite (i.e. it has three cusps, not two as in the permanent PM3). M1 is present and in the process of eruption.	
1	All pre-molars are milk teeth, M1 and M2 are present and in various stages of eruption.	
2	All milk teeth have been lost. M3 is partially erupted and its third cusp is not stained with tartar. The permanent pre-molars are lightly stained with tartar.	
3	Cemento-enamel junction is not visible on M2 and M3. All cusps stained evenly with tartar.	The third cusp of M3 shows no wear.
4	Cemento-enamel junction is not visible on M2 and M3.	Slight wear on the third cusp of M3. Contiguous path of dentine just isolates the pulp cavities on M1.
5	Cemento-enamel junction on M2 is just clear of the jaw bone. Cemento-enamel junction not visible on M3.	Dentine exposed throughout the length of all crests. Pulp cavities now incompletely isolated on M2.
6	Cemento-enamel junction is level with the jaw bone on M3.	Dentine is broader than enamel on all crests. M2 and M3 retain their pointed form.
7	Cemento-enamel junction is now above the level of the jaw bone on all cheek teeth	
8	Cemento-enamel junction is at least 1 mm above the jaw bone on all cheek teeth.	All pulp cavities are now isolated by dentine.

9	Pulp cavities on M1 are absent or non-functional and on M2 and M3 are becoming constricted in the mid region.
10	No crests remain on any cheek teeth above the level of the pulp cavities. Crown height is less than exposed root height on M1. The crown of M1 has worn exposing a patch of cementum.
11	Crown height is equal to or less than exposed root height in all cheek teeth. M1 has worn exposing a patch of cement between the cusps. Pulp cavities are small, shallow and constricted on M2 and are present only on the two anterior cusps of M3.
12	The anterior cusp of M1 is missing and the rot remains connected to the posterior cusp by a bridge of cement. PM3 pulp cavities have disappeared.

Removal of the second or third molar will reveal the cemento-enamel junction if this is not visible above the level of the jaw.

Note: The pre-molars are labelled PM1–3 in accordance with field practice although taxonomic precision in the dental description requires that they be labelled PM2–4, PM1 rarely occurring in deer.

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