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Protecting trees from deer: an overview of current knowledge and future work

There are six deer species in the UK: red, roe, sika, fallow, muntjac and Chinese water deer. Numbers of all, except perhaps Chinese water deer, are increasing and populations are expanding their range.

1. Group of fallow does in birch woodland [Forest Life Picture Library].
2. Red deer on the open hill [Alastair Baxter].
3. Sika stag in a spruce plantation [Norman Healy].
4. Muntjac doe in a grassy ride [Ian Wyllie].

INTRODUCTION

Deer browse young trees, fray saplings with their antlers and strip the bark from older trees (Plates 1, 2 and 3). This article provides an overview of how forest managers can protect young trees from deer. We discuss the reliability and application of different methods and the likely role of each in different woodland management scenarios. Details of many of the techniques can be found in various Forestry Commission publications listed in the References.

INITIAL QUESTIONS

In any situation there are three questions to be answered to determine the best approach to protecting trees from deer.

1. What are the objectives for the woodland?
2. Are deer likely to hinder the achievement of the objectives, either now or in the future?
3. If the answer is yes, which are the most applicable and affordable tools for reducing their impact?

At this stage, if the initial objectives are thought to be unattainable, it may be necessary to reconsider them. We will expand on each of these areas.

To determine whether success has been attained in any endeavour there must be a clear statement of what is to be achieved, and by when. This may be a very precise, quantifiable objective or it may be more imprecise and subjective, for example:

- 1100 oak seedlings per ha (plus or minus 100) at a height greater than 50 cm in three years' time;
- no more than 10% (plus or minus 5%) of restocked Sitka spruce saplings to have their leaders browsed by deer in any one year;
- young trees to be visible to a casual observer when walking through the woodland in two years' time.

The success or failure in achieving the objective has to be measured in some way. This might involve the use of either a formal measurement technique or a simple observational method. The choice will depend on the nature of the objective and on the precision required by the manager. Ferris-Kaan and Patterson (1992) and Pepper (1998) present methods for quantitatively sampling vegetation and planted saplings, respectively, to determine impacts by deer. Further guidance is being developed by Forest Research on methods of measuring, and estimating, deer impacts on a range of woodland features, including ground vegetation (see Plate 4), naturally regenerated seedlings and saplings, planted saplings and older trees.

Plate 1

Browsing damage by roe and red deer [Forest Life Picture Library].

Plate 2

Fraying to Scots pine by roe deer (a) and fallow deer (b).

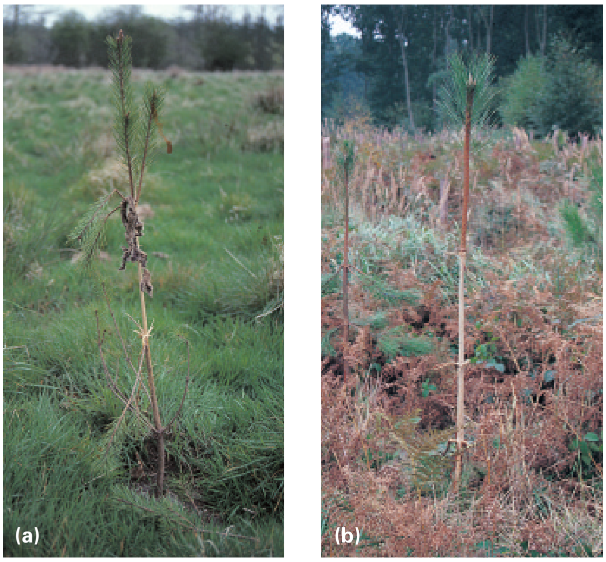


Plate 3

Stripping damage by sika deer in south Scotland to larch (a), examples indicated by arrows, and (b), and Sitka spruce (c).

If the objectives need to be fulfilled immediately then the next step is to use the most appropriate impact assessment method to determine whether there is currently a deer problem. If the objectives are to be obtained in future years, e.g. when regeneration or restocking is planned, then looking for current impacts will be of no use and the manager will need to predict the likelihood of deer becoming a problem. This will require information not only about deer densities and movements but also about the attractiveness of the site, and the trees, to the deer species present (see Plate 5). Managers who have many years' experience of their site and of deer impacts under a range of woodland management conditions and deer densities can often make very good predictions. However, for others, such predictions are difficult because of the large number of factors involved. In this case computer models can be useful in helping to make best use of current knowledge on deer population dynamics, movements and foraging behaviour. Forest Research has recently produced a simple spreadsheet model to help managers to predict the effect of different culling strategies on future deer populations (Armstrong, 2000). In the coming years we plan to improve on this model and to add site-specific predictions of deer movements, foraging behaviour, browsing rates and tree responses (see Predicting the Impacts of Management, page 37).

Plate 4

Bluebells browsed by muntjac deer in Monks Wood [A. Cooke].

Plate 5

Roe deer in restock/prethicket habitat [Forest Life Picture Library].

MANAGEMENT OPTIONS

If there is, or is likely to be, a problem with deer, the following are the four main options for protecting trees:

- reduce deer numbers
- physically protect trees from deer
- reduce the significance of deer damage
- reduce the attractiveness of trees to deer.

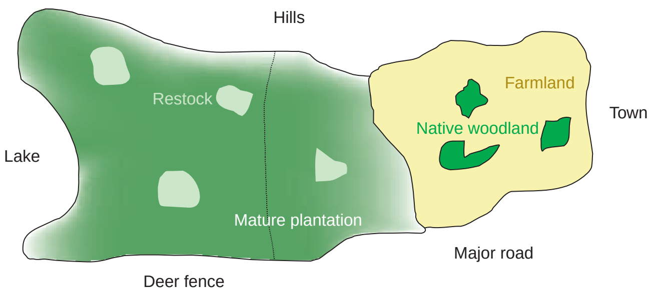
TOOLS TO REDUCE DEER NUMBERS

Culling is the obvious method of reducing the impact of deer on trees but may not always be possible where deer cannot be controlled over the whole deer range. Figure 1 illustrates the factors likely to constrain a deer range. Where the manager does not have control over the whole range it may be possible to join, or start up, a Deer Management Group and to obtain agreement from all members to cull the required number of deer. However, in some cases, different owners have different management objectives or some have inadequate resources to put into deer control. Safety might also rule out culling in areas used heavily by the public. To aid culling and extraction, forests should be designed with adequate glades and rides (Ratcliffe, 1985).

Where culling has the potential to have a significant impact on deer numbers in the problem area, there are various tools available to help with cull setting. The approach recommended by Forest Research for red and roe deer is outlined in Ratcliffe (1987) and Ratcliffe and Mayle (1992) respectively. This involves estimating initial deer population size, age structure and sex ratio as well as natural mortality and recruitment rates. Future populations can then be predicted using a simple model (Armstrong, 2000). The culling rate needed to achieve a particular deer density can then be determined. Where culling is unselective, the age

Figure 1

Schematic representation of a hypothetical deer management unit showing a range of habitats and potential barriers to deer movement.



structure of the deer population can be estimated from the age of culled animals. Field observations can be used to estimate sex ratio and recruitment rate. Ratcliffe (1987) and Ratcliffe and Mayle (1992) suggest appropriate natural mortality rates.

There are various methods of directly or indirectly assessing deer population size (Gill *et al.*, 1997; Mayle *et al.*, 1999). Direct methods include vantage point counts during daylight and distance sampling along transects at night using a thermal imager. The former requires locations within the woodland from where all deer are likely to be visible. The latter gives best results where there is a good network of roads and where there is a large component of open ground and/or the woodland is open. These methods give a value for deer numbers present at the time of counting. Indirect methods give an estimate of the average number of deer using the area sampled over a period of time. The most common indirect method is assessing the density of deer dung accumulated over a period that is either known or is estimated from dung decay trials. These methods are discussed in more detail in Mayle *et al.* (1999).

If the whole of a deer range is sampled then an estimate of the total number of deer in a population can be obtained. However, in many cases the manager is interested in only a small part of the deer range and it is impractical or too expensive to sample the whole deer range. Since deer use different habitats to varying degrees in summer and winter, any estimate of deer density that does not cover the whole range is likely to be affected by season. However, if repeated in one or more years at the same time of year, it can give a good indication of any changes in deer usage. It can also be useful when estimating the degree of immigration to an area. If culls are set at a level that should reduce the population and this does not happen, then the difference between the predicted and the measured population is likely to be due to immigration. Density assessment can therefore be a useful tool in assessing the numbers of immigrating deer.

Deer impacts need to be assessed to determine whether culling has been successful in achieving not only a reduction in deer numbers but also impact levels that are acceptable. Pepper (1998) describes a method of measuring rates of browsing on young trees and Ferris-Kaan and Patterson (1992) describe methods of monitoring the condition of ground vegetation. The method should be tailored to the objectives and the level of precision required. Forest Research is currently working to provide further guidance on a range of methods (see Initial Questions, page 29).

Another potential method of reducing deer numbers is through immuno-contraception. There has been considerable work and some success with a range of species, but especially white-tailed and fallow deer in the USA and Canada (Kirkpatrick and Turner, 1997; Muller *et al.*, 1997; Fraker *et al.*, in press). However, to date, no practical means of using immuno-contraception on wild deer populations has yet been developed in Britain.

TOOLS TO PHYSICALLY PROTECT TREES FROM DEER

Methods for physically protecting trees from deer include tree guards (Pepper *et al.*, 1985; Pepper, 1987; Hodge and Pepper, 1998; Potter, 1991), fences (Pepper, 1992; Pepper *et al.*, 1992; Pepper, 1999) and 'natural' protection. There are many types of tree guard on the market, however the efficacy of the latest designs has not yet been tested. Tree guards are usually too expensive for anything other than amenity planting or small woodlands. Hodge and Pepper (1998) provide a comparison of the cost of using fencing and tree guards for different sizes and shapes of woodland.

Permanent fencing can also be expensive and the fence specification needs to be tailored to the deer species present and the management objective (Pepper, 1992, currently being updated). Alternative, lower cost, fence specifications have been developed for temporary and reusable fencing (Pepper, 1999). To date, electric fences have been found to be of limited use against roe deer (Pepper *et al.*, 2001) but they may be more effective against red deer if there is a reliable electricity supply and the fence can be checked daily. Forest Research plans to investigate their use as short-term protection for coppiced lowland woods.

Fences may have other drawbacks, however; they are a barrier to walkers and the straight edges caused by fences can have significant landscape effects if badly positioned. It is recommended that where fences will result in a visual intrusion, they should be set within the edge of the woodland or trees should not be planted up against the entire length of the fence (Forestry Authority, 1994). Complete removal of large grazing animals by fencing may also cause a decline in woodland biodiversity over a number of years (Gill, 2000). In some parts of Britain, mortality of capercaillie and black grouse through collision with fences can be significant unless a visible fence marking system is used (Petty, 1995). Summers and Dugan (2001) provide advice on a number of such systems and further work is ongoing.

Brushwood 'hedging', made from cut branches, has protected small areas of coppice against roe and fallow for up to 18 months (Mayle, 1999a) but it is ineffective against muntjac as they push through the bottom of the hedge. Brash 'fences', made of piled up brash, have recently been found useful in some circumstances (RTS Ltd, 2002). Both these 'fence' types could provide useful habitats and are unlikely to cause woodland grouse mortality. Brash 'fences' can also be cheaper than ordinary fences if the brash has to be removed anyway. However, their durability is not yet known, they have the same landscape and biodiversity drawbacks of other fence types, they may harbour rabbit populations and are not easy to modify to provide deer-proof access to the fenced area. Covering coppice stumps with brash can reduce browsing rates on re-growing shoots.

In native woodlands, there is some anecdotal evidence that piles of dead branches formed when old trees fall over, or patches of blackthorn, hawthorn, dog rose, juniper, holly, bramble or even bracken can protect young, naturally regenerated trees from deer browsing (Sanderson, 1996; Hamard and Ballon, 1998). In native woodlands where there is insufficient natural regeneration, it might be worth considering the possibility of increasing the amount of these features. However, bramble and holly are also preferred browse species so may be difficult to establish at high deer densities and increased amounts might attract more deer to the site. Bracken can inhibit the seedlings of some tree species, such as oak (Humphrey and Swaine, 1997). There is an increasing body of opinion that in large, unmanaged native woodlands, where deadwood and shrubs have not been removed, 'natural' protection may allow enough trees to regenerate to maintain the woodland (Sanderson, 1996; Vera, 2000). However, this approach has not been tested as a management tool and we know little about the conditions under which it might be feasible.

TOOLS TO REDUCE THE SIGNIFICANCE OF DEER DAMAGE

In some cases, successful natural regeneration might be achieved by increasing the density of young trees rather than by decreasing the rate of browsing. In closed canopy woodland some thinning of adult trees may achieve this. Where there is dense ground vegetation, grazing animals can help break this up and so create additional germination sites. Pigs can do this job, as can cattle at the right densities (Mayle, 1999b). Both species can, however, damage woodland biodiversity if stocked at too high a density. We are currently concluding a survey of cattle grazed woodlands to improve our guidance on appropriate cattle management systems.

For planted trees, increasing the density of planting may increase the chances of the required number remaining undamaged but will increase the expense. However, it is difficult to predict how browsing rates change with the density of young trees and, in some cases, the proportion of trees browsed may increase if the density of trees increases. This approach is more likely to have the desired effect when applied to the less preferred tree species (Table 1) but is an expensive approach to take when there is little certainty of success.

Healthy trees are likely to suffer fewer lasting effects of browsing than less healthy ones. The significance of browsing impacts on planted trees can therefore be reduced by ensuring that the planting stock are healthy and carefully handled.

Table 1

Relative preferences of deer for saplings of different tree species (adapted from Ferris and Carter, 2000). The species are listed in order of preference with the most preferred at the top. Preferences vary with deer species, season, site type and with the amount and quality of other food sources available, therefore this is only an approximate guide. Preferences for coppice shoots may differ from those given here for saplings.

Broadleaf browsing	Conifer browsing	Bark stripping
Aspen	Silver fir	Willows
Willows	Douglas fir	Ash
Oak	Larch	Rowan
Rowan	Norway spruce	Aspen
Norway maple	Scots pine	Lodgepole pine
Sycamore	Sitka spruce	Beech
Beech	Lodgepole pine	Norway spruce
Lime	Corsican pine	Scots pine
Hornbeam		Larch
Birch		Douglas fir
Alder		Sitka spruce
		Silver fir
		Oak
		Alder
		Birch

TOOLS TO REDUCE THE ATTRACTIVENESS OF TREES TO DEER

If trees are being planted, the manager can consider choosing species that are less attractive to deer (Table 1). However, browsing preference is relative and whether a tree is eaten or not depends not only on the number and species of other trees present but also on the quality and quantity of ground vegetation available. Even the most unattractive species will be eaten if there is nothing else to eat.

The only effective and approved chemical repellent is Aaprotect (Pepper *et al.*, 1996). This protects against winter browsing by rabbits as well as deer, but can only be used during the dormant season as it is phytotoxic. Generally, most repellents do not work for long enough to be useful other than to protect an area in the short term while more permanent measures are organised.

All chemical repellents need to be reapplied at least annually to protect new growth. There is a continuing need to test new materials as they become available.

Alternative shelter and diversionary feeding are potential methods of reducing the attractiveness of trees to deer. In theory, if deer are being attracted to a site for either shelter or feed, the provision of a better alternative may divert them. Most woodland deer are not short of shelter hence the provision of alternative shelter is unlikely to be successful. Diversionary feeding, however, has been used successfully in other countries though not in Britain (Gill, 1992). It is more likely to work with deer species, such as red deer, that have a large range and that will move long distances between shelter and regular feeding sites. Roe and muntjac deer, on the other hand, are territorial and generally remain in their own territories regardless of the quality of the forage available there. In the long term, if the population is not being culled appropriately, diversionary feeding will be counterproductive since it will result in a higher deer density. Currently, it is very difficult to predict the effect of such alternative food supplies on deer behaviour since many factors, which vary from site to site, will affect the outcome. Forest Research's planned modelling work will help with these predictions (see Predicting the Impacts of Management, page 37).

CHOOSING THE RIGHT TOOLS

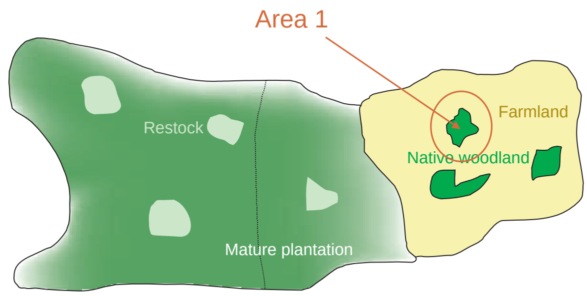
One of the major factors affecting which tools are appropriate or possible is the proportion of the deer range over which they can be appropriately controlled. This determines whether reducing deer numbers is likely to be feasible. The range of a deer population is likely to be bounded by water, mountain ranges, deer fences, railways, major roads (if fenced) or built up areas (Figure 1, page 31). Within that range, deer can move freely. We will discuss three scenarios, each of which will require a different approach.

In **scenario 1** shown in Figure 2, the manager has control over a very small piece of native woodland surrounded by agricultural land. Close by is a large area of mature plantation with a few restock coupes. The aim is to achieve significant natural regeneration of broadleaved species. Firstly, the manager has to decide on the density of different tree species that are needed. Secondly, the adequacy of current levels of regeneration must be assessed and, if they are not high enough, whether deer damage is likely to be the limiting factor. This will be aided by a field visit to record density, height and damage to young trees as well as canopy cover and ground cover. This can be done quantitatively or by visual assessment depending on how accurate the result needs to be.

It might be possible to cull deer but it is likely to have very little effect on the overall population and hence on damage to trees. If it is not possible to work with the neighbouring landowners to control deer then this leaves the options of protecting trees from damage using a fence, tree guards or 'natural' protection. Cost,

Figure 2

Scenario 1: the area to be managed is one of three patches of native woodland surrounded by farmland and near to a large commercial plantation.

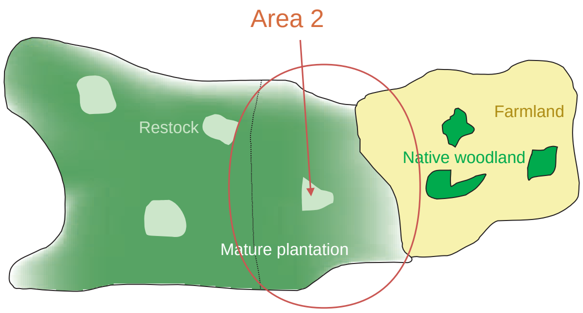


effects on biodiversity and accessibility to other woodland users are likely to determine whether any of these will be suitable. Alternatively, it may be possible to increase the density of young trees through scarification or opening up the canopy and /or accept that only the less attractive species will regenerate successfully.

In **scenario 2** shown in Figure 3, the manager wants to restock a clearfelled area of a conifer plantation. He/she has control over a significant proportion of the deer range but not over the whole area. The chances of getting significant damage depend on the density of deer and on the availability of alternative feed through the year. Culling is an option but if the neighbouring land owners are not also culling at a high rate then replacement of culled deer with deer from the neighbouring areas may be a problem. Assessing the initial deer density in the area, recording numbers, sex and age of culled animals, running a population model (Armstrong, 2000) and reassessing the deer density in later years can help in determining whether significant immigration is occurring or not. This can help to persuade neighbours that there is a problem. A cull of 25–30% is usually needed to reduce deer numbers but, even with this level of cull, it will take several years to achieve a significant reduction. This approach can work where the restock area is not attractive to deer relative to surrounding areas. This is likely to be the case in southern England where winters are relatively mild and where there is always alternative food around. It would also apply to a red deer hind wintering range where immigration of hinds from another range may be very slow. Assessing damage levels will determine whether the approach is working or not. However, it is impossible to be sure that this approach will work until it has been tried and it is expensive to carry out the culling and monitoring required.

Figure 3

Scenario 2: the area to be managed is a recently felled stand within a large plantation forest, which is soon to be planted with young trees.

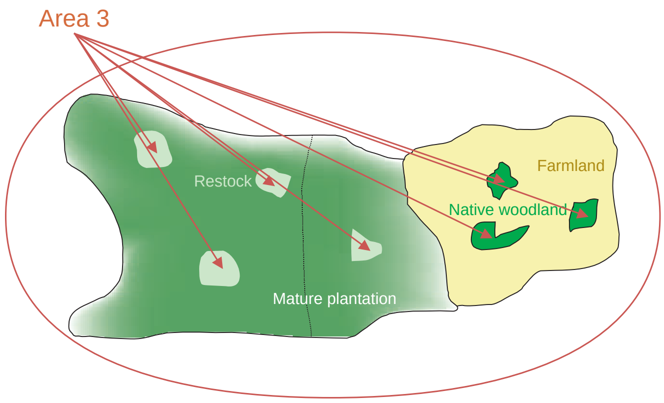


It might be possible to increase the planting density and accept the losses but it is hard to predict what the losses will be and how increasing the density of trees might affect this. Alternatively the manager might be able to plant a less attractive species of tree but that depends on objectives and site type. This is probably the most difficult type of site for which to decide on the best approach and is where a predictive model would be of most use.

In **scenario 3** shown in Figure 4, the manager has control over a whole deer range and has a variety of objectives for different areas, from natural regeneration in native woodland to restocking areas of a conifer plantation. In this case culling deer will normally be the most viable option. The approach to deer management outlined above can be used to set the cull and monitor populations and damage. Once deer numbers are at the appropriate level a 'holding' cull can be implemented. But predicting the density of deer that will allow the woodland objectives to be achieved is not easy since

Figure 4

Scenario 3: the area to be managed includes three small patches of native woodland surrounded by farmland as well as four stands within an adjacent plantation that are to be replanted.



there is not always a direct relationship between deer density and degree of damage (Putman, 1996; Hester *et al.*, 2000). Forest Research currently has a large-scale experiment in progress to improve knowledge of the factors that affect the relationship between deer density and damage. Again, it will normally take several years to get a population of deer that has been unculled, or lightly culled, down to a suitable level unless very high culling rates can be applied. So forward planning is needed. Predictive models will help to set appropriate cull targets and target populations and to predict how long it will take to reach the target population (see Predicting the Impacts of Management, page 37).

Fencing and tree guards may be the best option for particularly sensitive areas, but will normally be too expensive and unsuitable for use in all restock areas at this type of site. It might be possible to also increase the density of naturally regenerated trees in the native woodland by opening up the canopy or by creating regeneration niches. But this can result in too much regeneration of the wrong sort such as a flush of dense birch regeneration where pines are wanted.

PREDICTING THE IMPACTS OF MANAGEMENT

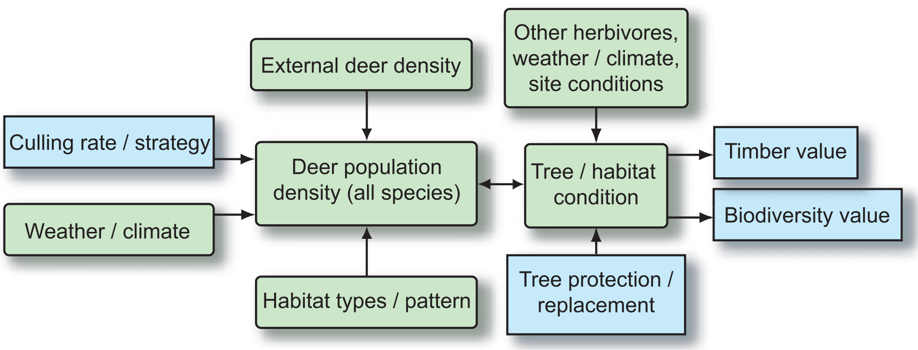
To decide on the most cost-effective approach to protecting trees from deer, woodland managers need to know if the resources required will pay off in terms of the final outputs. Figure 5 illustrates the factors that influence the impact that deer management and tree protection measures will have on final woodland outputs. Every site is different, so, as noted above, it is usually not possible to give general advice. There are also usually too many factors for the manager to be able to predict the outcome without many years of detailed knowledge. Our aim is to remedy this by building a computer model that incorporates all the factors illustrated in Figure 5. Eventually, it will predict not only the economic impact of a given approach but also the impact on biodiversity and nature conservation value. Our intention is to make this new model spatially based so that it can be linked to GIS-based stand and habitat maps and co-ordinated with production forecasting. The model will form the core of a computer-based decision support tool.

In making its site-specific predictions, the decision support system would make use of all existing knowledge, both of the general processes that influence the interactions between deer, trees and vegetation and of their current state at the site in question. Managers would then be able to readily assess the likely consequences of different deer management regimes as well as of changes in woodland management systems such as a change towards continuous cover forestry. Without modelling, optimal management can only be arrived at by years of trial and error at each site.

Current knowledge is far from perfect but it will be more cost-effective to use it to make site-specific predictions than to try out each approach by trial and error at each site over many years. Information coming from operational site monitoring will provide practical tests of the model. The use of the site monitoring methods that we have provided, and will continue to improve upon (see Initial Questions, page 29), will help to ensure that monitoring is carried out to as high a standard as possible, given the objectives, and resources available, at any site. The model will also help to highlight key gaps in our knowledge, which we will then address. As our knowledge increases we will improve and refine the model leading to increased confidence in its predictions. In the meantime, decisions on best practice in protecting trees from deer require detailed site information and a good knowledge of deer numbers and behaviour as well as tree responses.

Figure 5

The elements of a deer management decision support system. Blue boxes represent resource inputs and outputs from the system. Green boxes represent other elements of the system that have to be understood and modelled to predict the effect of changing inputs on outputs.



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