4. Options for management

Where levels of damage by deer are considered unacceptable, management of the problem is traditionally by attempted reduction of population densities in the local area. Additional damage limitation may be attempted through exclusion of deer from sensitive areas by temporary or permanent fencing, by protection of trees with individual tree guards, or by use of certain chemical repellents.

A detailed review of management options in agriculture and forestry as well as in conservation habitats has recently been prepared for MAFF (Putman 1995a). In order to provide context for a narrower look at measures applicable specifically for management in conservation areas, a summary of all options available - and their advantages and disadvantages - will be presented here first, thus offering an overview of the entire range of measures available to managers in whatever context. Following this more general overview, we will focus more explicit attention on those options which may be particularly relevant in conservational contexts and make specific management recommendations for the future.

4.1 Population 'control'

The killing of deer is circumscribed by a number of statutory provisions which impose restrictions on firearms and ammunition, time of day and season in which deer may be taken (most importantly the Deer Act of 1991 and the Wildlife and Countryside Act 1981, and subsequent amendments). Legislation for England and Wales differs from that in place in Northern Ireland or Scotland which leads to some conflict and confusions; in particular statutory 'close' seasons and permitted firearms differ between the countries. The law currently applying to culling of deer in England and Wales is summarised in Appendix 2.

Against such context we should note that populations of most species continue to increase in number and distribution throughout lowland England (Putman 1995). Current management techniques are clearly failing to control numbers or contain damage beyond providing merely temporary alleviation of the problem in very local areas where culling effort is high. A number of contributing factors have been suggested for this failure to achieve more general control; many of these same factors also militate against any long-term effectiveness of culling even in more local context. These may be loosely divided into i) actual logistical problems; ii) problems due to lack of knowledge or lack of proper planning of a management programme and iii) purely biological problems of achieving and sustaining a reduction in population size of animals which respond to any reduction of density by increased recruitment. Finally we should note that data available to date suggest that damage levels sustained may in any case bear only weak relationship to deer population density within an area; thus any management based exclusively on reduction of population densities is unlikely to prove effective on its own.

Logistical problems: Coordination of management effort

Many professional organisations such as the British Deer Society or BASC argue that the failure to exercise adequate control over expanding deer populations stems at least in part from the difficulty of killing sufficient animals under the restrictions imposed by current legislation - and have been pressing for changes to 'close' seasons to extend the legal cull period, as well as changes in the legislation to permit night shooting and permit the use of smaller calibre weapons. These organisations and others also argue that some part of the problem in exercising control over deer populations comes through lack of coordination of management effort over a sufficiently large area. Implications of this are apparent at two distinct levels. At present most culling effort is patchily distributed: undertaken by individual stalkers over a small patch of ground. Only a small area within the UK is subject to any such management at all, so the overall impact of any management effort of this sort on deer numbers at a national, or even regional level is insignificant (Putman 1995a).

Even at the local level, each management block is commonly surrounded by huge areas of land where no management may be undertaken at all, clearly reducing any individual manager's chances of achieving any measurable reduction in numbers. Further, the stalking area covered by any individual may or may not extend to embrace the whole home range of the population it is sought to control.

Deer, particularly the larger and more social species such as fallow, sika and red, are mobile animals which have extensive home ranges. Populations (especially those in agricultural landscapes comprising a mosaic of small woodland blocks interspersed with open arable or pasture land) tend to range over areas far beyond the boundaries of one land-holding and thus the practical 'management area' for that population may embrace a number of adjoining estates. If culling effort and objectives for any given population differ from one part of its range to another (where it is on someone else's land who either has different ideas about what management is required, or undertakes no management at all) then effective control is impossible to achieve. For effective management, culling effort must be coordinated over the entire population range - currently the exception rather than the rule, with most managers forced to attempt to control deer populations solely within the boundaries of their own properties in isolation.

Definition of management objectives

Even where prophylactic management of deer populations is attempted on a continuous basis, management is commonly ill-directed through lack of consistency due in turn to imprecise definition of management objectives. Effective management of any deer population requires clear definition of objectives, some common policy of purpose and a management strategy directed towards satisfaction of those defined objectives. But it should be noted that the final management 'package' adopted will differ markedly in different situations *and will depend very heavily on the objectives of that management.*

On the positive side, high deer numbers enhance the chances of visitors to the countryside to see wild deer. A reasonably high deer density is also desirable from the point of view of those landowners who aim to maximise income from venison revenue. On the other hand, damage to local agricultural, woodland or conservation vegetation may become unacceptable at densities far below those that might be suggested by such considerations. Those responsible for management must therefore define very clearly from the outset the objectives of management; only once those objectives are recognised can effective management policy be determined.

The biological problems of population bounce-back

Besides these essentially logistical difficulties, it is important to note that there are in addition a number of essentially biological reasons why it is difficult to achieve and maintain reductions of density in deer populations and why culling may not always prove particularly effective in achieving long term reduction of damage.

In the first place we should note that efforts at population reduction, even where well-conceived and well-coordinated, are working against the natural response of most mammalian species to respond to a decrease in density with an increase in productivity. The response of any wild animal population to a local reduction in density is to increase recruitment: through increased reproductive rate or juvenile survival within the population itself, or through an increase in immigration of individuals from neighbouring populations. Keeping populations of potential pest species below a level at which they may cause ecological or economic damage thus requires a continued input of effort, indeed may require ever-increasing effort merely to achieve the same effect. Further, if such management efforts are poorly conceived they may exacerbate the original problem: they may result in an actual increase in numbers overall and/or may cause fragmentation of the population and dispersal to areas hitherto free of damage. The advantages of culling are its simplicity, the fact that it is an obvious solution (and, cynical though it may seem, the additional fact that the farmer /forester feels something is being done about the problem). The disadvantages are less obvious - but need careful consideration; we will therefore rehearse them in some detail here.

First, as already noted, any reduction in population number achieved is likely to be short-lived. Total extermination of any vertebrate is both difficult and impractical. More commonly managers are satisfied with a short-term reduction in numbers. But, as noted, this means that any control policy based on population reduction must be sustained and repeated year after year; both financially and in terms of manpower a costly decision.

Quite simply, many populations which have reached a density at which they constitute a problem are already themselves suffering the effects of that density in terms of a decrease in recruitment and survival. Most species of mammals respond in a variety of ways to their own increasing density: mortality increases and reproductive rate declines as the population reaches the capacity of the environment to sustain it. If population levels are lowered artificially, this density-dependent brake on population growth is released: reproduction increases, mortality declines and the population rapidly "bounces back" to its former status (Putman 1989).

Such response to changing density is now extremely well-documented for red deer, roe and fallow and similar responses are reported in sika deer (see Putman *et al* 1996). Thus in response to increasing population density, we may record an increase in the age of first breeding (eg. Mitchell and Brown 1974, Mitchell *et al* 1977), decreased frequency of breeding of mature animals [breeding perhaps in alternate years rather than every year (Mitchell 1973, Clutton Brock *et al* 1983, Mitchell *et al* 1986), decreased litter size in roe (the only native British species with multiple births; eg Hewison 1993). At the same time increasing density is accompanied by an increase in neonatal mortality or in overwinter mortality of juveniles in their first winter (Clutton Brock *et al* 1985, 1987b, Gaillard *et al* 1993), or in extreme an increase in adult mortality (Hanks 1981, Putman *et al* 1996). By converse, in response to a natural or artificially imposed reduction in effective density, i) age of reproductive maturity decreases; ii) the majority of adults breed every year rather than in alternate years; iii) juvenile mortality declines; iv) in polytocous roe, the number of successful foetuses per pregnancy rises and the population rapidly recovers in numbers to its previous abundance.

Even in populations where we cannot prove such density-dependent effects on reproduction and survival, local reduction of the species in one area is rapidly compensated for by immigration from outside.

Ill-considered or indiscriminate culling may compound the problem further (Putman 1989). A cull concentrating on the wrong age- or sex-class of animals may not only fail to achieve any reduction in numbers at all but may distort the social structure of the population resulting in the appearance of abnormal behaviours or an increase in the frequency of aggressive interaction and of associated damage. Distortion of the social structure may also encourage emigration, while the disturbance caused by shooting may in its own right cause fragmentation and dispersal of the population to new areas. Finally, regular shooting over a protracted period may cause a shyness of behaviour that makes future control even more difficult (eg. Challies 1985, Putman 1989).

The complex relationship between damage and deer density

In addition to all this we should note that even successful attempts at reducing deer populations within some defined area may in practice not be rewarded with any equivalent reductions in levels of damage sustained, since all available evidence would suggest that damage levels do not appear to be related in any straight-forward way to simple density, but are affected by a complex interplay of various different factors such as forage quality, habitat structure, climate.

We have already noted (above), that levels of damage suffered by coppiced woodland blocks showed no linear relationship with density (Kay 1992, Putman 1994b). Similar conclusions are reached by Gill (1992), Reimoser (1995), Nahlik (1995) and others for browsing damage more generally and clearly have substantial implications for control. Rather than a progressive increase in levels of damage suffered as population density increases it would appear that once deer numbers exceed a certain minimum threshold damage may be expected - and that further variation in density has very little relationship to actual damage levels sustained.

Thus, at least for most species, damage levels tend to remain low - and relatively constant, until the population density passes a certain breakpoint, when impact suddenly and dramatically increases Gill 1992, Putman 1994b). Yet the truth is we know very little of such thresholds. Threshold densities have been suggested for deer below which damage levels are broadly tolerable, as 4 deer per 100 ha - but such figures are largely untested.

Further it is clear that different thresholds obtain for different types of damage. Within forestry, population densities at which natural regeneration is suppressed are markedly lower than those at which browsing damage to established or planted trees, or bark-stripping damage reach economic significance. Densities of deer which may be tolerated in planted forests are thus substantially higher than those which would be acceptable in ancient woodlands managed for conservation or amenity value, or commercial forests replenished by natural regeneration (as is the case in many continental European forestry systems). Densities at which impact on sensitive ground flora (such as oxlips) becomes unacceptable are probably lower still, but are largely unknown.

More importantly, even at a given density, damage levels caused by deer show very substantial variation depending on a number of environmental and cultural factors. These include (*inter alia*) crop type, distance of sensitive crop from cover, size of planted area, distance of sensitive crop from alternative preferred forages, habitat structure etc. Reimoser (1995) for example suggests that levels of deer damage to forestry or agricultural crops relate not simply to deer density *per se* but to the effective balance between (food-independent) 'attraction factors' for deer (Reimoser cites factors such as extent of woodland edge, amount of thermal cover etc.) and natural food supply. Where habitat structure is very attractive to deer yet the natural food supply is sparse, more damage may be anticipated than where the 'attractiveness' of an area is low in relation to the forage availability.

Such conclusions - in indicating that damage levels are at best only weakly related to actual densities of deer within the woodland suggest that direct population reduction alone, while it may alleviate the problem in the short term, is unlikely to have any marked effect unless deer numbers are reduced very substantially to a minimum presence. Thus (unless populations are reduced to very low levels indeed) management efforts based exclusively or primarily on attempted reduction of deer numbers in an area may not have any significant impact in reducing damage levels.

All this is not intended to suggest that control of a perceived pest problem involving deer by direct population reduction is never appropriate. In many situations it may be the only option available and if carried out carefully and with full understanding of the underlying dynamics of the species concerned it may prove an effective method of control. However, it is far from a simple panacea. Finally we should not discount one additional problem. Shooting of deer, or killing by other means may also in certain areas or circumstances be politically sensitive in itself. Managers of nature reserves for example, seeking to reduce impact on coppice regrowth or ground flora by reducing browsing pressure may face considerable resistance from members of the public (or members of their own society, if the reserve is owned by a local Wildlife Trust or other Conservation body), if they appear to support a regime involving killing animals on the reserve.

Such sensitivity is particularly pronounced in urban areas (in Chapman *et al*'s (1994b) survey of suburban households, 11.6% of respondents positively liked having muntjac visiting their gardens) and constitutes a further problem to control which should not be lightly dismissed.

Perhaps the biggest flaw in all such initiatives however is that they attempt to address perceived problems by direct control of deer population numbers *per* *se* - yet as we have seen, levels of damage suffered may relate only weakly to deer numbers. Despite the current focus of attention, management of the actual impact of deer cannot therefore be addressed solely (or even primarily?) by improving control of deer populations, but must also embrace a variety of other methods: physical, chemical or cultural, to reduce damage caused.

One set of measures which may be taken towards limiting the impact of local deer populations upon agricultural crops, forest crops or in conservation areas is to limit access to vulnerable areas by using chemical or physical barriers, or by attempting to protect individual plants (forest or amenity trees) with individual tree guards or chemical feeding repellents. Some considerable expertise has been developed (particularly within the Forestry Authority) on the efficacy of different types of deterrent, specifications required and relative costs.

4.2 Chemical repellents

Chemical repellents may be applied to reduce deer damage in either of two main ways: as barrier repellents, leaving an 'olfactory fence' which animals will not willingly cross, or as feeding repellents, applied to individual vulnerable plants which by scent or taste, repel or inhibit feeding.

Only one barrier repellent (Renardine) is, I understand currently approved for use under the Pesticides Registration scheme; it appears to be ineffective against deer. The Wildlife and Conservation Branch (Woodland Ecology Branch) of the Forestry Authority has tested the efficacy of over 65 chemicals or proprietary compounds sold for application to individual plants (trees); application of all repellents tested is by painting or spray. Repellent properties were detected for a number of the products (about half; H.W. Pepper *personal communication*) but in most cases the time period over which the repellent effect was maintained was too brief (2 weeks - 3 months) to be effective in long term protection of growing trees. Currently only one approved product (Aaprotect) is recommended by the Forestry Commission for the protection of conifers in winter. A variety of other folk-lore treatments (lion dung, human hair etc) proved to have no repellent properties. No chemical repellents are currently available in this country which appear to have any potential in reducing damage by deer to agriculture, forestry or conservation interests.

4.3 Physical protection

Physical protection to vulnerable areas may be provided by temporary or permanent fencing of vulnerable areas with wire netting or electric fencing. For small sites (less than 12 hectares), complete perimeter fencing may be appropriate. In other cases however costs of such ring-fencing may be prohibitive or inappropriate on aesthetic grounds. Further, whatever their impact within the site, deer are an integral and important part of the wildlife assemblage of any site; total exclusion may perhaps be considered inappropriate on ecological or conservational grounds in that they are themselves part of that natural community. In such case temporary or permanent fencing of particularly vulnerable areas within the site may be preferred.

Unless completely impermeable, the effectiveness of any form of physical (or indeed chemical) barrier, will depend on the attractiveness to deer of the area enclosed; in effect the probability of challenging a barrier will be dependent on the differential between food and cover offered inside and outside the fence line. Where what is protected offers little extra in the way of forage or cover from what is already available in the general environment outside the protected area even relatively weak barriers may prove effective; however, as the attractiveness of the protected area increases over time, so will the probability that deer will breach these more permeable defences. Despite this, cost-considerations may determine that a cheaper form of barrier (less effective in itself, or of shorter life-expectancy) is used if only small areas are to be protected from deer damage only over a relatively short period (eg to protect small areas of short-rotation coppice until regrowth is above browse height or offer temporary protection to small regeneration blocks within established woodland).

Barrier fencing/ Whole-site fencing

Traditional wire mesh fencing, when constructed to the right specifications and well-maintained, provides the most effective protection from deer in all contexts (agricultural, woodland/forestry, conservational) for perhaps ten years. However, no form of fencing can expect to provide permanent exclusion of deer; fencing can only slow down rates of (re-) colonisation.

Specifications required effectively to exclude deer depend on deer species concerned. Based on extensive experience, the Forestry Authority recommends the following minimum fence heights (Pepper 1992):

for	**red deer**	2.0 metres
	fallow and sika deer	1.7 m
	roe and muntjac	1.5 m

Clearly in any area where more than one species of deer may occur, specifications adopted must be those for the largest species encountered.

The recommended deer fence is constructed from two rolls of wire stock netting, one secured above the other. The netting is supported along wires of high tensile spring steel and linked together by spiral lashing rods. Standard pig rings commonly used in stock fencing are unsuitable for deer. Red, sika and fallow deer require a heavy duty fence, while a lighter specification is adequate for roe and muntjac. Mesh size is also an important consideration. 300 mm. square mesh for the upper netting and 150 mm for the lower netting is recommended for red, sika and fallow deer. For roe deer, both top and bottom net should be of 150 mm mesh, while where muntjac are to be excluded a 75 mm hexagonal mesh is recommended for the lower net. Again, at any site, the precise specification to be adopted will depend on the combination of animals to be excluded. In this case mesh size adopted should be that designed to exclude the *smallest* species; thus where red and roe deer occur together the top half of the fence will need to be composed of narrower mesh size than would be required to exclude red deer alone.

In practice, the specification selected will also be determined by cost. Security fencing may be 100% effective. But where there is a low deer pressure and/or some small level of damage is acceptable, a lower fence may prove adequate. For example, Forestry Authority trials have shown that a 1.8 metre fence will be wholly effective in excluding roe; however a 1.5 m fence is adequate and even a 1.2 m fence will still exclude 90% of the deer held by the 1.8 m fence. Finally, minimum specifications must be increased to compensate for effects of severe weather, difficult soil conditions and heavy deer pressure: post spacing needs to be reduced and height/length increased.

Deer creeps and downfalls

One of the major problems with barrier fences is that they are as effective in keeping deer in as at excluding them. Once deer have penetrated the barrier, they may be unable to find their way out and become trapped inside the fences; where obvious breaches in established fences are subsequently repaired, animals may even be closed within the fence line. In the same way, even in the initial erection of fences, when large areas are to be protected there are likely to be animals remaining within the block when fencing is completed, unless they are specifically blanked out. To reduce risk of exacerbated damage within enclosures, it is often appropriate to provide some (uni-directional) means of escape; such escape routes may be provided as deer leaps or creeps (one-way gates) at intervals along the perimeter line.

Where extensive areas are to be fenced an additional problem may be encountered in that fences may run across regularly used tracks or pathways traditionally used (particularly by the larger and more mobile species: red, fallow and sika) for movements around their extended home range, or movements between seasonal ranges of summer and winter where these are spatially separated. Faced with such obstruction the deer will follow the fence line some distance to either side in search of an alternative pathway of lesser resistance. Where no obvious alternative route is immediately apparent however, they will commonly attempt to force the fence. Larger fenced blocks lying across such paths should therefore be broken where possible by downfalls: fenced corridors passing right through from one side of the enclosure to the other to draw the deer safely through the area (see Prior 1994). Where possible such downfalls or 'alleys' should have a lead-in; that is to say that the perimeter fence should funnel towards the entrance to encourage deer to move into and through these corridors; study of the woodland or agricultural block to be fenced will determine the routes most regularly taken by the deer which should be incorporated into the downfalls.

Temporary fencing

Fencing to such specifications is expensive and may be justified only if a whole site is to be permanently protected. In many instances, only temporary protection of small blocks within a site may be required during vulnerable periods of a few months to a few years. Such protection may be undertaken block by block within otherwise unfenced sites and may be achieved at lesser cost. [In general such fencing may be appropriate to provide regeneration blocks within established woodland until trees exceed the growth stage at which damage is significant, or perhaps to protect areas of coppice until regeneration is satisfactory and shoots exceed browse height; it will rarely be appropriate/adequate where concerns about deer damage relate to damage to ground flora].

Wire fencing should meet the specifications recommended above, but costs may be reduced in selecting for example untreated rather than treated timber for posts, as well as in reduced maintenance. Prior (1994) suggests that effective protection of small plots within established woodland may be achieved over a short period by using 2m high Weldmesh or woven wire fencing, slung from the surrounding trees; such fencing is left in place only until the leaders of newly planted trees are above browsing height and may then be removed for re-use elsewhere. Such temporary fencing may survive two or even three moves.

In the same context of small blocks of woodland, coppice areas are commonly offered temporary protection by creation of a brushwood fence around the newly coppiced area, formed from unsaleable coppiced stems. In analyses of Kay (1992) and Putman (1994) such dead hedging was not found significantly to reduce the severity of damage, since in general such fences did not prove adequately deer-proof. Similar experiences are reported by Petley-Jones (1995) although he reports more recent success with a high barrier of woven brashings (effectively a 2m high continuous hurdle) erected by National Trust staff at Eaves Wood in north Lancashire and similar woven hurdle fences have proved extremely effective over the required two-year period in protecting fresh coppice at Bradfield Woods (Suffolk). 'Hurdle hedges' such as these are however extremely expensive of time and effort and generally are economical only when erected by volunteer help.

Electric fencing, particularly the more modern form of high voltage 'ribbon' or tape fence, has also been recommended by some in providing temporary protection to areas vulnerable only for a short period of time. However it is prone to breakdown or to shorting out on ground vegetation and any interruption of supply will allow deer to enter the protected area. Further, such fencing does not reliably exclude deer, even when operating effectively; as noted above, the efficacy of any barrier depends on the relative differential of attractiveness of areas on the two sides of the fence. Within the constraints of animal welfare and safety legislation, current equipment may not produce a sufficient shock to deter absolutely red, fallow, sika or roe deer (Pepper *et al* 1992; R Gill, personal communication). Electric fencing has been of varying effectiveness in excluding muntjac from coppice panels in Monk's Wood NNR, although Petley-Jones (1995) reports success with double-fence lines against roe (Gait Barrows NNR). In this case two rows of electric fencing are erected, one at 60 cm behind the other, both of 0.9 m in height. The outer fence supports two wires, or tapes at 60 and 90 cm; the inner fence supports three strands at 90, 60 cm and with the bottom strand at 10-15 cms from ground level in the winter, raised to 30-40 cms in summer depending on vegetation growth. Costs of such fencing initially stand at around £2 per metre (from Petley-Jones 1995), but fencing materials are mostly reusable and can be transferred to new areas, reducing long-term costs overall.

Alternative fencing specifications

To reduce costs and to allow smaller areas to be cost-effectively protected, a number of alternative fencing specifications have been proposed for both temporary and permanent protection (eg Poore 1995, Robinson 1995). Poore (1995) is currently experimenting with two fencing designs against primarily roe and fallow deer. One, based on HT stock net (@ 1.05 m) with four high tensile line wires above to a height of 1.75 metres, using normal deer fence timber with intermediates at 7m intervals may be erected at a current contractor cost of £3.40 per metre. The second design, specifically conceived of as temporary and suitable for short-term protection of smaller blocks, employs 1.8 m high, 75mm hexagonal mesh chicken wire supported by unpeeled, unpointed double 'scissors' of locally-derived timber, which merely rest on the ground at 1.5 m intervals. Cost is approximately £2.25 per metre.

In the Wyre Forest Robinson (1995) reports considerable success over a number of years in excluding fallow deer from coppice areas. Working from the premise that although deer *can* jump high fences they generally prefer to push beneath the bottom wire, Robinson has experimented with standard stock-netting / pig-netting but erected above ground level and with a single (subsequently double) strand of plain line wire or high tensile barbed wire stretched taut *below* the netting. Current specifications are for light gauge high-tensile stock netting 81 cm in depth, erected at 39 cm above the ground and with two strands of high tensile barbed wire strained below that with three gaps of 13 cms. Total fence height is 1.2 metres. More than fifty of these enclosures have been erected within the Wyre Forest (with costs currently around £2 per metre, contract-erected); there has been only one case of a deer getting into one of these areas. Robinson notes as advantages of this type of fencing i) reduced economic cost; ii) re-usable: being of light gauge wire and less complicated than standard deer fences they can be taken down and the wire at least re-used fairly easily; iii) the fences, of light gauge wire, are not visually intrusive; iv) on estates where game is a concern, the gap at the bottom provides no barrier to game birds and small ground game.

(Note: These fences are designed specifically for use against fallow and would not be effective at the current specifications against roe or muntjac deer.)

While these alternative forms of fencing are still not widely promoted, they must warrant close attention as potential low cost alternatives permitting wider use of fencing in protection of agricultural and economic-woodland blocks as well as conservation lands.

Tree guards and shelters

Although not widely applicable in many conservation contexts, where the protection of new plantings of small numbers of trees is required, for commercial or amenity purposes, individual trees may be protected with guards or shelters. A wide variety of such shelters are now commercially available. Conventional shelters are simply continuous tubes of translucent plastic that surround the tree; as well as offering protection from browsing and barkstripping or fraying damage while the sapling remains within the tube, the shelter further provides a microclimate which itself acts to promote growth of the tree. Tree guards merely offer protection to the tree from browsing, barkstripping or antler damage. They are generally formed from wire or plastic mesh and are designed to encircle the main stem; as lateral shoots can grow through the mesh only the terminal bud will be protected. Both shelters and guards are supported independently of the tree with a firm stake.

Netting guards are suitable for both broadleaves and conifers. Plastic net guards provide suitable protection from roe deer and thicker plastic mesh guards, if well-supported, also provide reasonable protection from larger species. Welded wire mesh guards give the most effective protection. These are expensive but durable, lasting up to 20 years. In parks and amenity areas, individually-made "basket" guards of vertical metal palings may be constructed to provide long-term protection of specimen trees even into maturity.

Tree shelters cannot be so universally applied. Although they have the added benefits of providing a beneficial microclimate for growing trees they cannot be used for all tree species or situations. By virtue of their inherent shape and growth form, such shelters cannot be used to protect conifers. Some species of broadleaves do not favour the microclimate within the shelter and grow but poorly. Shelters are equally inappropriate for establishment of hedging or shelterbelts, where good growth of side-shoots is required, since this is inhibited within the confines of the growth tube (Trout *et al* 1994).

As with fencing, the height and specification of the tree guard or shelter is important. In many cases serious browsing damage is reported in new plantings because inadequate or inappropriate shelters have been provided. (Thus commonly serious damage is experienced by fallow deer in plantings when (cheaper) tubes of a height only suitable to protect trees from roe or muntjac have been installed as a false economy). A number of authors have noted that conifers are particularly vulnerable to (leading shoot) browse damage from for example red deer, when between 30 cm and 80cm in height (or for roe deer when between 0-50 cm) [eg Saint Andrieux *et al.* 1995, for silver fir *Abies alba*; Welch *et al* 1992, Staines 1995 for sitka spruce *Picea sitchensis*.]

However, browsing damage is merely reduced above these heights rather than eliminated and broadleaved species have a longer period of susceptibility. For protection from deer of different species, the Forestry Authority therefore recommends the following minimum heights for guards/shelters

for	**red deer**	1.8 metres	
	fallow and sika deer	1.6 m	
	roe and muntjac	1.2 m	(Pepper, Rowe & Tee 1985)

Costs of individual tree protection are (variable but) high. As well as fixed costs of installation and maintenance, prices vary due to height, diameter and robustness of shelter/guard used. At 1995, costs may be expected to be between £1.50 and £2.50 per tree. For fallow deer, effective guards can cost closer to £5.00 each; fallow bucks have a particular propensity for destroying and removing guards and shelters by rubbing their antlers against them, or lifting them from below with the antlers. Such behaviour may not only destroy the guard itself, but frequently causes abrasive damage to the bark of the tree within, analogous to that caused by direct antler fraying. Guards in fallow areas thus need to be extremely robust, of wide diameter and firmly secured by substantial full length stakes.