4.4 The potential of behavioural manipulations

Physical protection of the vulnerable area or crop is costly; hitherto no chemical repellents have been found which are wholly effective. Over the years a number of attempts have been made to explore various alternative management measures: methods of reducing the impact even of a constant density of deer, by changing in some way patterns of habitat use, altering foraging behaviour, so that the animals cause less damage in vulnerable areas. Such measures aim to reduce damage caused rather than reduce deer population density. Thus i) damage to agricultural crops for example or browsing damage or bark-stripping damage in woodland may be prevented or reduced, by supplying whatever commodity the deer obtains from such behaviour in an alternative form - either as an artificial supplement, or by planting/encouraging the development of suitable alternative natural forages; (food supplementation); ii) Economic crops may be protected from damage by intercropping them with more palatable forages as 'sacrificial lambs'. In an extension of this idea, animals may actually be drawn away from sensitive areas into other geographical locations by providing alternative, preferred, forages or 'sweetmeats' in these alternative sites [diversionary feeding]. Finally: iii) changes in cultural methods (eg alterations to coupe size in coppice, changes in weed control methods in woodlands) may also help to reduce damage sustained.

Not all such measures are applicable within a conservational context; many however may be adapted and may contribute significantly to reducing damage level suffered.

We may note for example that both Kay (1992) and Putman (1994) found that severity damage by deer [of any species] to coppice regrowth was influenced by size of coupe - or more particularly by overall perimeter length and length of perimeter adjacent to close cover [see also Thirgood and Staines 1989]. Such relationship has obvious implications in suggesting how simple changes in silvicultural management might contribute to reducing levels of damage experienced in such areas.

Damage sustained by any woodland block will be a function both of the amount of usage that coupe sustains (in terms of 'deer-hours' spent within it) and the proportion of that time which is spent actually feeding on vulnerable crops (young trees, coppice or ground flora). Both the attractiveness of an area for deer to be in the first place, and the probability that when there they may feed upon vulnerable species may be manipulated by appropriate changes in management.

Reimoser (1995) notes more formally that the amount of damage sustained within woodlands (in Austria) is related to the expressed balance between various, food- independent "attraction factors" making a given area of woodland attractive to deer (he cites as examples: the amount of edge, the amount of thermal cover provided in a given woodland block) and the available forage supply. Where cover, for example is high, deer may be expected to make high usage of an area and remain there for long periods; if at the same time availability of alternative forage is low, the woodland will itself sustain high levels of damage.

In the UK, higher average damage levels from roe deer were recorded by Kay in coppice sites with relatively shorter perimeter length and with a higher proportion of the perimeter length adjacent to thick cover; no such relationship was observed by Putman (1994) over a wider range of sites, but the actual proportion of stools browsed by roe and muntjac was significantly higher in sites with high perimeter cover. Neither study was able to show a direct relationship between levels of damage sustained and coupe area or shape. This may be a function of the limited range of areas considered in our analysis (0.03 to 1.74 ha) - itself a consequence of the general tendency to cut small blocks. Indeed the fact that damage levels declined with proportion of the perimeter adjoining closed cover suggests that larger blocks (within which an imaginary 1 ha site has an entirely open perimeter) would indeed sustain lower levels of damage overall - and strongly supports a policy of 'rolling coppice' where adjacent blocks are cut in successive years, effectively increasing each time the total open area.

Changes in coupe size may affect the amount of usage any given woodland block may sustain; availability of alternative forages may well affect the damage caused to vulnerable plant species during that use. While it is more usual practice when cutting fresh coppice, or establishing new plantations to clear the ground around the coppice stools or plant new saplings into clean ground, such cultural practices specifically remove any alternative available forage within the area, exposing the coppice regrowth or newly planted 'whips' as the only forage available. Where bramble and rose, hawthorn, blackthorn or other palatable species are left, the deer are offered alternative (generally preferred) forages within the area and will tend to leave alone the less preferred timber species. Petley-Jones (1995) has also recommended leaving (uncut) "browsing strips" between areas of conservation coppice where deer may feed unhindered. These zones need not be broad; a strip of between 3-5 metres between woodland edge and (fenced) coppice has been found to be effective in reducing pressure on coppiced areas.

In a similar way, changes to other management practices within woodlands may themselves contribute to a reduction in deer damage by drawing deer away from vulnerable areas. Thus programmes of ride widening to encourage establishment of tall herbs and provide nectaring sites for insects, incidentally also provide good foraging areas for deer which may thus be less prone to cause damage to woodland coppice or regeneration.

Diversionary feeding:

Perhaps in relatively few contexts would it be appropriate to extend such ideas yet further to the point of actually managing specific areas of a reserve for the deer to draw them away from other more sensitive areas - by sowing palatable crops, applying fertilisers or whatever to promote growth of attractive forage. In most cases such management would be directly contrary to other management objectives for the site in enhancing natural diversity. In consequence such approach has rarely been exploited in a conservational context. Yet, such diversionary feeding may prove in other contexts very effective.

Putman (1986) noted that use of agricultural crops by roe deer in the south of England corresponded very closely to a time when they were the only vegetational communities showing new growth and thus offering maximum concentration of digestible nutrients to this obligate concentrate selector. As soon as the grasses of woodland glades or rides began to flush, or buds burst on woody browse species, the deer switched their attention to these preferred foodstuffs and left the crops. In a number of pilot trials on private estates in Hampshire, existing woodland clearings were enlarged, reseeded with early maturing varieties of ryegrass and fertilised - to provide an early flush of growth within the preferred woodland cover; use of arable fields by roe declined significantly after such treatment. B.Mayle (*pers comm.*) also reports areas where mowing woodland rides in midsummer to promote regrowth has been successful in reducing damage by fallow deer to growing and maturing cereal crops in adjacent farmland.

The success of such diversionary feeding in reducing damage to agricultural and woodland crops suggests that it may indeed have some potential in a conservational context too - as long as such manipulation can be achieved in such a way that it will not compromise the management of conservational vegetation directly. In those sites however, where land ownership extends beyond the nature reserve to include in addition agricultural lands either in direct management by EN or leased under tenancy agreements, some potential may exist for such an approach.

Fertilisation of abandoned agricultural fields to enhance their productivity has proved highly effective in one Scottish site in reducing the pressure of red deer browsing on adjacent areas of native woodland and neighbouring moorland (where natural regeneration had previously been being suppressed; Graham 1995).

Problems with such cultural manipulations

Despite the cogency of both the principle - and these examples- of limitation of damage by cultural or behavioural manipulations of this kind, such methods are not without their own problems, comparable to those outlined earlier for measures based on direct population control.

Cultural methods designed to increase the availability of alternative forages to attract foraging away from some vulnerable crop, by effectively increasing the carrying capacity of the local area for the deer, may actually result in the longer term in an increase in numbers overall, quickly exceeding the newly raised carrying capacity and thus turning attention once again on the protected crop [Gill 1992]. At higher population densities, renewed damage may even be at higher levels.

4.5 Summary

Traditionally, the approach to control of any pest problem, worldwide, has been attempted reduction of the population of the species considered to be causing the damage. In many situations this may be the appropriate response, but it has become increasingly clear over the years that there are many problems with such an approach: both in achieving the desired level of population reduction in the first place and in the fact that damage levels are in themselves not necessarily directly related to population density in any simple way. Physical protection of the vulnerable area or crop is costly; hitherto no chemical repellents have been found which are wholly effective.

Alternative approaches seeking explicitly to limit damage itself, through habitat manipulation, diversionary feeding or other behavioural manipulations are themselves no simple cure-all. Cultural methods designed to increase the availability of alternative forages to attract foraging away from the target crop may make care and harvest of the commodity crop more difficult or costly; in addition, by effectively increasing the carrying capacity of the local area for the pest species, their numbers may well increase in response, quickly exceeding the newly raised carrying capacity and thus turning attention once again on the protected crop [Gill 1992].

In practice no single approach is likely to be effective and in most situations managers should move towards adoption of some system of integrated management involving both direct control of the pest population itself and also control of its pest status [Putman 1989]. And perhaps this is the most important point to emphasise in any review of management options: that no single measure is likely to prove effective in containing deer populations or reducing damage caused. Such a conclusion is based not only on somewhat 'intellectual' considerations of the various arguments raised here but is reaffirmed very clearly by my own extensive practical experience and observation. It is apparent that any effective management policy at local or national level must present a carefully-coordinated and integrated system of measures embracing population reduction, physical or chemical protection of vulnerable crops and imaginative cultural changes aimed at 'diversion' of grazing or browsing pressure.

Even if changes are made to extend current permitted seasons; even if control effort were better coordinated over larger local or regional areas (through the establishment of some national coordinating body, as has been promoted in some quarters), control of damage through attempted reduction of deer numbers alone suffers a number of serious disadvantages. By the same token, reliance on physical or chemical protection of crops - even where that option is available or economically reasonable, will rarely be effective on its own. As noted above no effective barrier repellents are available on the UK market and the only reasonably effective chemical anti-feedant available for direct application to vulnerable trees is expensive in repeated application required.

Physical barrier protection with fences is expensive - in initial cost of erection and in maintenance required to ensure integrity; permanent barrier fencing may in addition not be appropriate in many contexts due to visual intrusiveness and due to its effects in restricting natural movement and migration patterns of the deer themselves and other wildlife. In addition, economic considerations not-withstanding, no fence can be considered totally impermeable to deer. Even at 2.7 m a barrier fence erected along sections of Interstate 84 in Pennsylvania, USA, while it reduced the number of white-tailed deer observed actually on the right of way by comparison to an alternative 2.2 m fence erected on other sections, *was not effective in stopping all deer, nor was it effective in reducing the number of road-kills* (Feldhamer *et al* 1986). Particularly in relation to cheaper alternative forms of wire-fencing discussed above, chestnut paling barricades or electric fencing, ***any fence is only as good at the differential in attractiveness to deer of what is inside and what outside*** *the fenceline.* Results reported by many managers or deer-consultants are inconsistent in the conclusions reached. Many (eg Prior 1994, Putman 1995) have observed for example electric fencing to be totally ineffective in keeping fallow, roe or muntjac out of fresh coppice; others however (eg. Petley-Jones 1995) report excellent results in use of electric fences of identical specifications. Brushwood dead-hedges or chestnut paling fences are also effective in some circumstances and not in others.

These inconsistencies are however in themselves consistent. Closer examination reveals that in those situations where these barriers prove ineffective, no other form of deer management is being practised other than site protection; where fences and barricades have proved effective is universally in areas where deer numbers are also being maintained at low levels by regular culling and/or some form of 'habitat farming' is carried out to ensure alternative forages are readily available to the deer. None of these barriers are intrinsically impermeable; their effectiveness is in practice determined by the pressure they receive: itself a consequence at least in part of population density and the availability of alternative feeding areas.

Finally, cultural manipulations designed to provide deer with alternative palatable forages on, or off site, as a diversionary tactic to protect vulnerable crops will rarely be effective unsupported. Such measures are in any case not necessarily practicable or appropriate in all contexts (fertilisation of feeding lawns in the middle of a conservation woodland for example poses peculiar problems of a conflict of ethic or objective).

Further by effectively increasing the carrying capacity of the local area for the pest species, their numbers may well increase in response, quickly exceeding the newly raised carrying capacity and thus turning attention once again on the protected crop [Gill 1992]. At higher population densities, renewed damage may even be at higher levels. Thus while a useful complement to other measures, cultural manipulations should always be considered alongside physical protection or population regulation.

In response to all such theoretical arguments and practical observation, it would appear that the most effective management for the future will embrace elements of all available approaches in various combination depending on the context and constraints of each situation in turn.

5. A Review of current management practice on NNRS

5.1 The questionnaire response:

Analysis of responses to the questionnaires distributed to site-managers of all NNRs in England revealed, as noted above (Section 3) that damage from deer sufficient to conflict with management objectives of that site was reported only by 45% of site-managers recording deer visiting or resident within the reserve; only 20% of reserve managers however considered that damage sustained was sufficient to cause difficulty in meeting management objectives for the site; *all of these considered that current management measures (culling, fencing of vulnerable areas) was adequate at present to reduce damage to tolerable levels.*

As has already been noted, managers of 'open sites' (grasslands, meadows, heathland or fenland sites) generally regarded the presence of deer as neutral or positively advantageous in suppressing encroachment by scrub. Those sites which reported problems with deer were without exception woodland reserves; while as noted in Section 3 problems were reported in a small number of cases in relation to impact on sensitive ground flora, the majority concerned suppression of natural regeneration or browsing damage to coppice regrowth on those sites where coppice management has been reintroduced.

Culling was undertaken routinely on 35 of the reserves responding to the questionnaire (31%). 25 of the 50 reserves reporting significant damage undertook a cull as part of all of the management response; culling was also carried out on 10 of the remaining 62 reserves. (Only in 5/35 cases was culling undertaken directly by the site manager; in the majority of instances (30/35) culling was by outside stalkers appointed by the landowner or under licence from EN. In addition, even where no culling was carried out on a reserve, a number of site managers did note that they felt they benefitted from culling by others (or poaching!) taking place on adjacent properties. Only in 10 cases (28.6% of those killing deer) were sites part of a larger deer management area, with culling policy coordinated over a larger regional area through consultation within a local deer management group of neighbouring properties. From my own site visits it was apparent that those sites which were able to collaborate in this way with a local Deer Management Group, did indeed reap considerable benefits from seeing deer management coordinated over a larger surrounding area. However, it is not for EN perhaps to initiate the formation of such groups - and it was equally apparent that in many cases reserves were not involved in wider deer management initiatives rather because of lack of opportunity than from lack of will.

The majority of reserves which suffered damage responded with some level of fencing - whether or not this was accompanied by attempts also at reduction of deer numbers. Of 50 sites reporting deer damage 7 (14 %) resorted to fencing alone; 7 (14%) to culling alone. 4 site managers protected coppice by piling brash over recently cut stumps. 18 (36 %) adopted a mixed strategy of culling and site protection (fencing and/or brash-piling) while 14 (28% of those currently sustaining some degree of browsing damage) currently undertake no preventative management at all; these sites are however largely those who considered that present damage levels did not conflict with management aims for the site.

No sites opted for permanent whole-site fencing - although there is no doubt that on smaller sites (< 10-12 hectares) this ring-fencing would be the most economic option. Even within sites, where coppiced areas were concentrated in a single block of adjacent panels cut in rotation (and thus there was a clear 'internal' unit requiring protection), perimeter fencing of the entire unit was unusual, despite the fact that this again would have been both the most effective and economical solution. Instead, by and large, managers protected individual areas (of coppice or regeneration) within the site individually, as and when. In consequence of such approach, most fencing was temporary only, of wire (19/50 sites: 38%) or chestnut paling. Managers of 2 sites: Monk's Wood and Gait Barrows used electric fencing, although only in one site (Gait Barrows NNR) was this found wholly effective.

Few sites had experimented with any other form of damage alleviation (through for example changes in cultural practices: rolling coppice to increase coppice area at any time, diversionary feeding etc), although many respondents noted the value of leaving uncut areas to provide alternative foraging opportunities and many noted the value of ride-widening schemes in reducing pressure on coppice or regeneration.

Costs of management were hard to assess, because respondents in many cases did not include costs of labour (their own or volunteer labour) and equally charged usually only for costs of bought-in materials as against those available on site. Costs of culling were insignificant in that direct costs were offset by sale of venison; where outside stalkers were involved, local agreements usually provided for them to retain the venison in return for their time, or some form of profit-sharing agreed. Average costs of deer management reported therefore (@ £544 per annum) are probably not particularly meaningful, except insofar as it shows on a site budget.

5.2 Observations from individual site visits

Responses above to the questionnaire survey of all sites may be fleshed out further from impressions gained on direct site visits to 16 NNRs. Site visits were made, and discussions about deer, their impact and their management, to:

Bradfield Woods (Suffolk)
Castor Hanglands
Chaddesley Wood
Collyweston Great Wood and Easton Hornocks
Cotswolds Commons and Beechwoods (Buckholt Wood; Workman's Wood)
Downton Gorge NNR
Dunkery and Horner Wood (Exmoor)
Gait Barrows NNR
Hales Wood and Shadwell Wood
Highbury Wood
Monk's Wood
Park Wood (Cumbria)
Woodwalton Fen (opportunistic visit to a fen site)
Wyre Forest
Yarner Wood

This particular range of sites was selected on a number of criteria: they offer representation over a wide geographic spread within England and also offer example of sites 'troubled' with all different species of deer (red, roe, fallow, muntjac, Chinese Water deer). All are woodland sites, but problems experienced range from damage to ground flora (Hales Wood, Monk's Wood, Bradfield Wood) to problems of regeneration (Downton Gorge, Wyre Forest, Cotswolds Beechwoods) and problems of coppice damage (many sites). More significantly, the site managers of many of these particular sites have been experimenting with very different forms of management techniques -some of them really very novel - and thus they offer in themselves a most interesting overview of the range of management approaches adopted in different NNRs.

Management varied from complete non-intervention (eg Yarner Wood, Easton Hornocks) to reliance entirely on culling (Cotswold Beechwoods, Horner Wood) or entirely on site protection (Hales Wood, Monk's Wood, Downton Gorge). In the majority of sites however some form of temporary fencing (wire, electric fencing or chestnut paling) was used in conjunction with some level of culling. Experience gained in use of these different methods and combinations illustrates very neatly the advantages and disadvantages of the different management options - and more importantly the circumstances in which each may be expected to be effective.

At **Gait Barrows NNR** in Lancashire, protection of regenerating coppice from roe deer is achieved by a combination of protection of individual coppice blocks with electric fencing (Petley-Jones 1995) and reduction of the resident population of roe through culling. It is notable that even in the absence of fencing, cut hazel coppice does eventually get away, due to the lowered deer density within the reserve; but such unprotected coppice is checked, on this unproductive site, for up to three or four years before establishing successfully: resulting in too long a period of open ground in the coppice rotation for the main objective of coppice management in this site in providing suitable conditions for High Brown fritillaries. Protection of cut-over sites with double and single lines of electric fencing seems sufficient to reduce browsing damage by the remaining roe to acceptable levels so that the coppice rotation is not disturbed.

We may note that culling is effective in reducing deer densities to levels where coppice would eventually get away, albeit later than required for the specific management objectives of this site. The cull applied is not especially heavy at *c*.10 animals per year. However roe deer unlike other British deer species are relatively unsocial, for much of the year territorial, and in any case strongly hefted to relatively small home ranges. This species of all species is one where local reduction of population density can be achieved relatively effectively even by culling within the site alone. And in, practice, Gait Barrows is fortunate in that it is in addition a site in the middle of a larger area of active deer management, coordinated by an effective local Deer Management Group.

Gait Barrows in addition illustrates another general point. For in protection of coppice regrowth on this site, electric fencing has been used most successfully. Yet in general electric fencing has not proved effective (compare for example Monk's Wood in this particular set of sites, where electric fencing has been completely unsuccessful in excluding muntjac from coppiced areas); indeed I Have to acknowledge that Gait Barrows is the first site in my own personal experience where I have ever seen it work! It is apparent that the electric fencing here is effective because it is not used in isolation. I have noted earlier that the effectiveness of any fenceline is in large part dependent on the differential between the value of what is on offer to the deer inside and outside the fence. At Gait Barrows the effect of the fence is combined with a) active reduction of deer density within the site, b) deliberate provision of alternative foraging opportunities by leaving perimeter areas uncut and unfenced (Petley-Jones 1995) so that actual pressure on the fences is in any case substantially reduced.

By contrast, as noted, at **Monk's Wood** electric fencing has not proved entirely effective in excluding muntjac from regenerating coppice. Indeed a number of areas have been so severely browsed in the years following coppicing that the majority of stools are actually dead and the area cannot recover unless new trees are established. But here, protection was the only deterrent. No culling is undertaken on the site and muntjac have reached unusually high densities, causing significant changes in the ground flora as well as serious damage to fresh coppice (Cooke 1994); Monk's Wood indeed offers classic illustration of the difficulty of achieving 'control' of damage through protection alone. Management on this site however illustrates quite another point too. In this site, although one or two small panels are coppiced in patches throughout the woodland, the main coppice area is in fact contained as a block of contiguous panels cut strictly in rotation. All panels are adjacent and contiguous, yet each is protected by fencing independently when cut. Here surely is a clear case for perimeter fencing not of the entire wood, but at least of this internal coppice block.

Perimeter fencing, albeit just within the woodland edge for visual screening should also be considered the most economic option for **Hales Wood** in Essex, another site (in this case necessarily) managed by protection only. This small site (*c*.8ha) is almost entirely under coppice with a full rotation established in contiguous panels throughout the wood. With coppicing undertaken in large part to encourage oxlip populations, muntjac and fallow deer are causing serious damage not only to coppice regrowth, but also by grazing the oxlip plants directly. Problems here are acute, because of the difficulty in controlling deer numbers in such a small site where few of the deer are actually resident on site and no deer management is carried out on surrounding lands. Although individual coppice panels are protected when cut by brushwood hedges; these are however by no means entirely effective. They are also expensive of manpower if not materials and need continuous replacement. This is a site where perimeter fencing would indubitably be the most cost-effective measure in the longer term.

The **Cotswolds Beechwoods** provide interesting illustration of another approach. **Workman's Wood** was established and managed under forestry principles pioneered by Workman and dependent on natural regeneration. Vigorous natural regeneration is encouraged within the (beech/ash) woodland. Overstorey trees are singled to allow understorey saplings to establish; these are then thinned to provide the next canopy trees. Such a system of replenishment even for commercial forestry however relies on vigorous regeneration; the fact that it continues to work in this site suggests good levels of regeneration despite a resident population of fallow deer. The site is completely unfenced and unprotected; management is restricted to an annual cull to maintain deer populations art between 8-10 in this 120 hectare site. In my own exploration of the site, some browsing damage was apparent, but evidently not at sufficient intensity to suppress adequate regeneration. By direct contrast, in the nearby **Buckholt Wood,** no deer control is carried out. Extensive regeneration is apparent (but notably almost all sycamore and ash, with little beech < 5 years). Certain areas of Buckholt Wood have also been coppiced and here again damage is apparent in unprotected sites. Hazel, elm and ash are regrowing well in this highly productive site, but beech coppice is heavily browsed except where individual stools have been protected.

This offers classic illustration of points raised earlier in Section 2.4: that while in some sites protection from deer browsing may not appear necessary to the casual eye to allow satisfactory regeneration or coppice growth, regeneration in such unprotected sites may in fact suffer some deflection of species composition.

As noted earlier, few nature reserves are ring-fenced or utilise high-specification barrier fencing. In many sites however some form of temporary wire fencing is used to protect coppice regrowth or to set aside areas to permit natural regeneration within established woodlands. A number of different types of fencing have been used by different managers in the interests of reducing costs.

At **Highbury Wood**, coppiced areas are ring-fenced with full height deer netting, but costs are kept down by using standing live trees along the fenceline as living corner posts/straining posts; intervening posts are untreated poles cut from elsewhere within the woodland. Although these rot relatively quickly, integrity of the fence is only required for a short period until coppice regrowth is above browsing height. Such fences are clearly relatively inexpensive in using local materials - and inexpensive in manpower in saving on labour of posts and strainers. In theory too, fence wire may be removed and used again elsewhere. Malcolm Whitmore as site manager estimated costs of this style of fencing in 1993 at £280 per acre for initial erection of the fence (costs including a component for labour); costs for dismantling and re-erection of the fence in a new site (labour only) were estimated at (4 man days @ £30) £120. (English Nature Three Counties Team, 1993).

In practice I have some doubts as to the re-usability of this form of fencing. After some years growth of the field and shrub layers around the base of the wire will make extraction difficult; further, costs of dismantling (in terms of manpower) may actually exceed the costs of purchase of new wire. It is possible that such fencing might be temporary in protective usage only.... but rather less temporary in its continued presence because it is difficult to remove. The site may thus accumulate tangles of collapsed netting around older coppice blocks a rather undesirable endpoint of attempted cost-cutting.

For temporary protection of smaller areas, prefabricated chestnut paling of appropriate height may prove more effective. Although bulky and heavy to handle it has been successfully used at **Castor Hanglands** and **Shadwell Wood** amongst others for protecting new coppice. David Massen, site manager for **Monk's Wood** has recently been experimenting with the use of temporary fencing composed of prefabricated sectional panels of security fencing (rather like football stadium security screens). Although indubitably expensive, these are durable, lightweight and eminently portable and appear to be effective in excluding deer. Use of such panels should certainly be explored further and tests done on other sites.

One further method commonly used to protect coppice areas from deer damage is dead-hedging: using the waste materials provided after coppicing to lay a tangled rampart of dead brash around the perimeter of the site, or weave these materials into a continuous hurdle fence. Such dead-hedging or woven fences are widely used to protect coppice sites (eg. Hales Wood, above) and we should note that at **Bradfield Wood** in Suffolk, this type of fencing has proved extremely satisfactory. Although it is often argued that sufficient materials for a fence are usually readily available only from the first reclamation cut of neglected coppice and there is little waste wood remaining from subsequent cuts thereafter, in this site experience has shown that enough material remains for a fence even within well-established coppice; sufficient material may still be gleaned from offcuts and tops to weave an effective fence. However, weaving of effective hedges is extremely labour-intensive and thus costly unless experienced volunteer labour is available (as is the case at Bradfield, as a County Trust site) and such fencing is really only effective if it is extremely well-made. In addition even well made hedges have a very limited lifespan (of two, at most three years) before collapse. Such hedges are therefore only in reality a practical option for fast-growing coppice sites and where a great deal of volunteer time and labour is accessible.

Protection of areas set aside to encourage germination and natural regeneration in established woodlands may be approached by any of the above methods. In addition however a rather surprising new form of low-cost fencing has been pioneered by John Robinson, site manager at **Wyre Forest**. Working from the premise that although deer *can* jump high fences they generally prefer to push beneath the bottom wire, Robinson has experimented with excluding fallow deer from small regeneration plots with standard stock-netting /pig-netting 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.

It is commonly claimed that deer will not jump into small exclosures - where they can see the wire on the other side, as avoiding some form of trap; it might be thought that Robinson's enclosures work only by extension of this same principle. Certainly the first enclosures were relatively small, but more recently the same type of fencing has been found to be perfectly effective in excluding fallow from areas as large as 2 hectares in size. (Note however: These fences are designed specifically for use against fallow and would not be effective at the current specifications against roe or muntjac deer.)

There is no doubt at all that Robinson's fences work and provide an excellent inexpensive way of offering temporary protection from fallow to small sites for coppice regrowth of to permit natural regeneration. Robinson himself notes as advantages of this type of fencing (1995) 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.

One final important general point arises from a site visit to **Dunkery and Horner Wood** in Exmoor. Only recently declared an NNR, Horner suffers heavy grazing pressure from both sheep and red deer and regeneration within this ancient oak woodland is virtually non-existent. Experimental enclosures have been erected within the wood in a study of the precise effects of grazing by sheep and deer, and to monitor future changes in vegetational structure as grazing pressure and the relative balance of sheep and deer change over the next few years under the terms of a new ESA agreement (Langbein, study *in progress*); within these enclosures there is vigorous regeneration of rowan, holly and oak is vigorous.

Horner is typical of many other woodlands in the area where heavy grazing pressure has suppressed all regeneration, but already, grazing pressure varies across Exmoor and in sites of lower animal density (eg Watersmeet) good regeneration is apparent even in the absence of any additional site protection (Martin 1994). Despite the lack of regeneration, the policy at Horner continues to be non-intervention.

Nigel Hester as site manager echoes comments already made earlier in this report, that managers often over-react and transfer to conservational management the same worries that concern economic forestry. Management of an oak woodland is long-term, with a timespan measured in hundreds of years; conservation management of woodland only requires that the woodland persists with appropriate structure and diversity. Hester notes from this viewpoint that it therefore doesn't matter in a conservational context if you do not get much regeneration in any year, or indeed if you do not get any for a number of years. As long as a few seedlings establish now and then, or in periods of lowered grazing pressure an entire cohort gets away to stand as subcanopy until light conditions permit further development, recruitment to the mature canopy is assured. Hester's comments and policies nicely reinforce comments made earlier in this report in analysis of the persistence of ancient woodland even in the extraordinarily heavily grazed New Forest (Peterken and Tubbs 1965)

6. Recommendations for the future

Based on the general review of management options and their efficacy presented above in Section 4, as well as additional impressions gained while undertaking site visits specifically to NNRs (Section 5) I present below a synthesis of management options available and appropriate for adoption within National Nature reserves to minimise damaging impact of deer.

It is perhaps useful however first to preface these recommendations with a number of general points of policy, before addressing details:

6.1 General principles

i. One of the first points to be emphasised here must be to reiterate that deer are not universally a 'pest' within conservation sites. Indeed it is apparent even from the responses to the current questionnaire that many site managers value the presence of deer on the site and that the presence of deer is also positively enjoyed by visitors to the reserves. More generally, we would note that conflicts between deer and conservation objectives arise almost exclusively in woodland - and even there, problems are in the main experienced only where for one reason or another, coppice management has been reestablished in the whole or part site.

We may perhaps distinguish at this point between deer presence and impact. In heathland, wetland (saltmarsh, fenland), grassland or wood-pasture sites, the impact of deer is usual regarded as neutral or positively advantageous: either of no real significance or of positive benefit in helping to arrest scrub encroachment within open vegetation. Indeed English Nature should not forget that at least one of its reserves, Moccas Park in Herefordshire, is specifically managed as a deer park to maintain a characteristic vegetational composition. Only in *some* woodland sites is the impact of deer browsing considered a problem in relation to other management objectives.

Even within those sites, as with others where impact is insignificant or positively welcomed, the presence of deer may be considered an asset. They are after all part of the complete ecological community of the reserved area that managers seek to preserve; they are important not only in terms of their role within the functioning of that particular ecological system, but also in their own right as contributing to the overall diversity of the site. In addition, as large, charismatic mammals, they are of positive 'amenity' value in enhancing visitor enjoyment of the reserve.

ii. Only where some genuine conflict is experienced with other management objectives for the site, or where management is required in the interests of good-neighbourliness to adjacent agricultural or forestry land-holdings, may intervention be required; even here site managers should assure themselves through proper objective survey that damage is truly due to deer not other animals (eg. rabbits or hares) and that it is of sufficient significance to warrant intervention.

iii. Where management of deer populations is required, it is quite apparent, both from theoretical arguments of Section 4 and the case studies presented in Section 5 that no one approach will be effective on its own. Culling without protection will be of little value. Equally, protection by temporary or permanent fencing will be of limited effectiveness unless accompanied by a reduction in population density, or some form of provision of alternative foraging areas, to keep pressure off the fences. Thus as noted in Section 4: managers should in most situations move towards adoption of some system of integrated management involving both direct control of the pest population itself and also control of its pest status.

iv. That said, it is also important to note that no one management prescription can be offered for all sites. I will rehearse below a series of available alternative options appropriate for controlling numbers of deer and/or controlling their impact within conservation areas. However, site managers must be left to choose measures from within this portfolio of available methods, as appropriate to their own sites: simply, differences in site character or soil productivity, differences in management objectives for different sites - as well as differences in the management approaches which are effective for the various different species of deer mean that no single prescription will fit all circumstances.

Thus it is clear for example that different species of deer present on a site will not only have different impact, but will respond differently to any given management approach. Short-term reduction in local population density through culling, is more likely to be achieved for muntjac or roe deer, for example, than for fallow, red or sika. Both muntjac and roe are relatively solitary animals, well hefted to restricted home ranges; roe deer at least are territorial for part of the year.

Thus culling even within a reserve area is likely to be reasonably effective in achieving a (short-term) reduction in local population density (before numbers are replenished by immigration or recruitment); for highly social and highly mobile species like red or fallow deer, such local shooting is unlikely to be of much impact. [And in all cases, even for muntjac and roe, where some local effect may be achieved, we should emphasise that the most effective avenue to achieving real reduction in population density is where management is coordinated between adjacent landowners over a very substantial regional area]. Differences in effectiveness and relative cost of different management prescriptions will also vary with size of the site. Some of the options presented blow are practicable only for larger sites; others would be economic only for small reserves.

As noted: all I can hope to offer here is a list of appropriate options for managers to have as potential measures for use; it must remain up to the site manager's judgement and skill to determine how they may use this tool kit and how they may weight the different elements adopted in the final integrated package of measures. But at the same time let me repeat perhaps the single most important point to emphasise in any review of management options:

that no single measure is likely to prove effective in containing deer populations or reducing damage caused. It is apparent that any effective management policy must present a carefully-coordinated and integrated system of measures embracing population reduction, physical or chemical protection of vulnerable crops and imaginative cultural changes aimed at 'diversion' of grazing or browsing pressure.

Such conclusion is based not only on somewhat 'intellectual' considerations of the various arguments raised here but is reaffirmed very clearly by practical experience and observation.

v. Finally in this review of general points may I stress again the importance of a proper survey of deer density and damage before embarking on any management programme expensive of time or materials *and the absolute need for establishment of a proper monitoring programme to monitor the effectiveness of management measures adopted (deer densities, impact assessments etc).* It struck me forcibly in my review that in conservation sites as well as elsewhere, too many manager simply do, and then presume that whatever they have done is working. It is in my view critical not only that management is properly justified by objective assessment of damage beforehand, but that an effective programme of monitoring is established thereafter to determine the effects of that management - preferably against some control area.