ECONOMIC IMPACTS OF WILD DEER IN THE EAST OF ENGLAND

Piran C.L. White, James C.R. Smart, Monika Böhm, Jochen Langbein & Alastair I. Ward

EXECUTIVE SUMMARY

1. INTRODUCTION

1.1. The objective of this work was to provide an information base for the identification of regional management and research priorities to promote a sustainable and beneficial wild deer population in the East of England.

1.2. The research focused on the following sectors in which deer may contribute a value, whether negative (cost) or positive (benefit): road traffic accidents, agriculture, forestry and plantation woodlands, nature conservation, animal and human health, recreation and tourism, poaching and non-use values.

1.3. The work also sought to highlight gaps in existing knowledge and make predictions of the possible future impacts if deer populations continue to increase.

1.4. The approach was to quantify the costs and benefits (impacts) of deer in these different sectors, and where possible and relevant, express them explicitly as functions of deer population density.

1.5. This approach enables future estimates of the economic impact of deer to be made in line with current population trends and the financial implications of changing deer populations to be considered in the development of deer management strategies.

1.6. This report is structured as follows. In chapter 2, deer distribution and density in the East of England region are derived. Chapters 3-10 then cover the impact of deer in each of the sectors listed in section 1.2. In chapter 11, we summarise the current value of deer in the East of England and estimate the possible future value of deer with respect to possible increases in the deer population. Finally, in chapter 12, we identify priorities for the research and management of deer for the future.

1.7. The project was funded by the Forestry Commission and English Nature.

2. DEER DISTRIBUTION AND POPULATION DENSITIES

2.1. A method was presented to derive a deer density estimate for 10-km squares throughout the East of England using the number of deer road traffic casualties (RTCs) recorded by the RSPCA and Forest Enterprise, together with other data. Despite having various biases associated with them, the RSPCA and Forest Enterprise datasets represented the most complete coverage available at the time of the work.

2.2. The method identified significant causal factors which determined the expected number of reported deer RTCs by influencing either traffic flow, contact between deer and traffic, deer population density or recording intensity within each 10-km square. Those causal factors which were thought to influence deer population density were used, jointly, as a proxy for deer density within each 10-km square.

2.3. A deer proxy was constructed from the following eight causal factors: the percentage cover of both broadleaved woodland and coniferous woodland, the percentage cover of both arable cereal and arable-horticulture farmland, fallow deer presence, roe deer presence, whether plantation forests managed by Forest Enterprise were present in the 10-km square, and whether the square contained Forest Enterprise woodland blocks which were let for stalking. The deer proxy was thus derived from landscape and management characteristics of individual 10-km squares, rather than from the reported incidence of deer RTCs directly.

2.4. Actual landscape deer densities (i.e. species-specific densities averaged over an entire 10-km (10,000 ha) square) were derived from the deer proxy by using known deer numbers in Thetford Forest to produce a scale factor linking deer proxy to deer population size. Estimates of landscape deer densities ranged between 0 and 14.7 deer per km^2 across the East of England.

2.5. Woodland deer density was calculated by confining the estimated number of deer in each 10-km square within the total woodland area of that square. Woodland deer densities across the region ranged between 0 and 171 deer per km^2.

2.6. The total deer population size in the East of England was estimated to be between 51,650 and 124,568, with a best estimate of 76,237. This estimate accords well with maximum deer densities reported in the literature.

2.7. Species-specific population sizes were calculated on the basis of species presence/absence data, assumed maximum woodland deer densities (determined from the literature) and relative biomass considerations. Muntjac were most abundant with an estimated 45,079 individuals, followed by roe (15,983) and fallow deer (7,446). Red and Chinese water deer were less abundant (2,684 and 4,949 individuals respectively), while sika were rare in the East of England.

2.8. If consistent and unbiased deer RTC data become available for the whole of the region at some point in the future then the current mechanism could be applied to produce what should be a more precise estimate of deer population densities and population sizes. In due course, a more complete RTC dataset will be produced by the Deer Initiative's Deer Collisions project.

2.9. These population density estimates form the basis from which valuations of the various benefit and cost elements attributable to deer will be calculated in subsequent chapters. Relative deer densities across the region are not influenced by any potential over- or under-estimation of actual deer densities or population sizes. Since the costing mechanisms used for the majority of deer impacts respond, in the main, to relative deer densities rather than absolute deer densities, the valuations produced should not change substantially even if deer density estimates were to be revised should improved deer RTC record data become available in the future.

3. DEER-RELATED ROAD TRAFFIC ACCIDENTS

3.1. A predictive relationship was identified between the occurrence of deer-related road traffic accidents (RTAs) and particular characteristics of individual 10-km squares, such as the population density of muntjac in the square, the area of broadleaved woodland in the square and the area of coniferous woodland adjacent to main roads within the square. This relationship was derived from STATS19 data for Essex, Hertfordshire and Suffolk.

3.2. This predictive relationship was used to estimate the annual occurrence of deer-related RTAs which would result in human injury in the three counties of the East of England for which STATS19 records were not available.

3.3. The minimum cost arising annually from deer-related RTAs throughout the region which resulted in some form of human injury was estimated to be £4,130,966. This cost was based on standard valuations produced by the Department of Transport for the costs arising from accidents which caused human injuries of different severities.

3.4. Minimum and maximum estimates were produced for the annual regional incidence of deer-related RTAs which do not result in human injury; £162,450 and £638,400 respectively. These estimates were obtained by applying a valuation derived from data provided by a national insurance company which detailed the settlement cost of deer-related RTA claims.

3.5. Considerable uncertainty surrounds the estimated incidence of deer-related RTAs which do not result in human injury. However, this uncertainty has only a modest impact on the estimated minimum annual cost arising from all deer-related RTAs in the region. This is because the cost consequences of an accident which causes human injury, whatever the severity, are considerably higher than the cost consequences of an accident which only results in an insurance damage claim.

3.6. From the costs of human injury and non-injury deer-related RTAs calculated above, the estimated minimum annual cost arising from deer-related RTAs in the East of England was £4,293,416. Using a maximum value for the costs arising from the non-injury deer related RTAs occurring annually in the region increases this estimated annual cost to £4,769,366.

4. IMPACT OF DEER ON AGRICULTURE

4.1. Past research suggests that deer damage to agricultural crops will be concentrated close to woodland edges and occur within less than 1 km away from woodlands.

4.2. The relationship between damage by deer to agricultural crops and deer density is non-linear and there appears to be a threshold deer density above which damage occurs.

4.3. Damage to cereal crops is associated primarily with fallow and roe deer, followed by red deer. Muntjac also cause some damage to cereals, but have relatively less impact due to their closer association with woodland cover as well as their smaller size, which makes them less likely to feed on high cereal crops during ripening when most significant damage occurs.

4.4. Damage to root crops is mainly associated with roe deer and red deer, but might also be associated with fallow deer, though studies on this are lacking to date.

4.5. Sika and Chinese water deer are believed to have a negligible impact on agriculture in the East of England.

4.6. The medium threshold landscape densities (deer per km^2) at a 10-km square scale for deer damage to agriculture are estimated to be as follows: fallow, 0.437; muntjac, 1.838, red, 0.231; roe, 0.971.

4.7. The total cost of deer damage to agriculture in the East of England is estimated at between £1.92 and £4.57 million, with a medium estimate of £3.21 million. For this medium estimate, £3.11 million represents damage to cereals and £100,000 represents damage to root crops. Some of this damage may be offset slightly by venison or stalking revenue. There are no available data on this, but any such benefits will be small in comparison.

4.8. Two-thirds of agricultural damage is due to fallow deer and roe deer, with red deer being the next most significant species.

4.9. The economic cost of deer damage to cereal crops is greatest in Suffolk, followed by Essex. The cost of deer damage to root crops is greatest in Suffolk, Norfolk and Essex. The total cost of agricultural damage by deer is greatest in Suffolk, followed by Essex, and then Norfolk and Hertfordshire.

4.10. Our predictions suggest that damage from all species will be heaviest in Suffolk and Essex. Damage to agriculture from roe deer will be concentrated in west Norfolk, Suffolk and north and west Essex, damage from red deer in south and west Norfolk, Suffolk and north and west Essex, and damage from fallow deer in Suffolk, Essex and Hertfordshire. Damage from muntjac will occur throughout the region, but will be lower in Cambridgeshire.

4.11. Agricultural damage by deer may be highly localised, even within single farms, so even if agricultural damage is of limited significance at the landscape level, it may nonetheless represent a significant economic loss on an individual farm. This may be the case especially with high-value crops such as brassicas, peas and early potatoes.

4.12. Because of a lack of data, our figures for agricultural losses do not take into account the costs of any deer damage to materials used to protect high-value crops, or any potential economic damage resulting from rejection of an entire crop by buyers, for example due to deer damage or contamination.

5. IMPACT OF DEER ON FORESTRY AND PLANTATION WOODLANDS

5.1. The financial consequences arising from the presence of deer in the forests and woodlands of the East of England have been estimated by calculating the cost and benefit consequences arising from various sources.

5.2. The cost arising from deer browsing on saplings in young coniferous plantations was estimated by calculating the loss in timber revenue at harvest which results from volume loss due to growth delay. This calculation was based on Corsican pine.

5.3. Two scenarios were considered, in accordance with the forestry research literature. In the first scenario, browsing reduced harvest volume by the equivalent of one year's growth, and in the second scenario browsing reduced harvest volume by the equivalent of five year's growth. The present value equivalent cost of lost harvest revenue was calculated assuming a 55-year harvest cycle and a discount rate of 3% per annum.

5.4. Browsing damage could potentially occur where fallow deer, red deer, roe deer or sika occurred in the vicinity of young coniferous plantations. The relative locations of the young plantations and browsing deer species were assigned at a county spatial scale.

5.5. Estimates of browsing damage were based on the assumption that 0%, 10%, 20%, 30% or 100% of trees in vulnerable plantations suffered browsing damage, and that the damage induced a growth delay of either one year or five years. A range of potential costs were thus developed for the annual consequences of deer browsing in coniferous plantations across the East of England.

5.6. These costs ranged from £0 to £45,690. Annual costs towards the lower end of this spectrum, perhaps between £0 and £13,707, are considered the most likely, given that the consequences of coniferous browsing by deer in the region appear to cause little concern.

5.7. The annual cost of browsing damage to broadleaved plantations was also estimated for a range of browsing intensities derived from the literature. Annual damage costs for the East of England were estimated to lie between £1,821 and £5,501, based on the reduction in timber volume at harvest which would result from leader browsing in the early years.

5.8. These costs are low because the reported average incidence of leader browsing in young hardwood plantations is low, and also because the cost consequences of reduced harvest volume do not arise until 75-100 years in the future. Harvest losses become modest in present value terms when discounted at 3% per annum over 75-100 years.

5.9. The costs arising from bark stripping of young conifers by red deer were estimated by calculating the loss in timber revenue at harvest resulting from downgrading of the stump log of Corsican pine. Harvest revenue loss was converted into a present value equivalent loss assuming a 55-year rotation length and an annual discount rate of 3%.

5.10. Bark stripping of conifers was attributed solely to red deer, and only those conifer plantations in areas where red deer were present were deemed vulnerable to damage. Spatial concurrence between red deer and young conifer plantations was determined at the county level. Cumulative incidence of bark stripping over the vulnerable years was estimated using data from bark stripping assessments in 25 compartments containing Corsican pine and Scots pine in Thetford Forest.

5.11. A minimum annual cost for bark stripping of conifers by red deer in the region was estimated to be £12,793, on the assumption that bark stripping only occurred in those compartments of Thetford Forest in which it had been recorded.

5.12. A maximum annual cost for bark stripping by red deer in the region was estimated to be £153,544 on the assumption that bark stripping at the intensity estimated from the Thetford data occurred in all vulnerable stands within red deer range in the region.

5.13. These estimates are subject to considerable uncertainty, because the vulnerability of Corsican pine to bark stripping is not well established, and also because the reason for bark stripping is itself unclear.

5.14. The additional protection cost imposed by deer on broadleaved woodland plantations was established by comparing the cost of installing tree shelters of appropriate height in regions where different species of deer were present with the cost of installing basic protection against rabbits and hares.

5.15. The estimated additional cost imposed annually on broadleaved woodland planting in the region was £572,238. This cost depends primarily upon the area of young broadleaved plantations across the region, and upon the geographical range of the various deer species.

5.16. The estimated minimum annual gross cost of culling deer in the region, based on Forest Enterprise properties in the East Anglia Forest District, was between £78,938 and £132,615, depending on whether or not overhead costs (such as vehicle and equipment maintenance, deer larder operation etc.), were included in the calculation.

5.17. A value for the minimum venison revenue generated annually by culling deer in the region was produced using cull returns on Forest Enterprise properties in the East Anglia Forest District. This estimate was £47,380, including animals culled by Forest Enterprise rangers and on stalking blocks let from Forest Enterprise.

5.18. The total value of deer with respect to forestry and plantation woodlands was estimated at a minimum cost of £616,589 and a maximum cost of £862,208.

6. IMPACT OF DEER ON NATURE CONSERVATION

6.1. The rapid increase in deer numbers in recent years has produced some conflict between deer and conservation interests.

6.2. A number of studies have reviewed the damage that deer can inflict on conservation woodlands, but none have generated a quantified relationship between conservation impact and deer density.

6.3. We used the English Nature Site Information System (ENSIS) database of SSSIs and a questionnaire study of Nature Reserves to obtain data on deer damage at conservation sites in relation to deer density and surrounding habitats.

6.4. Analysis of the ENSIS data showed that landscape red and fallow deer densities were significant factors distinguishing 10-km squares containing any type of unfavourable site from squares containing only favourable sites. The significance of the Forest Enterprise-culling dummy variable highlights the fact that culling at the landscape level can reduce the likelihood of deer damage to conservation sites locally.

6.5. Questionnaire responses were obtained for 31 Nature Reserves throughout the East of England. Deer were present on 29 of these sites. Damage due to deer was recorded on 15 of the 29 sites on which deer were present, although formal monitoring of deer damage was only done on five sites. Deer population monitoring was also carried out on only five sites.

6.6. Sites with a high level of damage to ground flora, coppice regrowth and woodland regeneration had relative high numbers of roe deer, fallow deer and muntjac. At sites with a high level of damage to scrub regeneration, red deer, roe deer and muntjac were relatively abundant.

6.7. Expenditure on deer management at the sites ranged between £100 and £4,760 in any one year. Culling was carried out at six sites, with a maximum of 30 deer being culled at one site.

6.8. Damage was significantly related to deer density. There was no damage at very low deer densities, when there may even be some beneficial effects of deer grazing. However, damage increased rapidly as deer density increased.

6.9. There was a significant relationship between total annual expenditure on mitigation and control per hectare of woodland and damage score. This formed the basis for predictions of the costs of mitigation and control on a 10-km square basis throughout the region. Predicted costs of damage at the 10-km square level matched the locations of ENSIS-listed sites in unfavourable condition closely, highlighting sites concentrated in a band running through mid-Suffolk, Essex and Hertfordshire.

6.10. The cost of deer to conservation interests in the region is estimated at £265,775. This cost is based on expenditure for damage mitigation and control, and in more than half of these cases, the mitigation is not effective. It also takes no account of the non-market costs associated with deer impacts. This cost therefore represents the minimum cost of deer to conservation interests in the region.

7. IMPACT OF DEER ON ANIMAL AND HUMAN HEALTH

7.1. Deer may act as hosts for some diseases of significance to livestock, including bovine tuberculosis, paratuberculosis, foot and mouth disease, bovine diarrhoea virus and tick-borne fever.

7.2. These infections sometimes occur in deer at quite high prevalence levels, but the role of deer in transmitting these diseases to livestock appears to be negligible or unknown.

7.3. Deer act as a vector for the tick *Ixodes ricinus*, which is the principal vector for Lyme disease, a spirochaetal bacteria of the species group *Borrelia burgdorferi*.

7.4. There is at least some correlative evidence that deer play some role in increasing the risk of transmission of Lyme disease to humans, although other mammals and birds are also involved in the epidemiology of the disease.

7.5. Data on the incidence of Lyme disease in humans in the East of England between 1986-1998 were related to deer and habitat variables using a count data regression model.

7.6. Landscape deer density and whether fallow deer were present exerted the strongest influences on the incidence of Lyme disease in humans within each 10-km square. Other significant factors were the fragmentation of coniferous woodland and the woodland deer density. The use of small woodlands for pheasant rearing may be a reason for the inclusion of these factors in our model.

7.7. There were 48 cases of Lyme disease in humans in the East of England over the 13-year period 1986-1998 inclusive, an average of 3.69 per year. Based on disease-specific figures, the cost of Lyme disease to humans in the East of England is approximately £89,000 per year. The proportion of this cost that is specifically due to deer is not known.

8. DEER-RELATED RECREATION AND TOURISM

8.1. Deer-related recreation and tourism comprises both consumptive (e.g. deer stalking) and non-consumptive (e.g. biodiversity viewing) activities.

8.2. The economic net value of stalking in Forest Enterprise-managed forests and privately managed forests let from Forest Enterprise was estimated to be approximately £50,000, based on numbers of deer shot by fee-paying stalkers in 2001-2002 and average stalking fees per species and sex. The calculation also included revenue from venison sale and management costs. No data were available for fee-paying stalking in the private sector, and there is also a large amount of stalking that is arranged on a casual basis with farmers and landowners for which there are no data available. This figure therefore represents a minimum value, and the real value may be several times higher than this.

8.3. The total non-consumptive recreational value of deer in the East of England was estimated at around £343,066, assuming a 10% contribution of deer to the non-consumptive recreational benefit of wildlife tourism. This may however be an overestimate since deer are not frequently seen by tourists; consequently, a lower contribution of 5%, leading to a non-consumptive recreational value of deer of around £171,533, may be more realistic.

8.4. Despite these positive effects, deer also have a negative impact on tourism due to the damage they cause to woodland flora. However, the proportion of money spent on deer management programmes, as part of woodland improvement components of regional regeneration schemes, is unknown.

9. DEER POACHING

9.1. There are only sparse data available on deer poaching in the East of England, since poaching constitutes a non-recordable offence and evidence is mostly anecdotal. However, around 63 cases are likely to have been reported throughout the region in 2002.

9.2. Because of the lack of quantitative poaching data, considerable assumptions had to be made to derive a cost of deer poaching in the East of England.

9.3. It was estimated that poachers take around 65-134 red deer, 180-372 fallow deer and 387-799 roe deer in the region each year, assuming that only one of five poaching cases are reported, these are the only species taken and they are taken in direct proportion to their relative abundance.

9.4. The value of deer taken by poaching, based on carcass weight data and venison pricing, was estimated to range between £25,000 and £51,000.

9.5. The annual cost of police investigation of alleged poaching cases was estimated at £9,450. The cost of poaching patrols run by landowners was estimated as £19,000.

9.6. The approximate total costs of deer poaching range between a minimum of £53,000 and a maximum of £79,000 in the East of England per year.

10. NON-USE VALUES ASSOCIATED WITH DEER

10.1. This chapter has described various forms of non-use value which could be attributed to, or influenced by, the presence of deer in the East of England. In addition to intrinsic non-use value arising from the presence of deer in the region, it was suggested that deer presence would also influence the non-use value associated with woodland biodiversity.

10.2. Ecological evidence suggests that deer presence can exert both positive and negative influences on different elements of woodland biodiversity, but it is likely that excessive deer densities will exert an adverse overall influence on biodiversity. The relationship is not straightforward, however, and is likely to be confounded by many site-specific and species-specific factors.

10.3. High densities of deer impact on forest and woodland ecosystems and their biodiversity primarily by removing the shrub layer, with species such as bramble, ivy and honeysuckle being particularly affected. High densities of deer, particularly muntjac, have also been associated with reductions in the abundance of rare or nationally important flowering plants such as bluebells, dog's mercury and oxlips.

10.4. Reductions in the number and abundance of plant species, and simplification of woodland structure, are thought to contribute to reductions in the abundance of invertebrates including various species of beetles, and butterflies such as the white admiral, the meadow brown and the ringlet. These changes are also thought to lead to declines in insectivorous birds such as tits and woodpeckers, birds which nest and/or feed in the shrub layer such as nightingales and various species of warblers, and small mammals such as the yellow-necked mouse, the dormouse and the bank vole. Reductions in small mammal populations may also have detrimental knock-on effects on predators such as the tawny owl.

10.5. In contrast, various species of plants, invertebrates and animals may benefit from increased deer density and the changes in woodland structure that result. The pearl-bordered fritillary butterfly, various species of endangered carrion-eating beetle, and birds such as the pied flycatcher and the tree pipit, which thrive in wood pasture, are some examples.

10.6. Deer, as a charismatic species, are thought to be well regarded by the public at large. It may therefore be the case that although previous studies have shown that the public are prepared to support projects which enhance biodiversity, they may not be prepared to do so if this necessitates a significant reduction in deer population density, especially if this requires heavy and widespread culling.

11. CURRENT VALUE AND FUTURE TRENDS

11.1. Populations of all six deer species in Britain have been increasing over the last 40 years. Increased populations of deer may bring with them increases in the associated costs. However, prior to this study, these costs, and therefore the potential changes in them with increasing deer numbers, had not been quantified.

11.2. The total market value of deer in the East of England was estimated to be a cost of £7.0-10.2 million. The major contributors to this were deer-related road traffic accidents (£4.3-4.8 million) and damage to agriculture (£1.9-4.6 million), followed by damage to woodland plantations and forestry (£0.6-0.9 million) and damage to conservation (£0.3 million).

11.3. The potential future costs and benefits of deer over the next 5 and 10 years are estimated, based on the assumption that populations increase over the next 10 years at the same rate as ranges have expanded over the last 30 years. Our predictions suggest that in the next 5 years, the market value of deer to the region will be a cost of £8.8-11.5 million, and that this will increase to a cost of £10.1-12.4 million in 10 years. These changes will be equivalent to a 12-25% increase in costs over the next 5 years and a 21-44% increase in costs over the next 10 years.

11.4. The predicted overall increase in costs is therefore less than the assumed increase in the deer population over the same periods. However, the change shows different patterns in the different sectors, according to the nature of the impact-density functions. The cost of deer to forestry and woodland plantations is predicted to increase by only 2.7-6.7% over 10 years, whereas the cost of deer to conservation is predicted to increase by 167% over the next 10 years.

11.5. The most significant uncertainty in predicted costs is for agriculture, where the predicted increased cost of damage over the next 10 years is 6.1-70.9%. For this sector, the relationship between impact and deer density is thought to be non-linear, with damage occurring but being relatively unchanging above a threshold deer density. The value of this threshold is unknown, but variation in the threshold has a huge impact on the predicted costs, with the uncertainty of these costs increasing through time.

11.6. These predictions of the value of increases in the deer population assume that all factors other than the deer population remain constant. For example, it has been assumed that there are no changes in species distribution. In fact, there have been considerable changes over the last 30 years, as discussed in earlier sections, with all species expanding their ranges by an average annual compound rate of 4.29%.

11.7. In these predictions, it has been assumed that all deer species are increasing at an equal rate. However, changes in the relative abundance of different species may have a significant effect on the overall value of deer. For example, the increase in costs on agriculture would be relatively greater for increases in red deer or fallow deer, since these account for most of the damage.

11.8. The summaries of values in this chapter are based on market costs only, and do not incorporate any non-use values associated with deer, which may be considerable. The existence and bequest values of the native deer species in particular are likely to be very significant. This should be borne in mind when these estimates of market values are considered. It should also be noted that most mammals, including both native and introduced species, not just deer, impose some costs on human activities.

11.9. Throughout this study, we have used whatever data were available to generate functional relationships between impact and deer density, where these have been relevant. However, there are relatively few data behind some relationships, and for non-linear relationships, any errors are exacerbated as extrapolations are made.

11.10. For this reason, the predictions of changes in the costs and benefits associated with deer in relation to increasing deer density should be interpreted with caution, especially at higher levels of increase. Nevertheless, they do highlight those sectors where increased deer density may be of particular concern in the future, but where the relationships between impacts and density are least understood, such as agriculture and conservation.

12. PRIORITIES FOR RESEARCH AND MANAGEMENT

Priorities for research

12.1. There is scant information available on deer densities in broadleaved woodland, and especially in the mosaic woodland landscape that dominates much of the region. Obtaining information on densities in these different landscapes is important for improving the models, relating deer density to landscape features, that underpin much of the analysis in this report.

12.2. More data on the interactions between deer species at different densities would be extremely valuable in refining these models, although obtaining such data on the large scale that is needed would be an enormous task.

12.3. There is also a need to obtain more information from culled deer across the region, including species and sex as a minimum, and if possible, age class and reproductive condition as well. Such information would be of considerable value in assessing the status of deer populations in different parts of the region, as well as enhancing our understanding of their impacts.

12.4. The report has identified road traffic accidents (RTAs) as the most important economic impact of deer in market terms. As part of the ongoing Deer Collisions project, improved data on deer road traffic casualties (RTCs) and deer-related RTAs will become available. These data will help to refine the estimates of the economic impact of deer-related RTAs. Economic analysis of the different prevention measures in terms of their benefits and costs should form an integral part of planning for the mitigation of deer-related RTAs.

12.5. Damage to agriculture was identified as the second most important economic impact of deer in market terms, behind RTAs. However, the uncertainty associated with the estimate of agricultural losses due to deer was large. The cost consequences of agricultural damage need to be understood better, in particular how these are related to deer density.

12.6. The greatest concern in relation to forestry and plantation woodlands is deer damage to broadleaved woodlands. These woodlands may serve to enhance the landscape for deer, but are also likely to bear the consequences of increased deer numbers in terms of conservation damage and/or costly protection measures to mitigate against impacts of deer. Obtaining better data on the impact of deer on broadleaved woodland plantings in relation to density and the cost-effectiveness of protection should be a focus of research effort within this sector.

12.7. With respect to nature conservation, the relative lack of data and the nature of the function relating deer damage to density mean that there is a high degree of uncertainty associated with predictions. The relationship we have identified suggests that damage to conservation woodlands may increase exponentially with increasing deer density. Our costs of damage for this sector are almost certainly a gross underestimate. Quantifying these costs better and refining the impact-density relationship in this sector should therefore be a priority.

12.8. Deer stalking is likely to remain a minority, albeit significant, activity. However, ecotourism in terms of deer viewing or deer safaris among wild populations may have the potential to bring in much greater revenue.

12.9. Our research identified a correlative link between the incidence of Lyme disease and deer density. However, deer are just one component of the disease-host system for tick-borne diseases. Nevertheless, the costs of impacts on any sector that involves human health or livelihood can be considerable and the situation should therefore be monitored closely.

12.10. With increasing deer populations, there is potential for obtaining revenue from their exploitation for venison. Increased harvesting of the deer for venison may also contribute to bringing the deer population down more generally, with associated benefits of reduced impacts in other sectors. A full economic analysis would be required to investigate the potential for the development of large-scale venison production in the region.

12.11. Although there have been several studies that have addressed the non-market value of forests in the UK and their biodiversity, none have attempted to address the relative contribution made by deer to this value. It would be possible to examine this by the use of a carefully constructed willingness to pay (WTP) study, probably using a contingent ranking or rating approach. However, any such study would need to present respondents with a quantified trade-off between the abundance of deer and biodiversity, for which data are lacking at present. It would also be necessary for respondents to understand that deer management to enhance biodiversity would almost certainly include culling of deer.

12.12. Because of their potential economic significance and the relative paucity of data, quantifying damage-density relationships within the agriculture and conservation sectors should be the priority for further research on the impacts of deer in the region.

Priorities for management

12.13. According to our current (market-based) data, effective management to reduce deer-related RTAs and impacts on agriculture would bring the greatest overall economic benefits to the East of England region, followed by management to reduce impacts to woodlands and forestry and nature conservation.

12.14. The high-risk areas within the region differ slightly for the different sectors, but the greatest costs are faced in a belt running from south Norfolk though Suffolk, and north and west Essex into Hertfordshire. In these areas, agricultural crops, broadleaved woodland plantings and conservation woodlands are likely to be particularly susceptible to damage, so appropriate management, whether involving mitigation or direct management of the deer population would be expected to be beneficial in terms of reducing impacts.

12.15. Our analysis with respect to deer-related RTAs shows a slightly different geographical pattern, identifying specific ‘hotspots’ of risk around Thetford Forest and in the Essex-Hertfordshire border areas. This suggests that it is these areas in which mitigation measures would be most usefully employed.

12.16. On an intra-regional basis, our maps of predicted damage levels can be used to direct management priorities in different areas. Such an approach implies that there will be no single approach to deer management throughout the region. However, our analysis strongly suggests that the benefits of large-scale deer control in forestry are significant and are felt well beyond forestry in sectors such as agriculture and conservation.

12.17. Against a background of increasing deer populations, our study suggests that the most effective management of deer would involve a coordinated strategy across the whole region. However, our analysis of the conservation sector showed that very few Nature Reserves were associated with Deer Management Groups, so there is clearly much that remains to be done in working towards this goal.

12.18. The precise form that a coordinated deer management strategy should take is beyond the scope of this report. It is clear that culling of deer may be beneficial in reducing damage is some circumstances, but that in others, damage can be prevented or reduced to acceptable levels by other techniques such as physical exclusion or deterrence.

12.19. With the increasing interest and participation of the general public in decision-making on wildlife issues, management is being driven more and more by societal perceptions. As a consequence, there is a growing requirement to justify management actions. Any wildlife management therefore needs to be based on a proper understanding of the causes of the perceived problem. Moreover, mitigation methods should not only be cost-effective and environmentally acceptable, but also ethically acceptable to society. This may be a significant problem where culling is envisaged, especially with regard to reducing deer impacts on Nature Reserves.

12.20. Collation, monitoring and evaluation of deer-related data should form an integral part of any future management strategy, and standardised procedures should be established to monitor changes in deer populations and impacts, thereby ensuring comparability across the East of England region.

12.21. The impact-density function approach we have used for this research provides a means by which quantified targets for management can be set as a direct consequence of the relationship between damage and density. It is important that these targets are set in terms of reducing impacts rather than simply reducing deer density. This report represents the first stage in developing a framework for such target-led management.

12.22. The priority for management should be to continue to promote coordinated approaches to deer management, but also to invest in research to improve our understanding of these impact-density relationships, so that any management strategy has the best possible basis in scientific understanding.

Table 1 Current (2003) and predicted market values, and percentage changes relative to current values, associated with deer in the East of England for 5- and 10-year future scenarios. Deer populations are assumed to increase by 23.4% over current populations for the 5-year future scenario, and by 52.2% for the 10-year future scenario. For details of methods, see the main report.

Sector	Value								
	Now			5-year scenario			10-year scenario		
	Minimum	Medium	Maximum	Minimum	Medium	Maximum	Minimum	Medium	Maximum
Actual values									
RTAs	-4,293,416	-4,531,391	-4,769,366	-5,041,182	-5,320,509	-5,599,836	-5,481,140	-5,784,844	-6,088,548
Agriculture	-1,924,773	-3,211,475	-4,569,415	-2,689,005	-3,927,671	-4,755,645	-3,288,603	-4,367,126	-4,848,519
Forestry & plantations	-616,589	-729,332	-862,208	-623,964	-743,747	-884,619	-633,062	-761,530	-919,745
Conservation	-265,775	-265,775	-265,775	-440,568	-440,568	-440,568	-710,774	-710,774	-710,774
Health	-89,000	-89,000	-89,000	-117,510	-117,510	-117,510	-145,488	-145,488	-145,488
Recreation and tourism	221,533	307,300	393,066	221,533	307,300	393,066	221,533	307,300	393,066
Deer poaching	-53,118	-66,250	-79,382	-65,531	-81,733	-97,933	-80,846	-100.833	-120,819
Total	-7,021,138	-8,585,923	-10.242,080	-8,756,227	-10,324,438	-11,503,045	-10.118,380	-11,563,295	-12,440,827
Percentage changes									
RTAs				-17.41	-17.41	-17.41	-27.66	-27.66	-27.66
Agriculture				-39.71	-22.30	-4.08	-70.86	-35.99	-6.11
Forestry & plantations				-1.20	-1.98	-2.60	-2.67	-4.41	-6.67
Conservation				-65.77	-65.77	-65.77	-167.43	-167.43	-167.43
Health				-32.03	-32.03	-32.03	-63.47	-63.47	-63.47
Recreation and tourism				0.00	0.00	0.00	0.00	0.00	0.00
Deer poaching				-23.37	-23.37	-23.37	-52.20	-52.20	-52.20
Total				-24.71	-20.25	-12.31	-44.11	-34.68	-21.47